ELECTROPHYSIOLOGICAL CHANGES IN PRIMARY PIGMENTARY DISEASE OF THE RETINA

THESIS

SUBMITTED

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by

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بسم الله الرحمن الرحيم

ABBREVIATIONS

E.R.G.	:	Electroretinogram.
E.O.G.	:	Electrooculogram.
V.E.P.	:	Visual evoked potential.
Active electrode	:	One of two inputs other than the earth connection of a differential amplifier.
A.R.	:	Arden's ratio or index.
Bipolar recording	:	The name given to the arrangement of the terminals of a differential amplifier.
cm	:	centimeter.
mm, mm^2	:	Millimeter and square millimeter.
m.sec.	:	Millisecond = one thousandth of a second.
mv.	:	Millivolt = one thousandth of a volt.

Electrophysiological abbreviations in the tables of results:

E.R.G.

A(a)	:	amplitude of (a) wave in microvolts.
A(b)	:	amplitude of (b) wave in microvolts.
L(a)	:	latency of (a) wave, in milliseconds.
L(b)	:	latency of (b) wave, in milliseconds.
R- E.R.G.	:	Red E.R.G.
W- E.R.G.	:	White E.R.G.

V.E.P.

A(a)	:	amplitude of (a) wave of V.E.P.
A(b)	:	amplitude of (b) wave of V.E.P.
L(a)	:	latency of (a) wave of V.E.P.
L(b)	:	latency of (b) wave of V.E.P.

E.O.G.

A.R.	:	Arden's ratio.
Rt or lt	:	Arden's ratio of right or left eye.

CONTENTS

INTRODUCTION

and

REVIEW OF LITERATURE

HISTORY OF ELECTROPHYSIOLOGICAL STUDIES OF THE EYE

Electrophysiological measurements on the eye include up till now:

- Electroretinogram
- Electrooculogram
- Visual Evoked Potential
- Dark Adaptation
- Flicker Fusion Rate
- Early Receptor Potential
- Ultrasonography
- Electronystagmomyography
- Electromyography.

For many years these tests have been confined to laboratory and academic research but are becoming now part of the clinical routine in many advanced countries.

The principle of all these tests depends on the fact that there is an electro-potential difference between the cornea which is electrically positive and the posterior pole which is electrically negative.

The study of the electro-physiological changes started with the study of the electric circuit itself.

Dubois Reymond (1849), Professor of Physiology in Berlin recognised that the cornea is electrically positive with respect to the posterior pole. Sixteen years later, Holmgren (1865), in Sweden, observed that the resting potential can be modified by effect of light on the retina. Shortly after, Dewar and McKendrick (1873), working at Edinburgh came to the same conclusion as Holmgren.

Their experiments were carried out by placing electrodes on the cornea and on the posterior pole, and they discovered that this response can also be obtained by placing the electrodes on exposed brain and cornea allowing the eye to be left in situ and also by placing electrodes on cornea and on adjacent skin area. After that, they tried to use a clay trough filled with saline as corneal electrode in an attempt to produce and record human electroretinogram.

Dewar and McKendrick concluded that the method was too exhausting and uncertain to permit a qualitative observation.

Many researchers have studied the retina not just because of a primary interest in vision but with the hope of obtaining a better understanding of the central nervous system.

For this reason, one of the electrophysiologists noted that the retina can be regarded as a model for studying brain function.

Electroretinogram and its discovery:

Dubois Reymond (1849) discovered that when monopolarised electrode is attached to the cornea from one side and the optic nerve from another, and a simple galvanometer is connected to the circle, a difference in millivolts between the two electrodes can be detected easily, especially in fish, frogs and turtles. Dubois Reymond's demonstrations encouraged investigation and interested many workers in electrophysiology. Holmgren (1865-1866) conducted a significant series of experiments similar to Dubois Reymond's, adding a means of visual stimulation of the eye. His efforts were successful.

McKendrick (1873) discovered that if light was suddenly allowed to pass through the previously covered eye, the galvanometer gave a slight deflection. This deflection indicated that the cornea became more positive than the posterior pole; then the galvanometer would gradually go back to the original position.

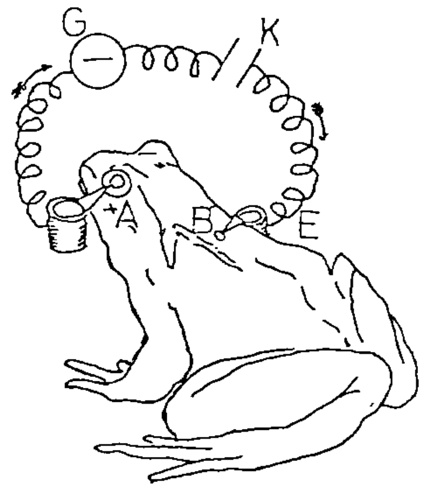
Investigators in these countries were motivated by the desire to understand better how the visual system works and in obtaining an objective indication of its action. They reached practically identical conclusions.

While the first investigations were made with extirpated eyes, it was soon discovered that some responses could be obtained from the entire organ.

Steps of development of technique:

It is important to discuss the historical steps that have led to the present recording technique and these steps to advances occurred.

1. Holmgren (1865-1866), Dewar and McKendrick (1873a,b,c) (Fig. 1) had no facilities to get more than the very simple stimulus and very simple recording and such facilities were not available to them, but they take the first steps towards quantification by controlling light power by changing the distance and by using filters (as the use of copper solution for preventing infra-red heat energy from reaching the eye. Moonlight was tried as a cool stimulus.
2. Gotch (1903), whose recording apparatus had a great advance in method by using the capillary electrometer instead of tha galvanometer.



Fig(1)

Recording the electroretingram from the frog. this figure shows how Dewar and M'Kendrick(1877)recorded the electroretinogram without removing the eye from the animal. the recorded method is essentially the same as might be used today. A wick electrode

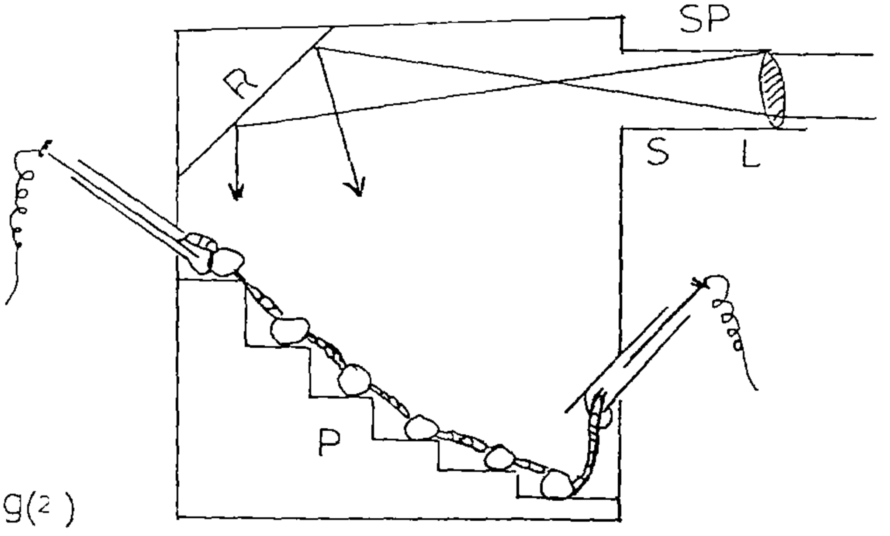
E, is placed on the animal; and a reference electrode,

B: is inserted in a wound on its back when the eye is stimulated, current flows through the circuit, causing the galvanometer,

G: to deflect.

K: is a key or switch which may be opened or closed as desired. the mechanism for stimulating the eye is not shown.

3. Soon afterwards, Bruck, Garten (1907), as well as Einthove, Jolly (1908) used the string galvanometer. This type of delicate recording facilitates the study of time relations and shows more details on wave form.
4. In an attempt to give a larger wave, Bruck and Garten (1907) enucleated up to ten frog eyes and put them all face up in a box and connected them in series; then, all eyes were stimulated simultaneously to get a much stronger response (Fig. 2).
5. A great advance in recording was the discovery and use of vacuum tube amplifier, which is a better means to increase sensitivity in recording technique. It was first used in electroretinogram by Chaffee et al. (1923).
6. Amplifiers actually used consist of transistors and cathode ray oscilloscopes. They are now used on a large universal scale instead of the galvanometer capillary electrometer.
7. The discovery of contact lens electrode: Investigation on humans, and not on animals, had always been hampered by the problems of fitting the corneal electrode. A great advance in this direction was made by Riggs (1941) who used the contact lens electrode for the first time, followed by Karpe (1945) in Stockholm.



Fig(2)

(Bruck and Garten(1907) summation technique)

connecting eyes in series to get more power
L-lens for stimulus light.
S-tube reflectd light bymirror(R).
SP-slot inseat a shutter.
P-group of eyes mounted on a steps.

Up to this time, clinical electroretinography did not really exist. Now, the use of this contact lens can also eliminate the problems of interference due to background noise.

8. Advances in recording technique:

   The technique of enlarging and amplifying minute electrical changes picked up from the electrodes, then re producing them on a paper, still resembles the original routine electroretinogram. Notable advances in recording were made by the use of oscilloscope and polaroid photography.

   Signal averging is a valuable method of separating true response from background interference. It is a more sophisticated and more recent useful method that entails feeding the recordings to a computer specially programmed for this purpose.

General morphology of electroretinogram (E.R.G.):

A polyphasic E.R.G. generally includes 4 main waves: a, b, c and d waves (Fig. 3).

It is very difficult, clinically, to obtain d waves.

a wave is electronegative.

b and c waves are electropositive.

a, b and c waves are responses of "on-effect".

d waves occur when stimulation ceases (off-effect).

Every wave is characterized by its form, latent period, amplitude, duration and time lapse until the peak is reached.

a wave, under certain conditions, split to $a_1 - a_2$.

b wave, under certain conditions, split to $b_1 - b_2$ (Adrain, 1956).

Aurbach (1955) named this wave scotopic one or photopic one:

$(a_1 - a_2)$ into a_p and a_s.

$(b_1 - b_2)$ into b_p and b_s.

The question is still open as to whether the a_s- wave is not rather the first oscillatory potential recorded on the rising slope of the b_p wave.