

The **clinical use** of electroretinography **in retinal** **diseases**

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There are two major categories of methods used during a typical eye exam: firstly, tests where the patient is expected to perform and secondly, tests where the doctor visually inspects the patients eyes. Example of the former category is visual acuity measurement, colour vision assessment and perimetry. These tests are subjective; they depended on the patients ability, cooperation and may, therefore, be affected by non-visual factors such as age, intelligence, verbal skill and reaction time. Example of latter category is bio-microscopy and ophthalmoscopy. These techniques provide information about the structure of the eye, in other words, the gross anatomy of the anterior and posterior segments, but they do not provide information about the functional status of the eye components. The standard clinical electroretinography (ERG) is a recording of the electrical discharges from certain outer retinal layers elicited by a flash of light. The response occurs as a result of transient movements of ions in extra cellular space induced by light stimulus. (1-3)



Electrodiagnostic procedure uses light to produce electrical signals from different parts of the visual systems. They are particularly useful in localizing the area of dysfunction in patients with visual loss of uncertain etiology. In addition, these tests have many advantages over standard clinical procedures. They provide information on how different parts of the visual system is actually functioning, and they are objective. Therefore, they are useful for nonverbal and mentally deficient patients. (e.g., infants, young children, mentally retarded patients), as well as patients who are purposely being uncooperative, such as malingerers, and for patients who give inconsistent subjective responses. Therefore, electro diag-

nostic techniques may aid in arriving to a diagnosis. In this article, we look at the standardization of clinical use with the electroretinography, interpretation relationship for different retinal diseases.

Clinical Electroretinogram

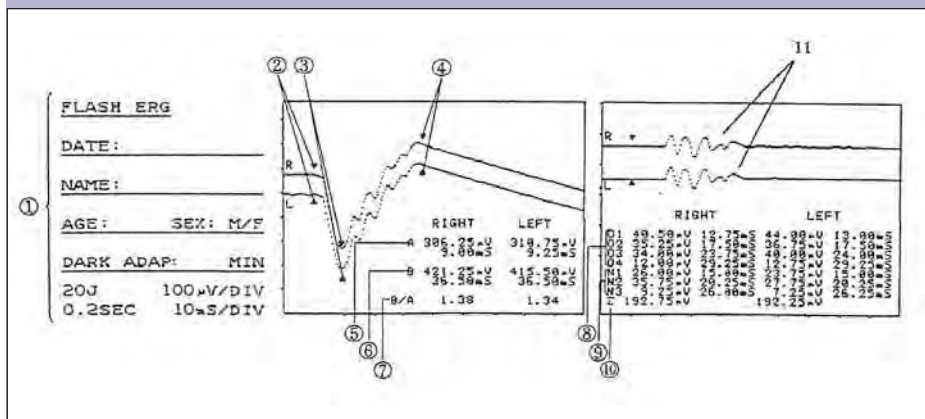
In the clinical setting only the early responses of retina (within the initial 200m sec) are measured because factor responses are usually obliterated by eye blinks.

Within this 200m sec time frame there are two predominant responses, the A-Wave and B-Wave shown in (fig .1).

FIG.1. - FLASH ERG. (1) Measurement conditions (dark adaptation: # of minutes), Light intensity (20 Joules), time

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Figure 1



ured from the base line to the trough of the A-Wave, whilst the B-Wave is measured from the trough of the A-Wave to the peak of B-Wave, Fig (1).

The implicit time is the second major parameter. It is defined as the time from the stimulus onset to the peak of response and is measured in milliseconds (m sec.).

The easiest and most accurate measure of implicit time is the B-Wave under high adapted or photopic conditions Fig(1).

Stimulus conditions

constant (0.2 seconds), Sensitivity (100 μ v/division), Sweep time (10 m sec / division). (2) Start of flash. (3) A-Wave measuring point. (4) B-Wave measuring point. (5) A-Wave measurement. (amplitude μ v , peak time m sec.). (6) B-Wave measurement (amplitude μ v, peak time m sec). (7) B/A wave ratio. (8) Measurements of positive OP (Oscillatory potential) waves (amplitude μ v, peak time m sec). (9) Measurements of negative OP waves. (10) Sum of positive and negative OP amplitude values. (11) Oscillatory potential.

(4) Under certain recording conditions small wavelets, called oscillations, may be seen on the down going and up going waves (fig, 2). These oscillatory potentials arise from a number of cell types in the mid retinal layers. (4) The full-field ERG reflects overall retinal functioning, but not including, The ganglion cell layer. Therefore, diseases affecting only the inner retina or the optic nerve should not alter the ERG. Thus, small-localized lesion (e.g., macular degeneration) will not be affected by ERG amplitude.

Parameters

Two major parameters are used to evaluate the ERG response in the clinical setting. First is the amplitude of the wave, which is measured, in micro-volts (μ v). The amplitude of the A-Wave is measured

Certain stimulus conditions allow the isolation of either the cone or rod responses So that each photosensitive receptor can be studied independently. (5,6) Under photopic or light- adapted conditions with bright background light the rods are sufficiently dampened so that the only response is from the cones. The cone response is rapid with a B-Wave implicit time usually between 28-32 m sec. Using a rapid flickering light can isolate the cone response,

Fig, (3) Flicker ERG: (1) Measurement conditions (number of response average: 30, stimulus frequency: 30 Hz, sensitivity: 50 μ v / division, sweep time: 10 m sec / division. (2) Stimulus interval – the ratio between the time of stimulus magnitude measured from the peak to the trough of each wavelet. (4) Peak time (m sec) –the average of time between successive peaks.

The A-Wave is the initial down going deflection and arises from the photoreceptor cells. (2) The B-Wave is the up going deflection that follows the A-Wave and arises from Müller cells. While the derivation of the B-Wave is from the Müller cells, it reflects such activity from the region of the bipolar cells.

Figure 2 The oscillatory potential (OP).

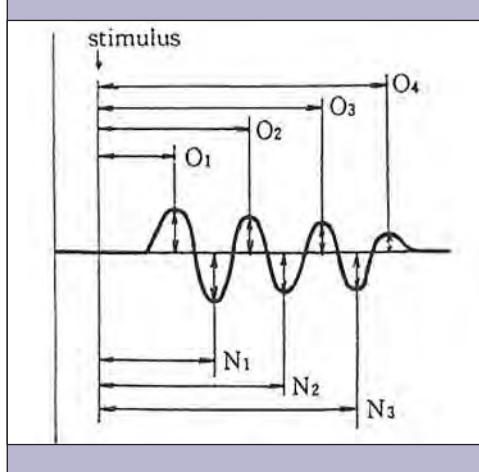
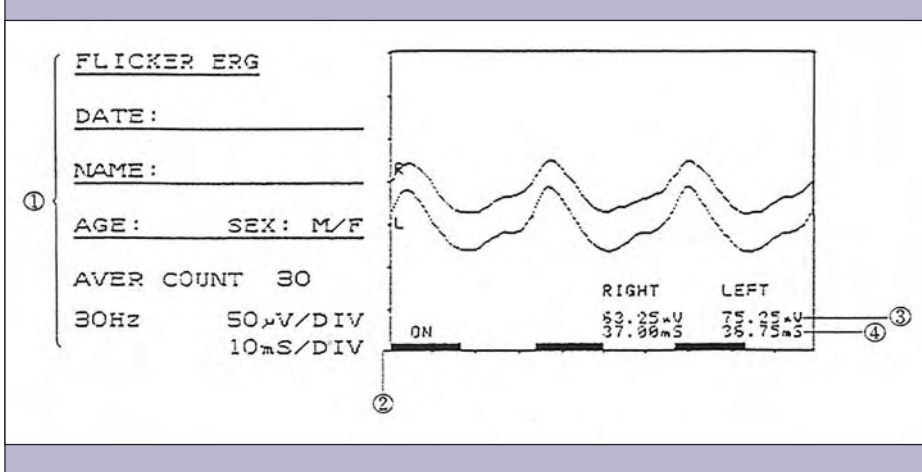


Figure 3



The cones follow a flickering light up to 60 to 70 Hz whereas the rods follow a flickering light only up to 12 to 16 Hz. Therefore a stimulus flickered at 30 Hz elicits a response only from cone receptors.

(7) After sufficient dark adaptation (30 min) the rod responses are optimized under these scotopic conditions. A single bright flash gives a response that is a composite of dark-adapted rods and dark-adapted cones.

This response is much larger and has a longer implicit time than that of the pure cone response. How does one then look at the rods alone? Since the rods are very sensitive to light at the blue end of the spectrum, a weak blue light stimulus produces an essentially pure rod response. Fig.,(4)

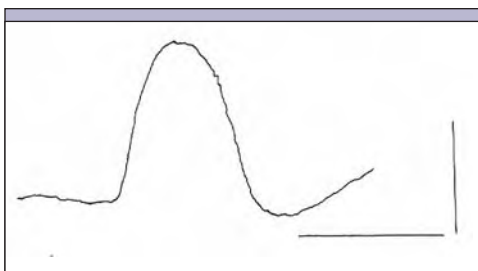


Figure 4 - ERG, Response of a dark-adapted eye to dim blue flashes. Calibration: 80m sec, 200 μ v.

A red stimulus under scotopic conditions results in biphasic response where as the initial wave represents a more rapidly responding cone than the second which is the slower responding rods Fig, (5). This biphasic response occurs because the rods are relatively insensitive to light in this longer wavelength.

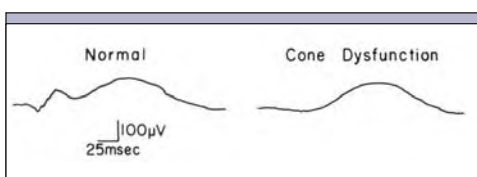


Figure 5 - ERG response of dark-adapted eyes to dim red flash, left rod and cone systems respond sufficiently different to allow separation of cone (initial positive response) and rod (second positive response) systems. right.

Therefore, not only can ERG indicate the layer of retina that is affected by different

disease; it can also distinguished between rod and cone photosensitive cells dysfunction.

Patient preparation and recording

The eye should be maximally dilated and the size of the pupil should be noted. To allow for proper dark adaptation, the testing room should be light proof so that when the lights are turned off. Additional time for dark-adaptation can be allowed if flourescin angiography or funds photography is performed prior to ERG recording. Before inserting the contact lens electrode, the eye should be anesthetized with topical anesthetic and the inner surface of the contact lens should be coated with a cushioning agent (e.g., 1% methylcellulose). Standardization of ERG protocol was discussed by an international committee.(8)

Clinical use

ERG is helpful in documenting, diagnosis, monitoring and determining the prognosis of many ocular diseases. Uses include.

- ◆ Diagnosing and monitoring the progressive degenerative disease of the retinal cells and choroid.
- ◆ Periodically assessing patients (particularly children) with family history of retinal hereditary disease to aid in determining the progresses and prognosis as well as the necessity for vocational or genetic counseling.
- ◆ distinguishing between stationary and progressive night blindness.
- ◆ distinguishing between rods and cone pathology.
- ◆ Assessing vascular integrity and monitoring retinal ischemia.
- ◆ Monitoring the progress of diabetic retinopathy.
- ◆ Evaluation of retinal cells drug in toxicity.
- ◆ Determine the retinal condition in patients with opaque media (cornea, lens, vitreous) to predict the out come of keratoplasty, vitreous and cataract extraction.

Criteria for abnormal ERG response

Determining and knowing where the different components of waveform originate enables different diagnosis when a particular component is abnormal. For example, a normal A-Wave but reduced B-Wave indicates that the photosensitive receptors are not affected and defect is located more proximally. The ratio of the B-wave amplitude to the A-wave amplitude (B/A ratio) is an indicator of ischemia in retinal vascular disease (9); a low b/a ratio indicates ischemia. Reduced amplitude of both A and B-wave as well as

We will concentrate on degenerative changes affecting the retinal cells

reduced oscillatory potential indicate severe degeneration of retinal cells. The major clinical application of oscillatory potentials is in determining the prognosis of proliferative diabetic retinopathy and predicting retinal vein occlusion.

We will concentrate on degenerative changes affecting the retinal cells, particularly, Retinitis Pigmentosa (R P). This condition attracted our interest in our neurophysiology clinic. In addition, the regional social behavioral status by which marriage between close relatives in our region, especially in rural areas, may still have a high incidence.

Retinitis pigmentosa

Retinitis pigmentosa is a group of hereditary retinal photosensitive degeneration's of retina with a worldwide prevalence of about 1 in 4000 (10-14).

In retinitis pigmentosa patents typically experience "night – blindness" or Problems adjusting to a dim lit environment, symptoms that usually appear during adolescence. As the conditions progress

they gradually develop loss side or peripheral vision. In later life, in most cases, patients lose central vision as well. As yet, no treatment is known for these conditions.

Patient with this disease characteristically have constricted visual fields and reduced electroretinogram (ERG) electrical responses that become smaller as the condition progresses.

Probably the most frequent use of ERG is for detecting retinal degenerative diseases, most notably retinitis pigmentosa. ERG changes can precede patient symptoms and ophthalmoscopically visible fundus signs, allowing early detection of the disease process. The earliest ERG abnormality is a reduction in the amplitude of dark-adapted response; latency delay also occurs in early stage.

In some genetic forms of retinitis pigmentosa, ERG may be severely reduced or even extinguished very early in the course of the disease (15). Patients, particularly children, with a family history of hereditary degenerative conditions can be periodically assessed using ERG to aid in determining the prognosis and for vocational or genetic counseling. Patients with this disease characteristically have constricted visual fields and reduced electroretinography (ERG) electrical responses that become smaller as the condition progresses, (16-20).

**Case 1
Typical retinitis pigmentosa**

A 55 year old male with 20/20 vision in both eyes (OU).Goldman perimetry Shows loss of visual field .(Fig,6).

**Case 2
Atypical retinitis pigmentosa**

60 year old male, complaining of poor vision OD (right eye), and normal vision OS (left eye).Fig (7).

The ERG responses and visual field showed reduced responses OS.

Case 3

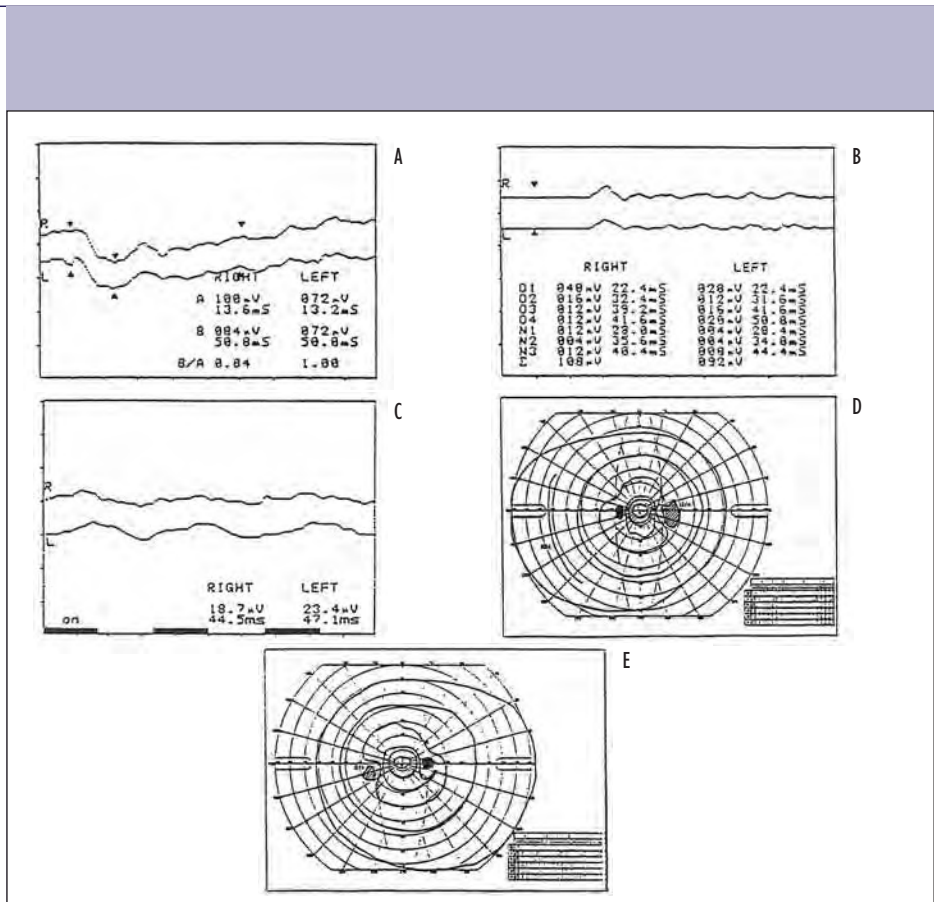


Figure 6 - Flash ERG (A), Oscillatory Potential (B), Flicker ERG (C) shows reduced responses OU (both eyes). Visual field for the right eye(C) and the Visual field Shows a concentric of smaller isopters and relative nasal and paracentral ring scotomas OU.

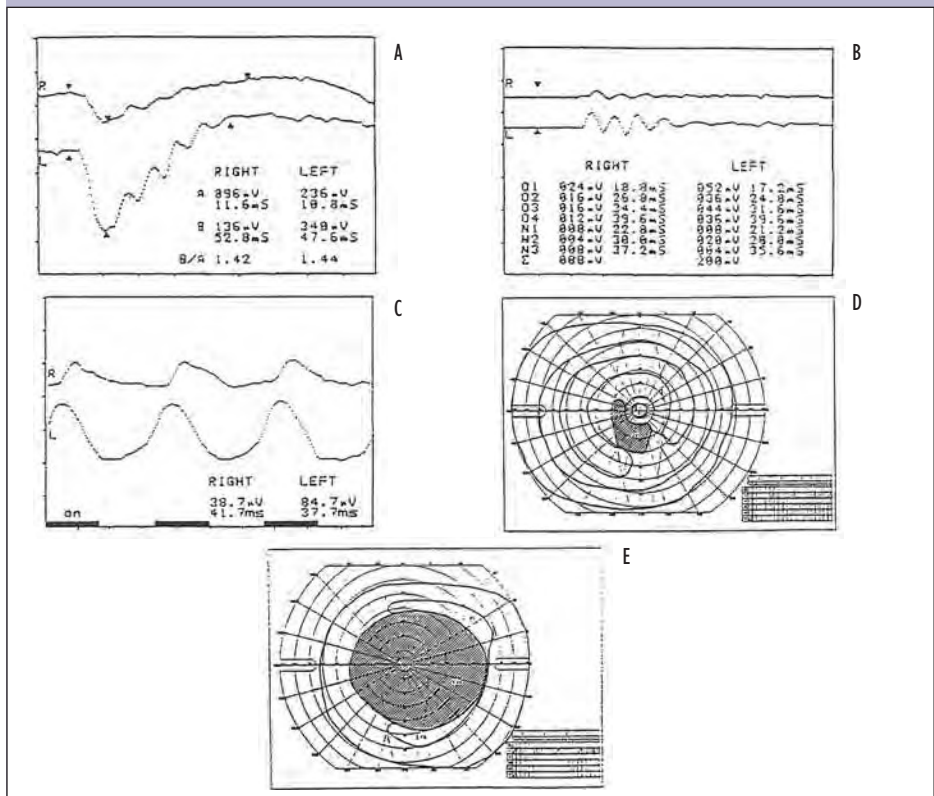


Figure 7 - Flash ERG (A) showed reduced amplitude OD, Reduced OP (B), Flicker ERG shows reduced amplitude (C). The visual field shows extensive field loss OD.

Advanced retinitis pigmentosa

30 year old male, with poor vision ,VA :OD 20/20 , OS 20/20. Fig.(8).

Fig.(8) Showed extinguished ERG components. Visual field results showed spared macula. The extinguished ERG and good visual acuity is not contradictory, since the full field ERG tests overall retinal functions and does not reflect activity from small areas, such as the fovea, which in this case is intact OU. The two most electrodiagnostic tests are Electroretinogram (ERG) and the visually evoked potential (VEP or VER: Visual Evoked Response). The ERG test retinal function, the VEP tests the integrity of visual neuronal pathways from the central retina through optic nerve to the primary visual cortex. While the ERG reflects overall retinal activity, The VEP on the other hand, reflects macula and macular pathway function. Since the ERG and VEP are affected by dysfunction of different components of the visual system, the two tests are complementary.

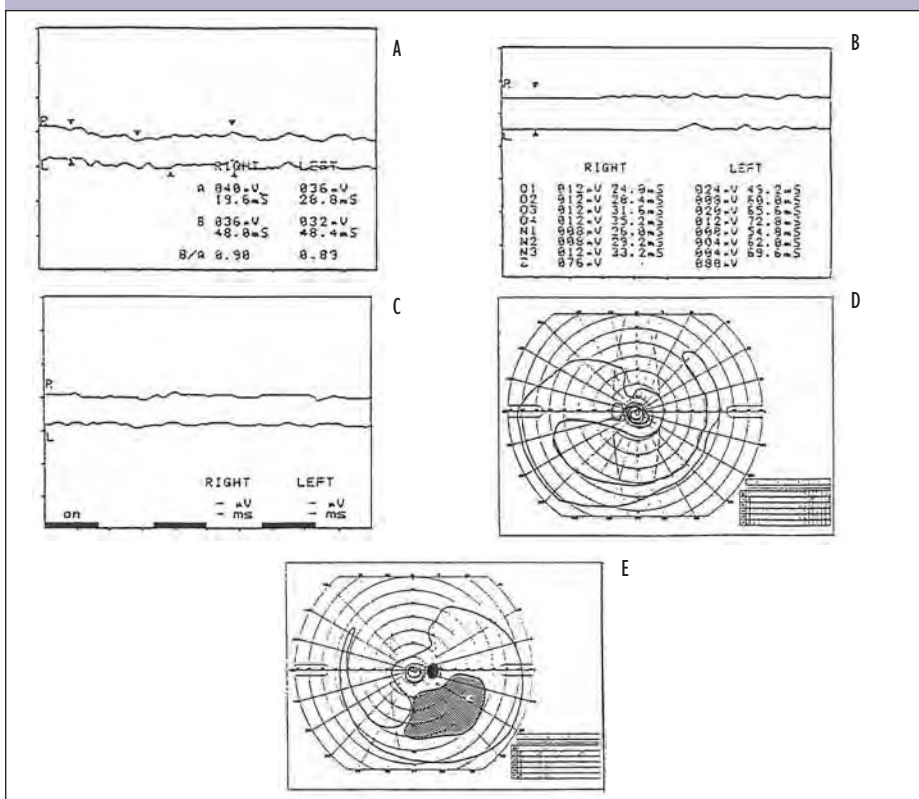


Figure 2 - The oscillatory potential (OP).

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