Multifocal ERG in Glaucoma

An essay
Submitted For fuifillment of master Degree
In
Ophthalmology

Presented by

Heba Metwally Ali
M.B.,B.CH

Supervised By

Prof. Dr. Mohammed Mahmoud EL Sayed

Professor Of Ophthalmology
Faculty Of medicine
Cairo university

Dr. Hoda Mohammed Mostafa

Lecturer Of Ophthalmology
Faculty Of medicine
Cairo university

Cairo university
2008

Abstract

The multifocal ERG is a technique for assessing the local ERG from different regions of the posterior retina. It can provide detailed information of the local activity of cone system.

Glaucoma is common cause of blindness in the world It results from imbalance between the IOP and the perfusion pressure and results into damage of the ganglion cell layer which cause damage of the RNFL and visual field defects. This damage are always asymptomatic at early stages and visual field defects don’t appear before 25-35% of the RNFL is damaged.

Key Words :

Electroretinogram – Electroculogram – Multifocal VEP .

ACKNOWLEDGEMENT

First and for most thanks to ″God″ for his help to fulfil this work.

I would like to express my deepest gratitude to Professor **Dr. Mohammed Mohammed El Sayed** ,professor of ophthalmology, faculty of medicine , Cairo university, for his kind guidance and supervision.

My sincere thanks to **Dr. Hoda Mohamed Mostafa ,** Lecturer of ophthalmology , Faculty of medicine ,Cairo university , For her generosity and positive attitude ,She devoted much efforts and time for me.

Last but not least, I am also expressing my warmest thanks to the Egytptian Eye Academy ″the respectable school of ophthalmology″ and all its members especially the head of the academy, Professor Dr. Karem Kolkailah for his support and encouragement.

Table of contents

	Page
Acknowledgment	**I**
Table of contents	**ii**
List of figures	**iv**
List of abbreviations	**vi**
Introduction	**viii**
Aim of the work	**ix**
Chapter 1: Anatomy of the retina	**1**
Chapter 2 : introduction to electrophysiology of vision	**12**
Chapter 3: guidelines to mfERG	**36**
Chapter 4 : early diagnosis of glaucoma	**67**
Chapter 5: Clinical applications of mfERG in glaucoma	**85**
Chapter 6 : comparison between conventional mfERG and mfPEG in ealy diagnosis of glaucoma	**98**
Chapter 7: other electrophysiological test used in early diagnosis of glaucoma	**100**
Conclusions and Recommendations	**103**
References	**104**

English summary **118**

Arabic summary **120**

List of figures

Page

Fig. (1) : Schematic representation of elements of the retina.
2
Fig. (2) : Diagram of the five basic ERGs.
12
Fig. (3) : Scotopic threshold response.
14
Fig. (4) : The Oscillatory potentials.
16
Fig. (5) : The onset offset components of the ERG response.
17
Fig. (6) : Diagram of normal PERG response.
19
Fig. (7) : Diagram of the focal ERG responses recorded at different positions. 21
Fig. (8) : Diagram showing components of focal macular ERG.
21
Fig. (9) : The pattern reversal VEP response.
25
Fig. (10) : The pattern onset offset VEP response.
26
Fig. (11) : Flash VEP response.
27
Fig. (12) : The multifocal VEP stimulus.
29
Fig. (13) : The multifocal VEP responses and probability plots.
29

Fig. (14) : The multifocal ERG hexagonal stimulus.
32
Fig. (15) : Different resolutions of the mfERG recordings using different hexagonal stimuli.
33
Fig. (16) : The multifocal ERG response (first order) .
34
Fig. (17) : The first order and second order mfERG responses.
35
Fig. (18) : Derivations of the first and second order mfERG responses.
36
Fig. (19) : The mfERG trace array and the probability plot from standard automated perimetry**.**
42
Fig. (20) : Common group averaging methods used in mfERG analysis.
43
Fig. (21) : Figure showing Electrical noise. The trace array shows 60 Hz signals contaminating the responses.
46
Fig. (22) : Eccentric fixation.
47
Fig. (23) : Shadowing error.
48
Fig. (24) : Weak signals and Erroneous central peak
49
Fig. (25) : Figure showing left superior paracentral scotoma on Humphrey 24-2 visual field examination.
61
Fig. (26) : Confocal laser scanning topographic map and reflected image display. 63

Fig. (27) : Nerve fibre layer analysis by GDx-VCC.
64
Fig. (28) : Circular scan around the optic nerve head with OCT.
65
Fig. (29) : Optic nerve head analysis.
66
Fig. (30) : Retinal nerve fibre layers thickness chart of OCT .
66
Fig. (31) : Ultrasound Biomicroscopy of the normal eye.
68
Fig. (32) : UBM showing Occludable angle by dark room provocative test. 69
Fig. (33) : UBM showing plateau iris with double hump sign.
69
Fig. (34) : Cross sectional image of the anterior segment made by AS-OCT. 70
Fig. (35) : Double circular scan transect all retinal blood vessels.
73
Fig. (36) : Dual-plane Doppler OCT measures blood flow direction and profile. 74
Fig. (37) : The variations of the oscillatory component on the descending limb from both glaucomatous patients and normal subject
80
Fig. (38) : Pattern ERG in glaucoma.
83
Fig. (39) : Multifocal pattern ERG of a glaucoma patient.
85

List of abbreviations

ERG	**Electroretinogram**
ERP	**Early Receptor Potential**
STR	**Scotopic Threshold Response**
Ops	**Oscillatory Potentials**
PERG	**Pattern Electroretinogram**
mfERG	**Multifocal Electroretinogram**
mfPERG	**Multifocal Pattern Electroretinogram**
EOG	**Electroculogram**
VEP	**Visual Evoked Potential**
mfVEP	**Multifocal VEP**
FOK	**First Order Kernal derivation of the mfERG**

IOP	**Intraocular Pressure**
ONH	**Optic Nerve Head**
SLO	**Scanning Laser Ophthalmoscope**
SLP	**Scanning Laser Polarimetry**
RNFL	**Retinal Nerve Fibre Layer**
OCT	**Ocular Coherance Tomography**
HRT	**Heidelberg Retinal Tomography**
UBM	**Ultrasound Biomicroscopy**
AS-OCT	**Anterior Segment OCT**
OBF	**Ocular Blood Flow**
BFA	**Blood Flow Analyzer**
SWAP	**Short Wave Length Automated Perimetry**
SITA	**Swedish Interactive Testing Algorithm**
FDT	**Frequency Doubling Technique Perimetry**
TOP	**Tendency Oriented Perimetry**
ROC	**Receiver- Operating Charachterestics**

Introduction

The electroretinography is a mass potential, the result of the summed electrical activity of the cells of the retina.

Full field electroretinography is a well established clinical technique for evaluating global retinal function.

The Multifocal ERG was developed to provide a topographic measure for retinal electrophysiological activity So Multifocal ERG can examine different retinal regions and give a clear indication of central and peripheral electrical responses in glaucoma in addition it can analyze the retinal response using kernel analysis so it can tell whether the macular central responses are affected by glaucoma as peripheral retina and whether the outer retinal layers are affected as inner layers.

However ,the value of mfERG in diagnosis and follow-up of glaucoma remain questionable.

Pattern ERG has a value in diagnosis of glaucoma as it can diagnose generalized disease of the ganglion cell layer, It can detect conversion of ocular hypertension into glaucoma and follow changes of glaucoma.

Multifocal pattern ERG is combination of Multifocal ERG and Pattern ERG to obtain a topographic mapping of the pattern ERG. It can detect local dysfunction of the ganglion cells and small macular lesions. it is the most significant tool in diagnosis and follow up of the glaucoma.

Aim Of the work : The essay will illustrate the role of Multifocal ERG in clinical diagnosis and follow-up of glaucoma and its comparison with other types of electrophysiological tests used in diagnosis of glaucoma.

Early diagnosis of Glaucoma

Introduction:

Glaucoma is a progressive optic neuropathy characterised by irreversible loss of neural tissue over time, it is a leading cause of preventable blindness worldwide. ***(Quigley HA,1996).***

Primary open-angle glaucoma is the most common type of glaucoma, Ocular hypertension (i.e. elevated intraocular pressure without glaucoma) is the most important risk factor to develop glaucoma. The diagnosis of glaucoma is based on the combination of abnormal optic disc cupping with corresponding visual field defects.***(Weinreb R et al.,2004).***

Because the glaucomatous optic nerve damage and visual field loss often are asymptomatic in the early stages, the identification of individuals with glaucoma at the earliest possible time allows for preventive observation and treatment. ***(Tuulonen A, et al.,2003).***

Histopathologic studies showed that approximately 25% to 35% of retina ganglion cell axons may be lost before visual field abnormalities are detected by the standard automated perimetry. ***(Kerrigan-Baumrind LA et al.,2000).***

So the object of interest has been shifted to many functional and structural tests that can help in early glaucoma detection and go beyond limitations of standard automated perimetry.

Diagnostic modalities in Glaucoma

There are a lot of recent methods help in early diagnosis of glaucoma in addition to the classical methods .

Classical methods

- ***Measuring intraocular pressure :*** by either indentation, applanation, pneumatic or non contact (air puff) tonometer.
- ***Examination of the anterior chamber angle by Gonioscopy.***
- ***Ophthalmoscopy:*** by either direct or indirect ophthalmoscopy.
- ***Slit lamp biomicroscopy.***
- ***Nerve fibre layer examination:*** by the red free light at slit lamp examination.
- ***Assessment of optic nerve head:*** during slit lamp biomicroscopy or ophthalmoscopy.
- ***Assessment of visual field*** **by using kinetic and/or static perimetric techniques *:***

-In static threshold perimetry:

The obvious advantage is finding the scotoma depth more accurately than in kinetic perimetry ,but it has the disadvantage that it is time consuming.

-In kinetic testing:

Utilizes a test object of known value which is moved from an area where it is not seen toward an area where it is seen ,and the location where it becomes visible is recorded. ***(Lynn,1969).***

1) Manual perimetry :

The bowel projection perimeter as the Goldman perimeter enables the examiner to test both central and peripheral fields with one instrument. The background illumination ,test distances ,stimulus size and stimulus intensities are all standard . ***(Anderson 1987).***

2) Automated perimetry:

The overwhelming majority of automated perimeters used are static perimeters, using static achromatic targets [white-on –white] (W/W) perimetry and employ suprathreshold and/or threshold strategies. The targets may either be projected onto the bowl or illuminated from light-emitting diodes (LEDs) or fibroptics in perimetric bowl .Projection perimeters ,such as Octopus and Humphrey Field Analyzer (HFA) have the advantage of unlimited possible test strategies ,and the ability to vary the size or colour of the stimulus. ***(Anderson 1987).***

Automated perimetry hold many advantages over manual testing ; as it is more standardized, with lower inter-technician variability ,less skill is required by technicians, field results are more uniformly interpretable, it generally has been assumed that automated testing is more sensitive in detecting visual field loss than manual perimetry ,in that it detects the defects before their appearance on manual testing ,it also provides an objective assessment of the patient performance, and it facilitates interpretation and statistical analysis of the test results and allows more credible and standardized follow-up.***(Kaiser and Flammer .1991).***