VEP AND ERG:
PRIMARY CARE ELECTRODIAGNOSTICS

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COPE Course ID: 36509-GO

BIOGRAPHY
• Principal in 2 practices in Galesburg, and Galva, IL
• Past-President, of the American Optometric Association
• Optometric contractor to Illinois Department of Corrections
• ICO Class of 1984
• Fellow, American Academy of Optometry
• Doctor of Science in Optometry – ICO 2009
• Diplomate – American Board of Optometry - 2011

DISCLOSURES
• Affiliated with Transitions Optical as a consultant for professional development
• Non-executive board member of Optos, Plc based in Scotland
• Consultant to Diopsys, Inc.
• Administrator for Vision Source in Illinois

ISCEV
International Society for Clinical Electrophysiology of Vision

http://www.iscev.org/

Mission
To promote and extend the knowledge of clinical electrophysiology of vision.
To promote co-operation and communication among workers in the field of clinical and basic electrophysiology of vision.

http://www.iscev.org/
ISCEV Standards, Recommendations and Guidelines
VISUAL ELECTRODIAGNOSTICS A Guide To Procedures

Confirmation of Neurological or Ophthalmological Disease
Unexplained Visual Loss
Pediatric Neurology
Opacities in Media
Monitoring Health - Toxicity
Detection of the Disease of Carrier States of Inherited Visual Disorders
Quantitative Assessment of Visual Disease
Assessment of Retinal and Optic Nerve Function Following Trauma
Infants with questionable vision

http://www.iscev.org/standards/proceduresguide.html

ISCEV
Documenta Ophthalmologica
http://www.springer.com/medicine/ophthalmology/journal/10633

ISCEV Standards, Recommendations and Guidelines
VISUAL ELECTRODIAGNOSTICS A Guide To Procedures

Vascular Disease of the Eye Including Diabetes
Opaque Media
Retrobulbar Neuritis
Unexplained Visual Loss
Pediatric Cases
Albinism
Toxic and Nutritional Eye Disease
Intracranial Lesion

http://www.iscev.org/standards/proceduresguide.html

AAO American Academy of Ophthalmology
Preferred Practice Patterns
http://one.aao.org/CE/PracticeGuidelines/PPP.aspx

AOA American optometric Association
Clinical Practice Guidelines
http://www.aoa.org/x4813.xml

Neuro-Physiology

Light
Photoreceptor
Mid-retinal Layers
Bipolar
Ganglion cell axon
Optic Chiasm/Tract
Relay neuron
LGN
Visual cortex neuron

Electrophysiology

- Electrocardiogram
- Electromyography
- Auditory Evoked Potential
- Electroencephalogram
VISUAL EVOKED POTENTIAL (VEP)

- Electric signal registered at the occipital region in response to a visual stimuli.
- **VEP**
  - Visual – patient observes a visual stimulus
  - Evoked – generates electrical energy at the retina
  - Potential – measure the electrical activity in the visual cortex
- Measure the function of the entire vision system; no patient response required – OBJECTIVE TEST 😊

Previous Limitations

- Test time was approximately 45 minutes
- Required highly trained operators
- Required highly trained interpretation (subjective)
- Limited to large research institutions

Advantages of Current Technology

- Test time is approximately 1 minute
- Does not require highly trained operators
- Does not require highly trained interpretation
  - Similar to interpreting VF or OCT
- Currently installed in about 2000 offices (one company), 2 or three other companies - limited

VEP Electrodes

Reference Ground Active

VEP Stimulus

- Flash
- Pattern
  - Reversal
  - Pattern-onset
  - Transient
  - Steady State

VEP Stimulus

- Pattern
  - Contrast Sensitivity
  - Visual Acuity
  - Color
VEP Components

- Amplitude usually translates to the amount of axons conducting along the visual pathway.
- Latency usually translates to the myelin status of the visual pathway.

Other Electrophysiological Tests

- Electroretinogram
- Multifocal Electroretinogram
- Pattern Electroretinogram
- Electrooculogram
- Multifocal Visual Evoked Potential

VEP and other Ophthalmic Diagnostic Tests

- Psychophysics
- VF
- GDx
- HRT
- OCT
Psychophysics of Vision

Visual Acuity Test

-options for customized VEP testing
- User-Defined Protocol
- LKC
- Diagnoys
- Diopsys® NOVA-TR
- Customize testing parameters specific to each patient and pathology
- Pattern Type & Size, Contrast Level, Eye
- Testing times are flexible and depend upon the customized settings

Psychophysics of Vision

Contrast Sensitivity Test

Psychophysics of Vision

Visual Field Test

EXAMPLE:
2 DIFFERENT SPATIAL FREQUENCIES

16 X 16

64 X 64

BUILDING PROTOCOLS
MULTIPLE SCLEROSIS EXAMPLE

EXPECTED P100 TIMING

ACTUAL P100 TIMING

PATIENT D.G. 35 Y.O. MS PATIENT

ABILITY TO USE FIXED PROTOCOLS

- Multi-Contrast Stimuli
  - LKC Requires User to Create Fixed
  - Diopsys® NOVA-LX

- Easy to follow fixed protocol guides the technician through the test procedure.

- Testing time takes 38-53 seconds per eye on Diopsys, or about 5 minutes total – about 1/3 of LKC
Increased pattern VEP latency was significantly correlated with both the severity and location of visual field defects and the degree of cupping and pallor of the optic disc.

The finding that is of clinical importance is the presence of abnormally long VEP latencies in some patients with ocular hypertension. The abnormal prolongation of VEP latency in these eyes may reflect subclinical optic nerve lesions that have not been uncovered with other techniques.

**WHY VEP?**

- Many optic nerve diseases are asymptomatic because central vision is not affected until late in the disease
- Diagnosis and management of optic nerve disorders are often based on structural or subjective visual field tests

**CLINICAL APPLICATIONS**

- Clinicians may objectively test all patients suspected of optic nerve disease with VEP testing (Diopsys® NOVA-LX) to assess the function of the entire vision system
- The NOVA-LX VEP Vision Testing System:
  - Has the sensitivity to help detect optic nerve disorders earlier, allowing treatment to start sooner
  - Allows tracking of disease progression
  - Normative database created over 3 years of testing at New York Eye & Ear Infirmary
Main Indications

- Glaucoma
- Multiple Sclerosis
- Ischemic Optic Neuropathy
- Traumatic Brain Injury
- Amblyopia
- Other Neuropathies

ASSESSMENT OF NEURO-VISUAL FUNCTION

HOW WE TEST

- Low contrast testing demonstrates degradation of magnocellular pathways
  - An early indication of glaucoma
- High contrast testing demonstrates degradation of parvocellular pathways
  - An early indicator of central vision loss and issues caused by problems before signal reaches optic nerve

**patient should be tested with best corrected vision**

BEFORE TREATMENT

- dead
- Suffering
- Alive

Glaucoma

AFTER TREATMENT

- dead
- Alive
- Alive

VEP

OCT

HRT

GDX

RUNNING TESTS – FIXED PROTOCOL

- Simple, automated protocol guides technician through the test
- Operator friendly - anyone in the office can be trained to run the test
- Patient set-up to printable results in as little as 4-6 minutes

1 Tests to run under the supervision of a physician.

ASSESSMENT OF NEURO-VISUAL FUNCTION


BEFORE TREATMENT

- dead
- Suffering
- Alive

Glaucoma

AFTER TREATMENT

- dead
- Alive
- Alive

VEP

OCT

HRT

GDX

ASSESSMENT OF NEURO-VISUAL FUNCTION

DEAD SUFFERING ALIVE

Glaucoma

VEP

OCT

HRT

GDX

BEFORE TREATMENT

- dead
- Suffering
- Alive

Glaucoma

AFTER TREATMENT

- dead
- Alive
- Alive

VEP

OCT

HRT

GDX

ASSESSMENT OF NEURO-VISUAL FUNCTION

Diopsys® VEP Report

**ASSESSMENT OF NEURO-VISUAL FUNCTION**

**READING THE RESULTS**
- Quickly interpret results to enhance medical decision making and treatment planning
- Easy-to-read reports allow clinician to demonstrate therapeutic results and monitor disease progression

MULTI-FOCAL ERG
THANKS TO:
Nathan Lightizer, O.D., F.A.A.O
Assistant Professor, NSUOCO
Chief of Specialty Care Clinics
Chief of Electrodiagnostics Clinic

**READING RESULTS:**
- NORMAL
- ABNORMAL
Photopic ERG of the central retina
Tests the central retinal function
35-40 degrees of central retina
Multifocal ERG (mfERG)

- Ring Ratios
  - $R_1/R_2 = 1.943$
  - $R_1/R_3 = 3.161$
  - $R_1/R_4 = 4.613$
  - $R_1/R_5 = 5.46$

Normal ring ratios
Elevated ring ratios

Multifocal Electroretinogram

- Modern Available Equipment
- Diagnosys mfERG & VEP testing equipment
  - Industry leader for 30+ years
- Dawson, Trick, Litzkow (DTL) Electrode
  - New industry standard, non-invasive
mfERG Test Results

- **mfERG - Normal**
  - All ring average responses within normal ranges for both amplitude and implicit time
  - Trace array consistent with normative data
  - 'Volcano-shaped' 3D plot represents healthy macular response with good fixation

- **mfERG - Plaquenil Toxicity**
  - Degradation in 2nd ring response OU demonstrates paracentral functional loss found in bull’s-eye maculopathy
  - Paracentral functional degradation illustrated by trace arrays and 3D plots allows practitioners to discontinue retinotoxic drugs and limit both structural and functional losses
  - Updated AAO screening guidelines specifically recommends multifocal ERGs as they, “objectively evaluate function and can be used in place of visual fields”

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**Multifocal ERG (mfERG)**

- Very good for:
  - Detecting small areas of damage to the central retina
  - **Plaquenil toxicity***
  - Detecting areas of functioning retina remaining

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**PERG CLINICAL APPLICATIONS**

- Developed for Eye Care Specialists to objectively measure retinal function to aid in diagnosis and monitoring of retinal disorders
- PERG has been recognized as an effective, objective test in helping to diagnose maculopathies including age-related macular degeneration (AMD), diabetic Retinopathy and the long term toxic effects on retinal health
- Provides quantitative information to support the clinician in the interpretation and diagnosis of retinal defects
- Reports and documents the results of practitioner intervention for tracking patients’ response and disease progression to support medical decision-making
- VEP and PERG testing together provide a complete objective, functional assessment of the visual pathways
- A small study by investigators at Albert-Ludwigs University of Freiburg, Germany showed that patients with ADHD displayed significantly elevated “background noise” on a pattern evoked response (PERG) compared with their healthy peers
INTERNATIONAL PERG STANDARD

- Time is measured in milliseconds (ms)
- Amplitude is measured in microvolts (uV)
- N35-P50-N95 Complex
  - N35: Negative Pulse around 35ms
  - P50: Positive pulse around 50ms
  - N95: Negative pulse around 95ms

PERG Electrodes

- Reference
- Ground
- Active

PERG FUNCTION PRECEDES STRUCTURE GLC-S

Main Indications

- Maculopathies
- Glaucoma

Clinical Ability of Pattern Electroretinograms and Visual Evoked Potentials in Detecting Visual Dysfunction in Ocular Hypertension and Glaucoma

Extensive and growing literature supports the clinical usage of PERG for the early diagnosis and tracking of Glaucoma.

Pattern Electroretinograms in Glaucoma Patients with Concomitant Visual Field Deficits

The Patterns Electroretinograms in Glaucoma Patients with Concomitant Visual Field Deficits

PERG Electrodes

Comfort       Convenience       Quality

ASSESSMENT OF NEURO-VISUAL FUNCTION
STEADY STATE – PATTERN ERG CONTRAST AND CONCENTRIC STIMULUS FIELD TESTING

- BCVA
  - Patient should be tested with best corrected vision
- 85% contrast – or High 85% and Low 15% Contrast
- 24" testing distance
- Right Eye (OD) then Left Eye (OS)
  - 8 second "warm up"
  - 20 seconds at 24° - Used for Hc and Lc
  - 20 seconds at 16°

ERG PROTOCOL SELECTION

Chronic Open Angle Glaucoma
Diabetic Retinopathy
AMD
Diabetic Macular Edema
Toxic Maculopathies

Healthy
Asymptomatic
Symptomatic
VF
Glaucoma
OCT
Non documented structural damage
Documented structural damage

PERG/VEP
Documented functional damage
Non documented functional damage

PERG/VEP
Documented functional damage
Non documented functional damage

PERG/VEP
Documented functional damage
Non documented functional damage

As measured by PERG, progressive loss of RGC function in early glaucoma is hindered after IOP lowering.

Glaucomatous Brain Damage

VEP (Function)

Eye

Brain

LGN

OCT
HRT
GDX

(Structure)

Stress (OHT)

Assessment of Neuro-Visual Function

Glaucomatous Brain Damage

Abnormal Concentric - ARMD

Abnormal Contrast - Glaucoma

Our Galesburg Practice

- 4 optometrists – two FT equivalent
- 6 exam lanes
- Pre-Test
  - FDT - AR/AL - LM – Topograher - Optos
  - Special Testing Room #1
    - HVF - HRT
  - Special Testing Room #2
    - Heidelberg Spectralis – PHP - QuantfEYE – Diopsys VEP
- Vision Therapy Specialty – Dr. Carter

Basic Premise of Our Practice

If it is good for the patient…..

It will be good for the practice!
TECHNOLOGY CONSIDERATIONS TODAY

- Does it do something our other technology doesn’t?
- Will it provide clinical information that will impact the treatment of our patients?
- Can it be incorporated into our office?
  - Space – Patient Flow - Staff
- Is it “standard of care” or “leading edge”? 
- Is it “patient friendly”? 
- Will it be profitable and/or Practice Builder? 
  - Efficiency – Billable - Referrals

DOES THE VEP + ERG IMPACT TREATMENT?

- ABSOLUTELY!

  - Glaucoma
    - Adjunct to visual fields (especially low reliability)
    - We now have 2 measures of “function” to go with 2 measures of “structure”
    - Developmental Disabled Patients – unable to do VF and even OCT/HRx
  - Amblyopia
    - Predictor of success and monitoring therapy
  - Maculopathies
    - Monitor function along with structure

VEP + ERG IS GOOD FOR THE PATIENT…. 

- Technology has always been a highlight of our practice
- Glaucoma went away, but came back in 1994 with TPA’s
- Visual Fields traditionally the only measure of “function”
  - Very subjective and patients don’t like the test
  - But now VEP can be incorporated in any practice
    - NOT subjective – and patients like the test
  - For structure, we use OCT and HRT
    - Objective and able to detect subtle changes

CLINICAL EXAMPLE #1 - AQ 11 Y.O. FEMALE

- Patient since 2008 in combination with IA City Ophthalmology
- Progressively more near sighted each year with good BCVA
- 4/2/2012 presented complaining of daily HA’s for 2 months and vision “not clear”. Full work ups at IA City found a seizure disorder with EEG and Johns Hopkins diagnosed malingering
- BCVA on 4/2/2012 was 20/150 OD, OS - cyclopleged
- Ocular health otherwise normal with c/d’s of .7x7 OU
- Ordered VEP and HVF

VEP/ERG – DOES IT DO SOMETHING DIFFERENT?

- Absolutely! – However, not the research based, school based systems that may or may not have been at your school
- VEP results are a representation of the functional integrity of all levels of the visual pathway including anterior seg, retina, optic nerve, LGN and visual cortex
- ERG measures function at the ganglion cell level
- An objective way to measure “function” for a variety of conditions
  - Glaucoma – MS – Amblyopia – Stroke – TBI
  - Maculopathies
  - InfantSEE

AQ – 11 Y.O. FEMALE 4-11-12 VISUAL FIELDS
• Normal Amp and Latency
  and essentially equal
  between eyes
• Another validation of no
  organic cause of reduced
  BCVA
• Since no refractive error
  asymmetry or strabismus
  “not amblyopia” – Streff
  Syndrome
• 6 weeks into vision therapy
  was 20/20 OD, OS

CLINICAL EXAMPLE #2 – JH 63 Y.O. FEMALE
• No Family History of glaucoma – had been watching her for
  reduced macular pigment, although no history of ARMD
• Each year, did poorly on FDT screening fields, with many
  fixation losses, but normal confrontations.
• 10/5/10 Exam showed advanced FDT changes from 2009 IOP
  was 16, 17 c/d remained at .2x.2 OU with right PPA. Pachymetry
  was 583, 592
• 12/3/10 Returned for VF, OCT and HRT

J.H. – FOLLOW UP AND VEP
• 3/1/11 IOP 19,18 gonio
  open
• 6/28/11 VEP
  • Right is essentially
    normal Amp / Latency
  • Left shows reduced
    High Contrast
    Amp but increased
    Low Contrast Latency
• Order repeat VF

CLINICAL EXAMPLE #2 – VISUAL FIELDS 12-3-10

J.H. – VISUAL FIELDS 7-1-2011
PATIENT JH – 3-3-15 (NO TX FOR 3 MONTHS – IOP 17)

JH – “WHY WE PURCHASED THIS TECHNOLOGY”
- The initial VEP prompted more testing and starting treatment early
- The VEP and ultimately the pERG allowed to watch the nerves progressively under more stress
- Removing the cataracts ultimately lowered pressures and allowed nerves to return to health
- Sensitivity allowed removal of treatment
- And ultimately back on treatment
- WE PREVENTED STRUCTURAL DAMAGE

INCORPORATING IN OUR PRACTICE
- Space – 4 feet by 7 feet in a corner
- Patient Flow
  - We schedule 15 minutes – usually 4-8 total
  - Incorporating in glaucoma care - coming
- Staff
  - Trained all paraoptometrics
  - We use primarily a “special test” para
  - More efficient and more consistent results

OUR GLAUCOMA PROTOCOL – INCLUDING VEP/ERG
- Annual exam – include photos - dilated
- 3 or 4 month visit – non dilated
  - IOP – Gonio (UBM) – VEP (95930) ERG (92275)
- Next 3 or 4 month visit – dilated
  - HVF – HRT – OCT
  - Initially did many VEP with this visit at the beginning to get initial data on our patients. Slows the flow in our system because it is preferred to do VEP un-dilated

OUR ARMD/DIABETIC PROTOCOL – INCLUDING ERG
- Annual exam – include photos - dilated
- We Do Macula Risk on all patients
  - Helps determine frequency of visits
  - Helps guide proper supplement prescribing
- Typical “Quarterly” Q4Months, Once a Year Etc. (Dilated)
  - pERG (concentric) – PHP – OCT
  - For Diabetic Retinopathy (must have retinopathy)
  - OCT and pERG (concentric)
LEADING EDGE

- VEP + ERG data for glaucoma is decades old, just didn't have a system that was truly office-based until Diopsys NOVA and now other companies
- Normative data comparison makes it much easier as a clinician to interpret the information and implement clinically
- We are no longer the only practice in the area that offers VEP - ERG
- Because of the multiple uses – our practice continues to be recognized as “the most high-tech” in the area
  - Referrals from patients, pediatricians, neurologists

OFFICE-BASED VEP + ERG IS PATIENT FRIENDLY

- Even on a “great hair day” – skilled technicians can attach the leads without much disruption
- Patients appreciate the simplicity – no stress when taking the test
- Easily understood report of findings for the patient – excellent patient education
- Relatively quick and easily incorporated with an office visit
- Patients tell their friends about the test – it is very accepted

PROFITABILITY

- We have had TWO coverage issues with any insurers including Illinois Medicaid CPT code – 95930/92275
- Medicare Allowable in “rest of IL” reimburses $119.16 / $137.88
  - OCT (92133) = $42.17 ($40.12)
  - Fundus Photos (92250) = $73.83 ($63.67)
  - HVF (92083) = $60.70 ($55.45)
- In Illinois there are no diagnosis codes associated/limited to CPT code – 95930 or 92275
- No frequency limitations – VEP usually annually ERG can be potentially quarterly or more frequent

OUR MOST COMMON DIAGNOSIS CODES

- 377.14 – Glaucomatous Atrophy (cupping) of optic nerve
- 368.4X – Visual Field Defect (abnormal VF – screening FDT)
- 368.0X – Amblyopia
- 377.11 – Primary Optic Atrophy
- 377.00 - Papilledema
- 368.12 – Transient Visual Loss
- 362.xx (now for pERG)
- 365.xx (pERG and in IL for VEP)
- LCD’s list over 80 diagnosis codes

YOU DO YOUR OWN MATH

- How many 365.xx patients do you have?
- How many 368.xx patients do you have?
- How many 377.xx patients do you have?
- How many 362.xx patients do you have
- If you do a screening FDT or other visual field – how many of them do you currently bring back for a full visual field – you should now consider adding a VEP to the battery of tests
- How many patients each year come in with “unspecified visual disturbance or transient visual loss”?

REFERRALS AND MARKETING = MORE PROFITS

- Neurologists have recognized my partner as very neuro oriented and now that we have Diopsys NOVA-VEP they are referring to our practice.
- We’ve successfully treated 2 “malingered” or “Streff Syndrome” patients and because the VEP was an additional test to rule out organic cause – pediatricians are referring patients for testing AND vision therapy
- Patients are telling friends that “their doctor has a VEP” and it is converting to new patients – children and glaucoma
IN SUMMARY – VEP + ERG

• Good for The Patient
  • Patients accept and understand the technology
  • Objective data with no patient stress

• Good for The Practice
  • Valuable clinical data for a variety of diagnoses
  • Easily incorporated into practice flow
  • A source of professional and patient referrals
  • One of the highest reimbursed procedures in the practice

QUESTIONS?

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