VEP & ERG: Electrodiagnostics in Clinical Practice

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Chief of Specialty Care Clinics
Chief of Electrodiagnostics Clinic
What is electrodiagnostics testing?

Visual Pathway – Basic Understanding

VEP

ERG
  - Full field flash
  - Pattern
  - mfERG

EOG

Clinical Cases
Visual Pathway

- **Upstream**
  - Photoreceptors
  - Mid-retinal layers
  - Ganglion cell layer
  - NFL/Optic Nerve
  - Optic Chiasm
  - Optic Tract
  - LGN
  - Visual Cortex

- **Downstream**
The Visual Evoked Potential (VEP) OBJECTIVELY measures the functionality of which structure?

A. Photoreceptors
B. RPE layer
C. Ganglion cell layer
D. Nerve fiber layer & optic nerve
E. Entire visual pathway
Which of the following is an indication to perform a VEP?

A. Glaucoma
B. Traumatic brain injury
C. Optic neuritis
D. Amblyopia
E. Unexplained vision loss
F. VF defect
G. All of the above
**Visually Evoked Potential (VEP)**

- AKA Visually Evoked Response (VER)
  - Flash vs. Pattern

- Measures the entire visual pathway
  - From cornea to occipital lobe

- 3 electrodes
  - Ground
  - Reference
  - Measuring -> occipital lobe
    - 1” above inion
VEP Electrodes

Reference  Ground  Active
VEP

- Amplitude usually translates to the amount of axons conducting along the visual pathway.
- Latency usually translates to the myelin status of the visual pathway.
Many optic nerve diseases are asymptomatic because central vision is not affected until late in the disease\(^1\)

Diagnosis and management of optic nerve disorders are often based on structural or subjective visual field tests\(^2\)

VEP is an **objective, functional** test that can help discriminate between healthy and glaucomatous eyes\(^2\)

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VEP and Glaucoma: Well Defined Science

The Visual Evoked Potential in Glaucoma and Ocular Hypertension: Effects of Check Size, Field Size, and Stimulation Rate

The Visual Evoked Potential in Glaucoma and Ocular Hypertension: Effects of Check Size, Field Size, and Stimulation Rate

Vernon L. Towle, Anne Moskowitz, Samuel Sokol, and Bernard Schwartz

In order to determine the optimum stimulus conditions for the detection of optic nerve damage due to glaucoma and ocular hypertension, checkerboard pattern reversal visual evoked potentials (VEPs) were recorded from 20 glaucoma patients, 20 ocular hypertensive patients, and 20 age-matched normals. Two check sizes (12 and 48), two field sizes (14° and 20°), and two alternation rates (1.9 and 7.5 alt/sec) were used. All subjects had visual acuities of 20/40 or better in each eye and equal pupils of 2 to 5 mm diameter. The largest number of VEP abnormalities were found with large checks (48) reversing at a fast rate (7.5 alt/sec). After correcting for the effects of age, visual acuity, and pupil size, 16 of 30 eyes with glaucomatous visual field defects had abnormally long VEP latencies. The pattern visual evoked potential (VEP) has been shown to be sensitive to optic nerve lesions caused by denervation, ischemia, and compression of the anterior visual pathway. Glaucoma has also been reported to affect the VEP by causing both reductions in amplitude and increases in latency. Increased pattern VEP latency has been associated with optic disc cupping and the presence of visual field loss. In ocular hypertension the pattern VEP has been normal unless eccentric viewing or provocative techniques have been employed. In those nonprognostic studies in which abnormally long VEP latencies were obtained it is not clear whether the results were due, in part, to the confounding effects of miotic pupils, advanced age, or reduced visual acuity. All three of these factors can cause VEP latency increases. The one study that carefully controlled for the effects of these three variables reported a small group difference in relative interocular VEP latency for glaucoma patients and normal control subjects.

The purpose of the present study was to obtain VEP latencies for various stimulus conditions in carefully selected groups of ocular hypertensive and glaucoma patients and visually normal controls while controlling for the confounding effects of pupil size, age, and visual acuity.

Materials and Methods

Subjects

All subjects were free from neurologic disease, had clear media, visual acuities of 20/40 or better in each eye, and equal pupils of 2 to 5 mm diameter. The 60 subjects formed three groups of 20 subjects each, as described below.

Group 1: Normal controls. This group consisted of ten volunteers (five men and five women) less than 50 years of age (5 = 30 years) and ten volunteers (six men and four women) older than 50 (5 = 63 years). All of these subjects had normal fundi and discs, fall and normal visual fields as measured on the Goldmann perimeter by standard static and kinetic methods, and ocular pressures less than 21 mmHg as measured by the Goldmann applanation tonometer. Stereoscopic fundus photographs were taken with the Donaldson stereoscopic fundus camera from six of these subjects.

“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 authors of this paper are world recognized electrophysiology specialist from New England Medical Center and University of Chicago.
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.

VEP Latency and Ocular Hypertension

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.

References


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.

VEP is an objective, functional test that can help discriminate between healthy and glaucomatous eyes.

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**
Main Indications

- Glaucoma
  - ***Glaucoma suspects***
- Multiple Sclerosis
- Ischemic Optic Neuropathy
- Traumatic Brain Injury
- Amblyopia
- Other Neuropathies
- Unexplained vision loss
- VF defect
  - FDT
## Office Based Neuro Optic Vision Assessment

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<th>First Name:</th>
<th>DOB:</th>
<th>Age:</th>
<th>VA:</th>
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<tbody>
<tr>
<td>Last Name:</td>
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<tr>
<td>Gender:</td>
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| Exam Date: | OD:  |      | VA: |
| Exam Time: | S/C/Ax/Ad:/// | | |

| OS:  | S/C/Ax/Ad:/// | VA: |

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<th>1.3</th>
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<tr>
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<td>121.1</td>
<td>120.1</td>
<td>1.6</td>
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<tr>
<td>Latency High Contrast</td>
<td>103.5</td>
<td>104.5</td>
<td>2.0</td>
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Operator: TA

Signature: 

Comments: 

Deepsys - 578
ASSESSMENT OF NEURO-VISUAL FUNCTION

VEP Report

Signal Quality: 129dBμV 60Hz noise

Signal Quality: 133dBμV 60Hz noise

Signal Quality: 160dBμV 60Hz noise

<table>
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<tr>
<th>OS</th>
<th>Difference</th>
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<td>4.4</td>
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<td>CURRENTLY NORMAL</td>
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Operator: TA
Depays: 578
Comments:
Signature:
ASSESSMENT OF NEURO-VISUAL FUNCTION

VEP Report

[Graphs showing VEP responses for low and high contrast stimuli]

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VEP Report

Lc: 92%
Hc: 100%

P100 Reliability Index

OD  OS  Difference
Amplitude Low Contrast μV  7.0  8.4  1.3
Amplitude High Contrast μV  6.7  16.8  10.1
Latency Low Contrast ms  121.1  126.1  5.0
Latency High Contrast ms  102.5  104.5  2.0

Remarks: CURRENTLY ABNORMAL

Operator: T.A  Signed: 6/78

Comments:

Signature: 
## VEP Report

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### Remarks

Operator: T.A

Comments:

Signature:
ASSESSMENT OF NEURO-VISUAL FUNCTION

VEP Report

Operator:

Comments:

Classification based on statistics. Diagnosis is doctor's responsibility.
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Signature:

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<td>Latency High Contrast ms</td>
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Remarks

Operator: TA
Comments:

Signature:

Classification based on statistics. Diagnosis is doctor's responsibility.
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VEP - Normal

**Signal Quality:**
12kHz/6/60Hz noise

**Amplitude**
- OD: Low Contrast = 10.5 μV, High Contrast = 10.9 μV
- OS: Low Contrast = 8.2 μV, High Contrast = 11.5 μV

**Latency**
- OD: Low Contrast = 114.3 ms, High Contrast = 107.4 ms
- OS: Low Contrast = 112.3 ms, High Contrast = 107.4 ms

**P100 Reliability Index**
- OD: Lc = 89%, Hc = 100%
- OS: Lc = 83%, Hc = 92%

**Remarks**
- OD: Normal
- OS: Normal
VEP - Abnormal

![Graph showing VEP results for OD and OS with abnormal findings.](image)

**Parameters**

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<td>Latency High Contrast ms</td>
<td>120.1</td>
<td>116.2</td>
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**Remarks**

- Borderline Delayed
- OD Delayed
VEP abnormal - Asymmetry

**OD**

**OS**

![Graphs showing VEP results with signal quality and parameters comparison](image)

- **Amplitude**
  - Low Contrast: OD 12.5 µV, OS 9.4 µV
  - High Contrast: OD 13.0 µV, OS 15.8 µV

- **Latency**
  - Low Contrast: OD 109.4 ms, OS 122.1 ms
  - High Contrast: OD 110.3 ms, OS 111.3 ms

**Remarks**

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<td>Latency High Contrast ms</td>
<td>110.3</td>
<td>111.3</td>
<td>1.0</td>
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Significant Difference
Pattern ERG (pERG)

- ERG’s are electrical signals that are a measure of the electrophysiological activity at the retina
  - ***Mid-retinal layers, ganglion cell layer, and nerve fiber layer***

- Objectively measures retinal function**

- ERG’s can help improve sensitivity and specificity in diagnosing optic neuropathies and maculopathies like glaucoma and macular degeneration when used in conjunction with other tests

- Can also help the clinician differentiate between retinal and optic nerve disorders when used in conjunction with Visual Evoked Potential (VEP).
pERG Advanced Protocols

1. Concentric Stimulus Fields
   - Drug toxicity
   - Diabetic macular edema
   - AMD

2. Contrast Sensitivity
   - Glaucoma
   - Diabetic retinopathy
1. Concentric Stimulus Fields
   - Stimulus delivered at 15 flips/second
   - BCVA
     - Pt should be properly refracted for 24”
   - 24” testing distance
   - 100% contrast
   - Right eye (OD) then Left Eye (OS)
     - 25 seconds at 24 degrees
     - 25 seconds at 16 degrees
2. Contrast Sensitivity

- Stimulus delivered at 15 flips/second
- BCVA
  - Pt should be properly refracted for 24"
  - 24” testing distance
- 85% and 15%

- Right eye (OD) then Left Eye (OS)
  - 25 seconds at High Contrast (Hc)
  - 25 seconds at Low Contrast (Lc)
“In patients who are glaucoma suspects, pERG signal anticipates an equivalent loss of OCT signal by several years (as many as 8 years).

“In patients who are glaucoma suspects, pERG signal anticipates an equivalent loss of OCT signal by several years (as many as 8 years).

Glaucoma
Optic Neuropathies
Maculopathies
  - AMD
  - Diabetic retinopathy
  - Diabetic macular edema
  - Macular toxicity
pERG Testing
Pattern ERG (pERG)

<table>
<thead>
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<th>Parameter</th>
<th>OD 24°</th>
<th>OD 16°</th>
<th>OS 24°</th>
<th>OS 16°</th>
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<td>13.7</td>
<td>&gt; 20</td>
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<td>Artifacts</td>
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Pattern ERG (pERG)

**OD**

**OS**

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<th>OD 16°</th>
<th>OS 24°</th>
<th>OS 16°</th>
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# Applying to Your Practice

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<tr>
<th>VEP</th>
<th>PERG</th>
<th>FLASH ERG</th>
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<tbody>
<tr>
<td>2.  Unexplained vision loss</td>
<td>2. Unexplained VF defects</td>
<td>2. Cone dystrophies &amp; Rod monochromat</td>
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<td>3.  Transient vision loss</td>
<td>3. Unreliable VF</td>
<td>3. Symptoms:</td>
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<td>4.  Unexplained VF defects</td>
<td>4. Optic neuropathies</td>
<td>- “Night blindness”</td>
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<td>5.  Unreliable VF</td>
<td>5. Maculopathies</td>
<td>- Restricted peripheral fields</td>
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<td>6.  Optic neuropathies</td>
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<td>- Color vision deficits</td>
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<td>7.  Optic neuritis/MS</td>
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<td>8.  Amblyopia</td>
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<tr>
<td>9.  TBI</td>
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