Visual Evoked Potentials

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Outline

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• Basic VEP principles
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  - Types of VEPs
  - Waveforms and generators
• VEP Techniques
  - Patient/Testing Conditions
  - Stimulation Parameters
  - Recording Montage
• Interpretation
  - Evaluation of the P100
  - Variables affecting the P100
• Example VEPs

Visual Pathway Anatomy
VEP

**Definition:** An electrophysiologic response time locked to a visual stimulus

VEPs can be categorized by stimulus characteristics:

1. **Stimulus type:** patterned (usually checkerboard) vs. unpatterned (flash).
2. **Field stimulated:** monocular full field vs. hemi-field
3. **Stimulus Frequency:** transient VEPs vs. steady state VEPs

**Clinical use:** most often used to evaluate optic nerve function, but can detect abnormalities at any point in the visual pathway

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Neural Generators of the VEP

- **P100:** Generators within occipital cortex (striate and extrastriate cortex)
- **Pattern VEP** is dominated by central (macular) vision serving the central 8-10 degrees of the visual field
- **N100:** separate generator in the frontal region

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**P100**

- A middle latency, near field potential
- It is the most consistent component of the VEP and thus used for interpretation
- Assesses the conduction of neuronal activity from the retina to the occipital cortex
- Typically maximal amplitude is in the mid-occipital region, but can be displaced above or below (normal variant)
VEP Testing:
Patient Assessment and Test Conditions

- Assess and record visual acuity of each eye (corrected)
- Assess alertness and ability to fixate
- Assess pupils and ensure no cycloplegics
- Conduct test with appropriate corrective lenses
- Conduct test in ordinary room illumination

VEP Testing:
Stimulation Parameters

- **Pattern Reversal**
  - Full field - Better for detecting lesions anterior to the chiasm
  - Hemi-field - Used for detecting lesions posterior to the chiasm (Limited utility overall)

- **Flash**
  - Use if subject unable to fixate or has very poor visual acuity
  - Responses are complex and variable
  - Interpretation largely limited to “all or none”

**Stimulus Parameters: Pattern Reversal**

- **Check Size**
  - 30 min checks
  - can use 15° and 60° as needed
  - Visual Angle = arctan(width/distance)

- **Intensity**
  - Photopic

- **Contrast**
  - 50-100%
  - Difference in luminance between bright and dim portions of pattern
  - \( \frac{L_{max} - L_{min}}{L_{max} + L_{min}} \times 100 \)

- **Luminance**
  - MUST KEEP CONSTANT

- **Distance**
  - >70 cm from screen

- **Reversal Rate**
  - < 4 rev/second
Effect of Check Size

- Checks too small
  False positives due to refractive error

- Checks too large
  Decreased sensitivity
  Antagonistic effects of peripheral/foveal responses

- Using multiple check sizes can be helpful
  If visual acuity is 20/50 or better:
    use 30 min and 15min checks
  If visual acuity is <20/50:
    use 30 min and 120 min checks (+/- flash)

Recording Parameters

- Passband: 1-100 Hz
- Sweep: 250msec, 500msec (flash)
- Number averaged: 100-200
- Replications: at least 2
- Sampling Rate: >2000/s

"Queens Square" electrode positions

MO = 5 cm aboveinion
LO, RO = 5 cm lateral to MO
MF = Midfrontal, 12 cm above nasion

ACNS Guideline 9B: Visual Evoked Potentials
Patient Factors affecting VEPs

- Visual Acuity (ability to resolve pattern stimulus)
- Visual Field defect
- Ocular Factors
- Cooperation: lack of focus/fixation
- Pupil Size
- Age
- Gender
Interpretation

• Identify major waveform components: N75, P100, N145
• Measure the P100 latency for each eye
• Calculate the latency difference between eyes: interocular latency difference
• Measure the mid occipital P100 amplitude for each eye: peak to peak (N75-P100) or (P100-N145)
• Calculate the interocular amplitude ratio
• Evaluate the topographic distribution of the P100. If using lateral electrodes, is P100 laterally displaced? If so, do hemi field stim.

Interpretation: Localization

Asymmetric Abnormality = anterior to chiasm (optic nerve or ocular)

Bilateral Abnormality = non localizing
Each lab must use its own normative data

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46 year-old man with episodes of “visual spots”

46 y/o woman with episode of dizziness
52 year-old man with headache and visual disturbance

52 year-old man with headache and visual disturbance

78 y/o woman with visual complaints
26 year-old woman with tingling in arms and leg
No visual symptoms

36 year old woman with right weakness, paresthesia
No visual symptoms
23 year old man with ataxia, vertigo, r/o MS
No visual symptoms

13 year-old with left eye pain and blurred vision
Acuity OS 20/80 OD 20/20
28 year old with dizziness, r/o MS

- Oz-Cz
- Oz-Cz

30 min
- OS 102
- OD 115
- >3s.d 114

15 min
- OS 125
- OD 125

25 ms/div
2 µv/div

48 y/o cocaine abuser, dysarthria, blurred vision

- OS
- OD

- Fz-A1
- Mpz-A1
- Oz-A1
- Oz-Fz

20 msec/div
3 µv/div

11 month-old with head trauma

- Oz-Cz
- Oz-Cz

25 ms/div
2 µv/div

Flash
35 y/o man with MS

Oz-Cz

Flash

OS 120 ms
OD 143 ms
OS-OD 23

Retrochiasmatic Pathology:
Hemifield stimulation Technique

• Imaging modalities have replaced this technique
• Technically difficult. Even small eye movement (one degree!) can lead to large contamination of hemifield responses.
• Arises from projections/activation of the peripheral visual field rather than just the area of the macula
  • -larger check sizes
  • -lateral recording electrodes: LT and RT

Hemifield Stimulation

Recall that LEFT hemifield stimulation projects to the LEFT occiput!!!
Summary

- Full Field Pattern VEPs reliably assess the pre-chiasmal visual pathway, but can also detect lesions elsewhere.
- Responses may be affected by a variety of patient factors and test conditions.
- Evaluation of the P100 latency must be based on laboratory specific normative data.
- Other stimulation techniques (flash and hemifield) can provide additional information, though their utility is more limited.