ELECTRONYSTAGMOGRAPHY
HANDBOOK
of
Balance Function
Testing

Gary P. Jacobson
Craig W. Newman
Jack M. Kartush

SINGULAR PUBLISHING GROUP, INC.
SAN DIEGO - LONDON
ENG measurements based on the presence of the corneoretinal potential

Cornea has a positive pole

Retina has a negative pole
ELECTRONYSTAGMOGRAPHY

Essentially ENG consists of 3 parts

- oculomotor evaluation
  - Calibration
  - Gaze
  - Fixation
  - Saccade
  - Tracking (Pursuit)
  - Optokinetic
- positioning/positional testing
- caloric stimulation.
History

- Stop all medications 24-72 h prior to testing
- 72 hours Alcohol (agonist or antagonist)
- Any medications taken should be clearly noted on the test results
- Limit food intake prior to examination
- Arrange for transportation after the examination
Examination

- Large perforations
  - increase air stimulation above expectation
  - cooling effect for warm (evaporation).
- cerumen must be removed
- Middle ear fluid affects stimulation
Saccades (calibration)

- Dots on the wall or ceiling
- center and 10°, 20°, and 30° off center
- patient to look back and forth between the dots
- head fixed
**Gaze**

**spontaneous nystagmus**

nystagmus in the absence of stimulation

- presence or absence of spontaneous nystagmus
- presence, absence, or exacerbation of nystagmus with addition of off-center gaze
- fixation suppression of spontaneous nystagmus
Gaze Test

- Nystagmus present with eyes open and enhanced by eye closure - lesion is peripheral
- Nystagmus is enhanced with ocular fixation and reduced by eye closure - lesion is central
**Administration**

- **For gaze testing**
  - the patient is instructed to look straight ahead and then to fixate on a target 30° to the right, left, up, and down.
  - Fixation is maintained for approximately 30 seconds in center gaze and 10 seconds in eccentric gaze.

- **Spontaneous nystagmus (eliminating suppression)**
  - eyes open in a dark room
  - eyes closed.
  - mental tasks (e.g., answering questions, counting by twos).
Gaze

- Normal gaze position - patient is able to maintain position with eyes open and closed
Spontaneous nystagmus

- Either central or peripheral pathology.
- with eyes open is always diagnostically significant.

Peripheral indicators
- Horizontal or horizontal rotary
- Suppressed by visual fixation
- Nondirection changing
- Exacerbated by gazing in the direction of the fast phase*

Central indicators
- Vertical
- Not suppressed by fixation
- Direction changing
Alexander's law

- Nystagmus increases when the patient gazes in the direction of the fast phase.
- Nystagmus decreases or disappears when the gaze in the direction of slow phase.
- This pattern is often seen in peripheral vestibular disorders and occasionally in central disorders.
Unilateral gaze-paretic nystagmus

- Nystagmus only occurs with eccentric gaze in one direction.
- Elicited nystagmus beats in the direction of the gaze.
- Consistent with CNS pathology
Bilateral gaze-paretic nystagmus

- right gaze $\rightarrow$ right-beating nystagmus
- left gaze $\rightarrow$ left-beating nystagmus
- suggests CNS pathology
Bruns nystagmus

- Combination of
  - Unilateral gaze-paretic nystagmus
  - Vestibular nystagmus
- Asymmetrical nystagmus in both directions of a gaze
- Associated with extra-axial mass lesions on the side of the gaze-paretic nystagmus
Ewald law

- Eyes always move in the plane of the canal being stimulated and in the direction of endolymph flow
- Ampulopetal in HSCC causes greater response than ampulofugal
- Ampulofugal in vertical SCCs cause greater response than ampulopetal

Resting (firing) level is 1.0 Hz → can not be <0 but can be high as 10 Hz
Fixation

- Congenital nystagmus
- Gaze-Evoked Nystagmus
- Rebound nystagmus
- Square-wave jerks
Congenital nystagmus

- Spiky appearance
- Increases with lateral gaze.
- Decrease in velocity or completely disappear with eyes closed
Congenital Gaze Findings
Gaze-Evoked Nystagmus

- Drift of the eye which is only present for certain directions of gaze
- EOG recordings, any persistent nystagmus for ocular displacements < 30 degrees is abnormal
- Causes of Gaze-evoked nystagmus
  - Medication
  - Brainstem or cerebellar disorder
  - Normal variant
  - Ocular muscle fatigue
  - Congenital nystagmus
Rebound nystagmus

- Burst of nystagmus
- begins when the eyes are returned to center gaze.
- lasting 5 seconds
- brainstem or cerebellar lesions
Square-wave jerks

- the most common abnormality with eyes closed.
- healthy patients
- increasing frequency with increasing age.
- abnormal if
  - In young patients
  - more frequently than 1 per second
  - eyes open.
- suggestive of a cerebellar disorder.
Fixation suppression

- For peripheral lesions, nystagmus that is evident with eyes closed or in the dark should be suppressed by visual fixation.
- If not CNS pathology is possible.
Peripheral Gaze Findings

Open

Closed
Gaze Findings With CNS Lesion

- Nystagmus may be horizontal, vertical, rotatory
- May demonstrate variation in amplitude
- If cause by a stable pathology, it declines slowly in time
- Enhanced by ocular fixation
- If horizontal, most often bilateral (bidirectional)
CNS Gaze Findings
Saccades Interpretation

- Accuracy
- Latency
- Velocity
Accuracy

- Normal or basal ganglia pathology
  - Hypometric – undershoots
- CNS pathology
  - Ocular flutter - spiky overshoot
- Cerebellum
  - Hypermetric overshoot then a correction.
  - Multistep saccades undershoots then multiple saccades
  - Postsaccadic drift (Glissade) eye drifting after saccade.
- PICA
  - Pulsion: pulling to left or right after vertical saccades.
Latency

- Short latency
  - artifact
  - patient anticipating the position of the target.
  - suggestive of CNS pathology.
- Asymmetrical latencies
  - occipital
  - parietal cortex.
Velocity

- **Saccadic slowing**
  - drug effects.
  - CNS degenerative conditions, basal ganglia pathology, and cerebellar disorders.
  - ocular disorders, including oculomotor weakness,

- **Abnormally fast saccades**
  - artifact and may be due to technical difficulties.
  - CNS
  - ocular pathology

- **Asymmetrical velocity - between the eyes or between directions.**
  - ocular nerve
  - muscle pathology (ie, lesions or palsies).
  - CNS pathology may also be indicated. A lesion in the MLF
Saccadic Abnormalities

Overshoot
Saccadic Abnormalities

Saccadic Slowing
Smooth pursuit tracking

- follow a sinusoidal moving target with eyes only.
- Tracking targets within the visual field
- interpreting with care in geriatric and pediatric
- affected by attention and patient cooperation.

**Interpretation**

- results should resemble a smooth sinusoid.
- Breakup of movement $\rightarrow$ CNS pathology.
Tracking Test: Normal
Tracking Test: Abnormal
impaired pursuit in patient with a cerebellar lesion
Optokinetic

- tracks multiple stimuli.
  - stripes on a rotating drum
  - stream of lighted dots across a light bar
  - full field array of moving stars or trees.
- moved at 300, 400, or 600 per second
- asymmetrical responses $\Rightarrow$ CNS pathology
Opokinetin Test: Normal

symmetry
Opokinetische Test: Abnormal

Asymmetry
Opokinetic Test: Abnormal Declining Response Intensity

20/s

60/s

100/s
Positioning

Dix-Hallpike maneuver

- should be completed prior to any other positional testing.
- Delayed onset - observe patient for at least 20 seconds
- Transient burst of nystagmus - Lasts about 10-15 seconds
- Subjective report of vertigo
- Fatigability
Positional tests

- minimum of 20-30 seconds
- Mental tasking infrared goggles or with the patient's eyes closed with electrodes
  - Head hanging
  - Supine
  - Supine, head right
  - Supine, head left
  - Lateral right
  - Lateral left
- considered abnormal
  - exceed 60 per second
  - change direction in any 1 position
  - persist in at least 3 different positions
  - intermittent in all positions
Positional tests

- Peripheral indicators include the following:
  - Direction-fixed
  - Geotropic direction changing in different positions, horizontal SCC variant of BPPV
  - Latency of onset
  - Fatigable

- Central indicators include the following:
  - Ageotropic direction changing in different positions,
  - Direction changing in a single position,
  - Immediate onset
  - Not fatigable
Positional Test: Abnormal
Peripheral

Direction: Fixed
Positional Test: Abnormal
Most Often CNS

Direction Changing

RL

LL
Caloric stimulation

- The most informative ENG subtest
- Water, air, and closed-loop cuff
- Water calorics provide a strong stimulus
- air, and closed-loop cuff used with PET or perforation of TM
- cool = 30 C  warm = 44 C
- Response pattern follows the form of COWS
Caloric test disadvantage

- Low frequency (0.003 Hz)* = PTA @125Hz
- Indirect (depend on heat transferring capacity of EE+ME)
- Lateral SCC
- LOC

*0.01-10.0 Hz Vestibular system
Caloric stimulation

- head at an angle of 30°
- LSCC in the vertical plane
- spontaneous nystagmus is evaluated 1st
- Bilateral weakness
  - Average responses of <60/s
  - bilateral peripheral or central
  - drug effects should be excluded
- Fixation after each test
  - R/O CNS No reduce nystagmus
  - Fast recovery.
- no response → Ice water for residual
Caloric Test: Normal

Fixation Suppression
Caloric Test

Failure of Fixation Suppression
Caloric stimulation

- **Unilateral weakness (UW)**  Labrynthine preponderance (LP)
  - evaluate symmetry
  - > 25% is significant.
  - \[
  \frac{(RC + RW - LC + LW)}{(RC + RW + LC + LW)} \times 100
  \]
  - peripheral lesion (nerve or end-organ)
  - lesion in the side of the weakness.

- **Directional preponderance (DP)**
  - with spontaneous nystagmus
  - >20-30% is considered significant.
  - \[
  \frac{(LC + RW - RC + LW)}{(RC + RW + LC + LW)} \times 100
  \]
Which direction?