Getting the Most out of VNG/ENG Testing

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Outline

• VNG/ENG test battery
  – Best practices in administering each test
  – Recognizing and avoiding common errors and artifacts
  – General interpretation guidelines for each test
  – Correlations among different tests

Anatomical Sites and Causes of Dizziness

• ICD-9 codes with primary complaint of dizziness ~63
  Source: A Guide to Evaluation and Management of Dizziness (2001), ICS Medical
  – Anatomical sites – ear, brain, eyes, muscles/joints, other
  – Underlying causes – infection, vascular, psychogenic, trauma, metabolic, tumors, neoplasms, toxic, congenital

VNG/ENG Pre-test Protocol

• Patient interview and chart review
  – To obtain clinical information and modify test procedures when necessary
• Otoscopic ear examination
  – To remove cerumen when necessary
• Eye movement examination
  – To modify recording method (electrode arrangement in ENG or camera configuration in VNG) when necessary
• Application of electrodes in ENG
  – To allow time for electrodes to settle
• Placement of goggles in VNG
• Electrode testing in ENG or video adjustment in VNG
• Calibration of eye movements
Overview of VNG/ENG Subtests

- Tests of oculomotor function (with fixation)
  - Saccade, tracking, optokinetic
- Tests of gaze stabilization (with fixation and without with alerting)
  - Gaze/spontaneous nystagmus, static position
- Tests of vestibular function
  - Caloric
- Tests for specific etiologies
  - Dix-Hallpike maneuver (dynamic positioning), pressure (fistula)

Best Practices in Oculomotor Tests

- Ask the patient to avoid head movements
- Ask the patient not to anticipate target movements
- Run the test as long as necessary to collect enough data
- Look for the patient’s best performance (repeat tests when necessary as true abnormalities are consistent and repeatable)

Interpretation of Oculomotor Tests

- Tests of oculomotor function (with fixation)
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Abnormal Saccades – Internuclear Ophthalmoplegia

- Internuclear Ophthalmoplegia denotes a central lesion in the medial longitudinal fasciculus on the side of sluggish adduction
  - Record from both eyes independently
Abnormal Saccades - *Saccadic Slowing*

- **Saccadic slowing** denotes a central lesion in the basal ganglia, brain stem, cerebellum, peripheral oculomotor nerves or muscles (typically in diffuse lesions of the central pathways associated with neurodegenerative diseases)
  - May be due to fatigue, drowsiness, or medication (reversible)

Abnormal Saccades – *Delayed*

- **Delayed saccades** (latencies >> 200 msec) denote a central lesion in the frontal/frontoparietal cortex or basal ganglia (interpret conservatively)
  - Low clinical value if bilateral (more significant if unilateral)
  - May be caused by inattention, poor visual acuity, and medication

Abnormal Saccades - *Dysmetria*

- **Saccadic dysmetria** denotes a central lesion in the cerebellar flocculus (hypometria) or the cerebellar vermis (hypermetria)

Saccade Test – *Anticipating Target Movements*

- Patient is anticipating target movements (latency << 200 msec)
- Also watch for head movements and calibration errors
Abnormal Tracking - *Unilateral Defective Pursuit*

Defective tracking (pursuit) denotes a central lesion. If symmetric – diffuse cortical, basal ganglia, or cerebellar diseases. If asymmetric – focal lesions involving ipsilateral cerebellar hemisphere, brain stem, or parieto-occipital region.

Effect of Superimposed Nystagmus on Tracking

Borderline unilateral defective tracking can be caused by strong spontaneous nystagmus (in the direction of fast phases).

Oculomotor Tests – *Anticipating Target Movements*

Abnormal

Anticipating

Also watch for head movements and calibration errors.

Correlations in Oculomotor Tests – *Tracking & OPK*

Since tracking and OPK findings are often overlapping, do they share the same central pathways?

- True OPK originates from retinal stimulation (requires full-field visual stimulation) and is a reflexive response
- Tracking originates from foveal stimulation (requires a small target) and is a voluntary response
- When the stimulus is a small target (as in a light bar), both tracking and OPK tests evaluate the same central pathways
- Full-field visual stimulation does not guarantee true OPK responses because both tracking (foveal) and OPK (retinal) receptors are stimulated
- True OPK testing requires removing foveal responses (optokinetic after-nystagmus test)
Correlations in Oculomotor Tests – Tracking & OPK

- Can instructions to the patient generate true OPK testing?
  - Neither set of instructions produces true OPK testing because foveal responses are present in both cases
  - OPK testing can be used to verify the results of the tracking test

- Reduced OPK nystagmus intensity for high-velocity leftward target movements

- Fixation suppression and tracking mechanisms share many central pathways
- Patients with failure of fixation suppression usually have abnormal tracking when test parameters are equivalent and if age effects are considered
  - If unilateral, tracking will be abnormal in the opposite direction of caloric nystagmus fast phases
Correlations in Tracking and Fixation Tests

Best Practices in Gaze Stabilization Tests

- For gaze test:
  - Hold right, left, up, and down gaze positions for at least 20 seconds
  - If nystagmus or other abnormalities are observed in any gaze position, return to that position and reexamine
  - The result should match the findings of the physical exam

- For spontaneous nystagmus test:
  - Record the eye movements in center gaze both with and without fixation
  - Testing without fixation can be deferred until the position test in the sitting position

Correlations in Tracking and Fixation Tests

Best Practices in Gaze Stabilization Tests

- For static position test:
  - Record eye movements for as long as necessary (at least 30 seconds) to determine the presence of nystagmus
  - Include at least 4 head positions: sitting, supine, head right, and head left (for the last 3 positions, use the standard caloric test position with the elevated 30° from the supine position)
  - Include testing in body right and body left positions to determine the effect of neck rotation if nystagmus is not present in sitting and supine positions but appears when head is turned right or left
  - Include any head position for which the patient has specific complaints
General Interpretation of Gaze Stabilization Tests

- The following information is needed for interpretation:
  - Presence of nystagmus in any gaze/head positions
  - Direction of nystagmus in any gaze/head positions
  - Intensity of nystagmus in any gaze/head positions (primarily for tests without fixation)
  - Effect of fixation on the presence or intensity of nystagmus

Interpretation of Gaze Stabilization Tests

- Tests of oculomotor function (with fixation)
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![Diagram of gaze stabilization tests](image)

- For horizontal nystagmus:
  - Changes direction in a single gaze/head position → Central
  - Is present with fixation and its intensity does not increase significantly (at least doubles) without fixation → Central
  - Is present without fixation and its intensity is less than a threshold (6º/sec in ENG, 4º/sec in VNG) → Normal
  - All other forms of horizontal nystagmus → Non-localizing
- For vertical nystagmus:
  - Is present with fixation → Central
  - Is present without fixation and its intensity is less than a threshold (7º/sec in VNG) → Normal
  - All other forms of vertical nystagmus → Unknown clinical significance
Abnormalities in the Gaze Stabilization Tests

- Gaze-evoked nystagmus – Cerebellum/brain stem lesions
  - Rule out end-point and “leak-through” spontaneous nystagmus
- Square wave jerk nystagmus (form of saccadic intrusion)
  - Abnormal only when present with fixation – Central lesion in the cerebellum or basal ganglia
  - Estimates of normal limits for amplitude, frequency, age dependency, etc. vary due to differences in recording methods (frequency increases with age)
- Ocular flutter (form of saccadic intrusion)
  - Central lesion in the brain stem or cerebellum
- Periodic alternating nystagmus – Central
  - Present with and without fixation
  - Reverses direction about every 2-4 minutes

Abnormalities in the Gaze Stabilization Tests

- Vestibular (spontaneous) nystagmus
  - Horizontal with or without torsional component or vertical with torsional component (in lesions involving vertical canals)
  - Horizontal and vertical components suppressed with fixation
    - Intensity decreases by at least 50%
    - Intensity may vary due to gaze position and alertness level
    - Stronger when gaze directed toward fast phases
    - Direction may vary in different head positions but not in different gaze positions
  - In the absence of fixation, abnormal only if intensity is greater than a threshold (all forms including geotropic and ageotropic)
    - Horizontal – 6°/sec in ENG, 4°/sec in VNG
    - Vertical – 7°/sec in VNG (upbeat more common in normal individuals)

Correlations in Gaze Stabilization Tests

- Spontaneous nystagmus can be seen in:
  - Gaze test without fixation at center gaze
  - Static position test without fixation in sitting and supine head positions
  - During the first 10-15 seconds of caloric irrigations
- Nystagmus intensity may vary slightly due to alerting levels and gaze position
- If the results do not match, investigate further and repeat tests when necessary
  - Technical error
  - Periodic alternating nystagmus (rare)

Baseline shift to the right - Leftbeating nystagmus without fixation should be seen in the supine position (~10°/sec)

Leftbeating nystagmus without fixation (~10°/sec)
**Best Practices in Caloric Test**

- Calibration between irrigations:
  - In computerized ENG and VNG, verify calibration (using mock saccade/tracking test) and recalibrate only if necessary
- Order of irrigations
  - Start with one temperature and irrigate ears in the same order for each temperature (ANSI recommends starting with warm)
- Wait period between irrigations
  - Wait a fixed period of time (3-5 minutes) after the previous caloric nystagmus ends before starting the next irrigation

**Testing fixation suppression**
- One for each nystagmus direction but nystagmus intensities just before fixation should be approximately equal

**Reducing chances of the patient becoming sick:**
- Interrupt the irrigation if nystagmus intensity exceeds a critical limit. Use the same time period for other irrigations

**Interpretation of Caloric Test**

- Tests of oculomotor function (with fixation)
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**General Interpretation of Caloric Test**

- BW - responses from both right and left ear < 12°/sec (Total RE < 12°/sec and Total LE < 12°/sec)
- |UW%| > 25% (alternative values 20% - 30%)
- |DP %| > 30% (alternative values 25% - 50%)
- FI % > 60% (alternative values 50% - 60%)
- Hyperactive – Total RE > 140°/sec or Total LE > 140°/sec
Abnormal Calorics – *Unilateral Weakness*

- Unilateral Weakness (canal paresis)
  - Denotes a peripheral vestibular lesion involving the lateral (horizontal) canal or its afferent pathways on the side of the weaker response (involved pathway extends from the end-organ to the root entry zone of the vestibular nerve in the brain stem)
  - In the acute phase, significant spontaneous nystagmus is present
  - Can be caused by diseases that affect the labyrinth, the vestibular nerve, or the blood supply to those sites
  - Central lesions that affect the root entry zone of the vestibular nerve (e.g., M.S.) can cause unilateral weakness but other CNS signs will be present

Abnormal Calorics – *Directional Preponderance*

\[ \text{DP} = \text{baseline shift} + \text{gain asymmetry} \]

- DP% = 48% to the left
  - Baseline shift = 10 deg/sec
  - Gain Asymmetry = 0%

Abnormal Calorics – *Bilateral Weakness*

When bilateral caloric weakness is present, an additional test (rotation chair, active head rotation, head thrust, or bilateral ice water) is needed to determine if true bilateral vestibular lesion or hyporesponsiveness exists. *Hyporesponsiveness (BW)* denotes either peripheral vestibular lesion in both ears or a central lesion

General Interpretation of Caloric Test

- Caloric-induced vertical nystagmus
  - Caloric induced vertical nystagmus is present in normal individuals and patients with various disorders
  - Most likely due to stimulation of posterior/anterior canals
  - Caloric perversity
    - All four irrigations must generate purely vertical nystagmus or,
    - Vertical nystagmus must be much stronger than horizontal nystagmus
    - Central finding but extremely rare (consider other options first)
  - Rule out crosstalk
General Interpretation of Caloric Test

Best Practices in Dix-Hallpike Maneuver

- Turn the head 45 degrees right or left before moving the patient to avoid false-positive bilateral BPPV
  - No difference which side is done first
- No need to move the patient too vigorously from the sitting to supine position
  - Particles are moved primarily by gravity
- No need to hang the head too far over the edge in the supine position
- When responses are delayed, listen to the patient to determine if you have waited enough time
- Check for possible contraindications
  - Severe neck or back problems/arterial blood supply anomalies

Interpretation of Dix-Hallpike Maneuver

- Tests of oculomotor function (with fixation)
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Abnormal Dix-Hallpike – BPPV-Type Nystagmus

- Torsional–vertical nystagmus (usually upbeat and torsion toward the undermost ear indicating posterior canal BPPV)
- Usually delayed onset
- Transient
- Fatiguable
- Subjective sensation of vertigo
### General Interpretation of Dynamic Position Test

- **What if the patient has static positional nystagmus?**
  - Static positional nystagmus – Look for nystagmus that is present as long as head remains in critical position
  - Dynamic positioning nystagmus – Look for transient nystagmus that is provoked by head moving to critical position
- **What if the nystagmus has no torsional component?**
  - Purely vertical nystagmus – Not BPPV!
  - Purely horizontal nystagmus– Perform roll maneuver for horizontal canal BPPV

### Role of VNG/ENG In Clinical Decision-Making

- **Support diagnosis**
  - Document unilateral/bilateral loss of vestibular function
  - Confirm BPPV
  - Detect central lesions that are missed during routine physical exam
- **Decide if additional tests (e.g., MRI) are needed**
- **Preoperative evaluation**
  - Acoustic neuroma/ablative procedure/cochlear implants
- **Detects abnormalities in ~50% of dizzy patients, many localizing**
- **Provides information not available from other tests**
- **Does not rule out vestibular lesion**
- **VNG/ENG tests function - Rarely identifies underlying disease**
  - Must be used along with history, physical exam, and other tests to make diagnosis

### Contact Information

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