VNG testing basics

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Introduction: What is VNG?

- Videonystagmography (VNG)
  - also called videooculography (VOG)
  - video recording of nystagmus
  - directly measures eye movement by tracking movements of the pupil
- Eye movement images can be video-recorded
- VNG is a series of tests designed to evaluate vestibular function

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Advantages of VNG

- See the eyes at all times
  - Insures patient compliance
  - Provides more sensitive measure of nystagmus
- Video recording of eye movements (BPPV)
- Improves accuracy of analysis and interpretation
  - Cleaner tracings
- One calibration needed unless goggles are completely removed
- Eliminates cost of accessories (leads, electrodes, pastes)

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VNG Considerations

- All testing with VNG is done with eyes open, or the software will not be able to detect the eye movement

- "Eyes closed" is "without vision" or "vision denied"
  - Goggle shield closed

- Any abnormalities that obscure or break up the image of the pupils, will lead to artifact in the tracings
  - Eyelashes
  - Drooping eyelids
  - Eye surgery

- Eyeglasses must be removed but contact lenses can remain

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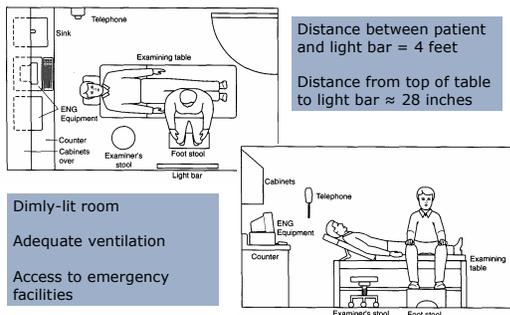

Preparing the test environment

- Equipment check
  - Calorics
    - Air irrigator
      - Air temperatures: 50°C warm, 24°C cool
      - Air flow rate: 8 LPM
    - Water irrigator (open loop)
      - Water temperatures: 44°C warm, 30°C cool
      - Water flow rate: 500 ml/min
  - Goggles
    - Clean lenses with eyeglass cleaner and soft cloth
    - Clean goggle face pad

- Room set-up
  - Control external light
  - Distance between light bar and patient (4 feet)

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Preparing the test environment

Distance between patient and light bar = 4 feet

Distance from top of table to light bar ≈ 28 inches

Dimly-lit room

Adequate ventilation

Access to emergency facilities

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Preparing the patient: Before testing

- Stop tranquilizers, sedatives, or vestibular suppressants for at least 48 hours before the test
  - Continue medications that are vital, such as insulin, heart meds, seizure meds, and possibly antidepressants
  - When in doubt, check it out!
- No alcohol for 48 hours before testing
- Do not wear make-up around the eyes
- Do not eat (or eat a light meal) two hours before testing
- Wear comfortable clothing
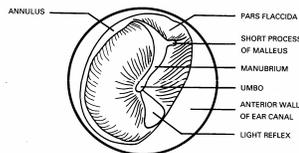
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Preparing the patient: Day of test

- Explain the test in an honest and reassuring manner
- Obtain clinical information
  - Heart/circulation problems?
  - Severe hearing impairment?
  - Severe visual problems?
  - Seizures?
  - Ear surgery?
  - Head trauma?
  - Description of vertigo? (When? How long? How often?)
- Ear exam
- Eye movement exam

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Ear exam

ANNULUS
PARS FLACCIDA
SHORT PROCESS OF MALLEUS
MANUBRIUM
UMBO
ANTERIOR WALL OF EAR CANAL
LIGHT REFLEX

- Is there a tympanic membrane perforation?
  - Cannot do standard caloric testing
- Is the canal blocked by cerumen?
  - Cannot do water or air calorics effectively
- Is the canal straight or tortuous?
  - Must be able to get air streaming directly onto tympanic membrane or posterior wall
  - Does not affect water calorics

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Eye movement exam

Normal Patient

- Is there nystagmus in any gaze position?
  - Center and ~30° right/left/up/down gaze
  - Hold at least 20 sec.
- Can they track a finger?
- Can they jump from one finger to the other?
- Are the eye movements conjugate?
  - Strabismus?
  - Internuclear opthalmoplegia (sluggish adduction)?

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Eye movement exam

- Strabismus
  - Eyes misaligned
  - Record from eye with normal range of motion only
- Disconjugate eye movements
  - Eyes have same range of motion but move at different speeds
  - Bilateral or unilateral
  - Record from each eye separately
  - Internuclear opthalmoplegia (sluggish adduction)

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Video goggles

Infrared LED lights illuminate the eyes. The image of the eyes is bounced back to the cameras from the dichroic mirror, while the patient is able to look through the mirror to see the optical target.

VISIBLE   VISIBLE

DICHROIC MIRRORS

LEFT CAMERA   IR   IR   RT CAMERA

IRED ARRAYS

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Adjusting the video goggles

- Optimize recordings by using automatic and manual adjustments as recommended by your manufacturer

- Ask the patient to move his/her eyes; make sure the crosshairs follow the pupils

- If the amount of light in the room affects the video, try adjusting with the goggles closed
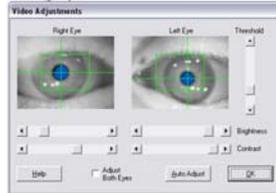
Adjusting the video goggles

Poor video adjustment = Poor tracing
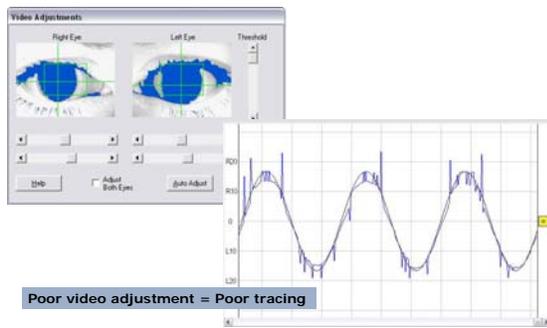
Calibration

- The patient's distance from the light bar should be 4 feet (+/- 4 inches)
  - The 4 feet gives the appropriate 30-degree angle from the eye to the outermost light on the light bar

- Calibration calculates conversion factor between measured parameters and eye movements

- Adjusts the recording system so that deflections correspond to amplitude of eye movements

- Calibrate before beginning data collection
  - Only recalibrate if goggles are moved off of the head or if you switch the eye to be tested
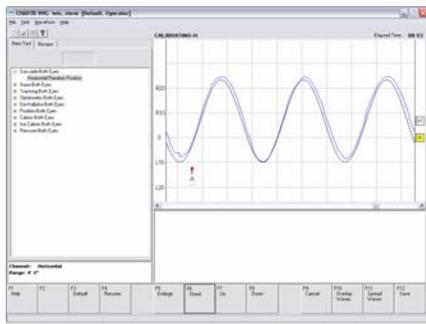
Good calibration

Poor calibration
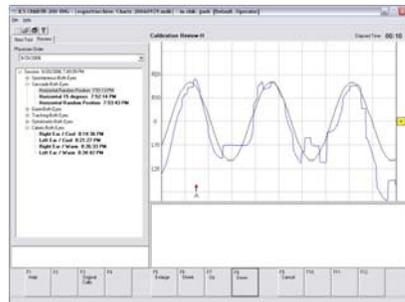
Standard VNG test battery

- Saccade test
- Gaze test
- Tracking/OPK tests

→ **Oculomotor tests**

- Positional tests
  - Dix-Hallpike Maneuver
- Bithermal caloric tests

Saccade test: General

- Records eye movements as the patient follows a visual target that jumps back and forth on the light bar
- Instruct the patient to follow the target, not anticipate the movements
- Instruct the patient to move only the eyes, and **avoid moving the head**
- Record randomized amplitude and direction saccades for 1 to 1½ minutes
    - Automatically stops recording at 3 minutes

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Saccade test: Analysis

- Amplitude (degrees): size of the jump between initial position and first stop of the eye movement
- Peak Velocity (deg/sec): speed of the eye movement
- Accuracy (percent): size of excursion compared with target excursion
- Latency (ms): reaction time or time between target movement and first eye movement

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Saccade test: Analysis

- Delete stray data points
- Need enough raw data points accepted to have at least 3 averaged points for movements in each direction (leftward and rightward movements)
- Normative data depends on the age of the patient
- Data points can be rejected if the patient response is too far off of the target
    - Not paying attention
    - Anticipating the target

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Saccade test: Analysis
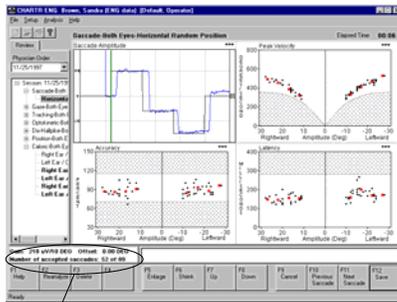
Number of accepted saccades: 52 of 89

Gaze test: General

- Records eye movements as the patient fixates on targets:
  - 30° rightward
  - 30° leftward
  - 30° upward
  - 30° downward
  - center gaze (optional)
- In each gaze position, record for at least 20 seconds
- If nystagmus is present, record longer than 2 minutes in order to catch periodic alternating nystagmus
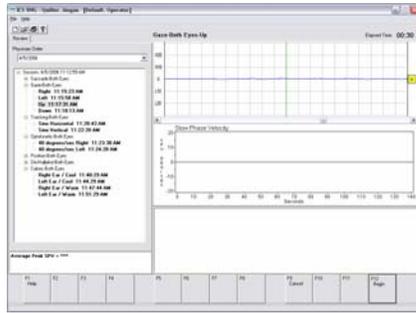- Results must match one-minute eye exam results

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Gaze test: Analysis

- In normal patients, there is no nystagmus produced during gaze
- Measure the amplitude of any nystagmus produced
- Artifacts are common if the patient does not attend to the task

Gaze test: Analysis

Tracking test: General

- Tests visual pursuit system
- Records eye movements as the patient follows a visual target moving smoothly across (or up and down) the light bar
- Instruct the patient to move only the eyes, and **avoid moving the head**
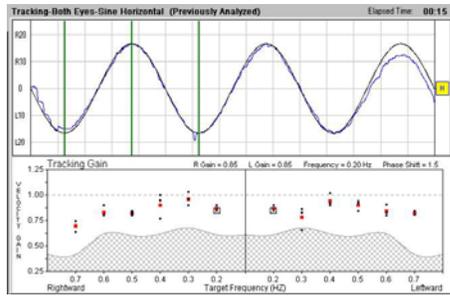- Stimulus cycles through slow-medium-fast

Tracking test: Analysis

- Analyze the patient's best performance
- Delete stray data points
- Data analysis is across several frequencies of target movement
  - 0.2 Hz to 0.7 Hz
- Normative data depends on the age of the patient
- Data points can be rejected if the patient response is too far off of the target
  - Not paying attention
  - Anticipating the target
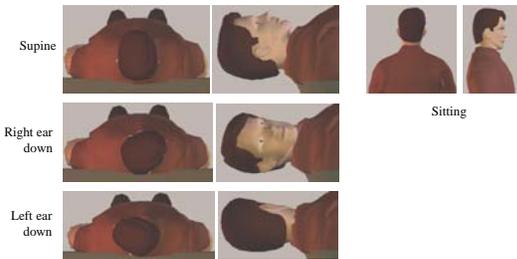
Tracking test: Analysis

Optokinetic test: General

- When done on a lightbar, OPK tests visual pursuit system
- Records eye movements as the patient watches a series of visual targets moving first to the right and then to the left in the horizontal plane on the light bar
- Instruct the patient
  - **Avoid moving the head**
  - Relax the eyes and watch for the individual points as they move through the middle of the light bar
  OR
  - Follow one dot across the field of vision, then pick up another dot and track it across the field of vision, etc.
- Record for 20 seconds in each (horizontal) direction
  - Standard test is 40 deg/sec

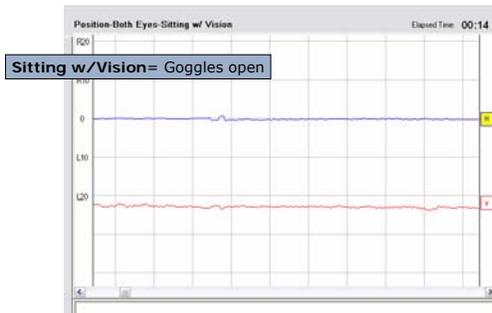## Optokinetic test: Analysis

- Results (normal/abnormal) should match tracking findings
- The patient should perform equally in each direction
  - Nystagmus SPV should be greater than 75% of the target velocity for each direction
  - For stimulus at 40 deg/sec, patient should perform at 30 deg/sec or better in each direction
- Analyze the patient's best performance

Optokinetic test: Analysis

Optokinetic test: Analysis

Positional tests: General

- Tests semicircular canals in different positions
  - Be aware of goggle position while moving the patient
- Static position tests
  - Record eye movements as the patient's head is in a critical position
  - Record with goggles open and goggles closed
  - **Task the patient when goggles are closed**
  - Record for at least 20 seconds in each position
- Dynamic position test: Dix-Hallpike maneuver
  - Records eye movements that are evoked by patient's head moving into a critical position
  - Use video recording to catch torsional nystagmus

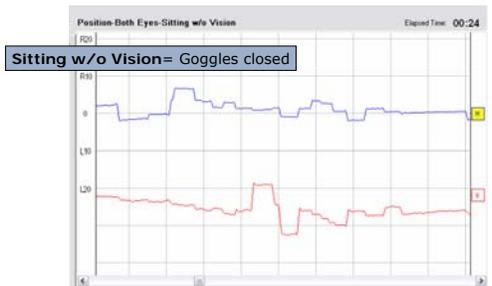## Static position tests: General

Supine

Right ear down

Left ear down

Sitting

If nystagmus appears when head is turned to right or left, check the effect of neck rotation by turning the body to right or left.

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Static position tests: Analysis

Position-Both Eyes-Sitting w/ Vision   Elapsed Time: 00:14

Sitting w/Vision= Goggles open

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Static position tests: Analysis

Position-Both Eyes-Sitting w/o Vision   Elapsed Time: 00:24

Sitting w/o Vision= Goggles closed

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Static position tests: Analysis

- In normal patients, there is little or no nystagmus produced when the head is placed in different positions

- Criteria for abnormality:
  - Greater than 6 degrees per second in any one head position

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Dynamic position test: Dix-Hallpike

- Instruct the patient about the procedure
- **Start the video recording**
- Begin from sitting position with head turned 45° right or left, move rapidly to supine head hanging (~10 degrees) while supporting the patient's neck
- After nystagmus subsides, bring the patient back to sitting position
- Repeat to determine fatigability if nystagmus detected

Dynamic position tests: Analysis

- In normal patients, there is little or no nystagmus produced when the patient changes position

- Use the eye movements recorded in the video for analysis

- **Do not** use the tracings to determine presence/absence of torsional nystagmus
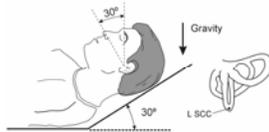
Bithermal caloric test: General

- Records eye movements as the temperature is changed in the patient's ear canals
- Allows independent assessment of responses from right and left lateral semicircular canals, making it useful for detection of unilateral vestibular abnormalities
- Describe procedure and expected response to the patient
- Perform the each of the four irrigations as follows:
  - Instruct the patient to keep eyes open
  - Close goggles
  - Start collecting response and start irrigation
  - Start tasking patient 20-30 seconds into irrigation to reduce suppression of response
  - Collect eye movements until response subsides (~2 minutes)

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Bithermal caloric test: General

- Position the patient to be supine with head flexed forward 30°

- In this position, warm irrigations cause excitatory responses and cold irrigations cause inhibitory responses

- Normal nystagmus follows the COWS rule: Cold Opposite, Warm Same

This positioning places the lateral canal in the vertical plane

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Bithermal caloric test: General

- Test sequence
  - RW, LW, RC, LC

- Record with eyes open, goggles closed

- Wait at least at least 5 minutes between irrigations

- Use water or air
  - Water: irrigate 30 seconds (44 and 30 degrees Celsius)
  - Air: irrigate 60 seconds (50 and 24 degrees Celsius)

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Bithermal caloric test: Analysis

- Delete stray data points
- Three different time intervals must be carefully analyzed
  - First 10-15 seconds after the onset of irrigation: spontaneous nystagmus
  - 30-60 seconds after irrigation: peak of caloric response
  - 60-90 seconds after irrigation: fixation suppression
- Measure peak of each caloric irrigation
  - RC, RW, LC, LW

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Bithermal caloric test: Calculations

- Unilateral Weakness (UW) and Directional Preponderance (DP) are calculated according to the following formulae:
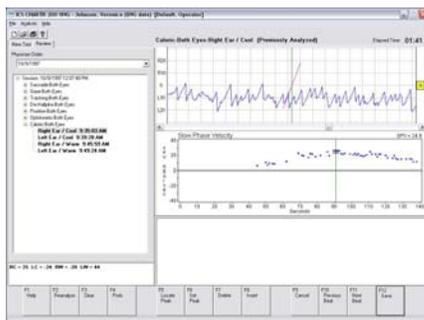
$$UW\% = \frac{(RC + RW) - (LC+LW)}{RC + RW + LC + LW} \times 100$$

$$DP\% = \frac{(RW + LC) - (LW+RC)}{RC + RW + LC + LW} \times 100$$

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Bithermal caloric test: Analysis

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Bithermal caloric test: Analysis

Caloric - Both Eyes
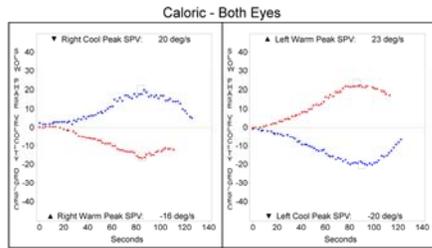
Caloric Weakness: 9% in the right ear
Directional Preponderance: 9% to the left

Questions?