VENG/ENG Testing

The test suite
- Large enough room
- Exam table
- Sink
- ENG equipment
  - LARGE monitor
  - Computer
  - Air/water irrigator
  - Examiner’s stool
  - Computer display screen

Video Goggles
- Video is preferred to electrodes.
- Clean, accurate don’t drift, low noise
- Two types of goggles:
  - Binocular goggles record from both eyes
  - Monocular goggles record from one eye while viewing from other.

ENG Electrodes – not recommended
- Bad aspects
  - Noisy and drift
  - Expensive disposable supplies
  - Harder to set up
- Good:
  - Can wear glasses so can see the target
  - May work when goggles don’t (e.g. false eye one side with monocular goggles)

We suggest using an external eye monitor- the bigger, the better!

Pre test instructions for the patient
- No tranquilizers, sedatives, or vestibular suppressants for at least 48 hours before the test. Ondansetron is OK (for nausea)
- No alcoholic beverages for at least 24 hours before the test
- No food before the test (breakfast only is OK if test is after lunch)
- No make up around eyes
- Patient should bring/wear usual glasses or contacts
- Patient should have someone available to bring them home, if necessary
Clinical Considerations

- Vision
- Hearing
- Ear anatomy
- Positional vertigo
- Neck and back complaints
- Drug & Alcohol use

Pre-test eye exam

- Does that patient have a visual impairment? If so, they may not be able to see the visual stimuli.
- Goggles should be used with usual contact lenses but glasses must be removed.
- If the patient cannot see the target without their glasses, say so in the report. Oculomotor testing will be useless.

Pre-test eye check

- Check for conjugate eye movement, eyelid droop, and nystagmus in these positions:
  - Eyes center
  - Eyes right and left
  - Eyes up and down

Case where someone didn’t look – don’t be a teaching case

Man with head run over by a bulldozer (really)
Blind in one eye
Couldn’t move other eye past midline

ENG lab reported his oculomotor testing as “normal”.

Pre-test ear exam

- Tympanic membrane perforation (s)
- Water caloric irrigation is contraindicated
- Air caloric is OK but comparisons between ears are not valid
- Abnormal external or middle ear anatomy (e.g. mastoid cavity)
- Water calorics may be contraindicated
- Air calorics are OK but comparisons between ears may not be valid
Pre-test ear exam
- Excessive cerumen in the ear canal
- Cerumen may block the irrigation
  - Should be removed prior to testing
- Narrow ear canal
  - Adequate irrigation may be impossible
  - Caloric responses may then appear weak
  - Rotatory chair testing is needed here

Ear wax error example
- Patient seen at prominent institution
- Reduced caloric response on left
- Exam 1 month later revealed near impaction of left ear canal.
- Repeat ENG after impaction is removed normal.

Drugs and medications
- Has the patient taken vestibular suppressants, tranquilizers or sedatives or consumed alcohol in the last 48 hours?
- If so, there may be a suppression of vestibular nystagmus or other eye movement abnormalities (such as slowing).
- Best usually to proceed with test and note in interpretation

Test instructions to the patient
- Talk to the patient, establish rapport.
- Ask how they feel today – are they dizzy?
- Ask about vision, ear/hearing, back and neck problems prior to testing
- Do they vomit easily? (consider pretreating with ondansetron)

Test Instructions to the patient
- The test is divided into 3 main segments:
  - Looking at light on the wall (oculomotor)
  - Lying in various positions (position)
  - Running cool and warm water (or air) in each ear, one at a time (caloric)
- Breaks may be given if necessary but it is easiest to do this between segments.
- Ask the patient to report spinning or dizziness during the test.

Test instructions to the patient
- Let the patient know that:
  - They will feel some spinning or dizziness during parts of the test.
  - You are trying to measure the eye movements that occur when you feel this way.
  - It will not persist
  - You are in control of the situation and you will be here the whole time.
Patient preparation

- Place goggles on the patient and center the pupil. (Clean the skin and apply the electrodes if not using VNG goggles.)

- Darken the room
- A darker room will dilate the pupil and make it easier to track for the vision allowed portions.
- Center pupil on the video screen. Adjust “tracking” so only pupil is white.
- For electrodes, impedance should be under 5kohms.

The Basic ENG Test Battery

Oculomotor:
- Spontaneous
- Gaze
- Saccades
- Pursuit
- Optokinetic
- Positional/Positioning
- Calorics

The optional ENG tests

Cervical testing
- Head Shake
- Hyperventilation
- Fatula
- Rebound nystagmus
- Tullio’s
- Valsalva
- Vibration

(Suggest always doing those in bold)

Suggested order for testing

- Calibrate (H/V)
- Saccades (H/V)
- Pursuit (H/V)
- Spontaneous nystagmus
- Gaze and Rebound (H)
- Head-shake (H)
- Vibration
- Optional special tests
  - Fistula, Valsalva, HVT
  - Cervical test
  - Dix-Hallpike
  - Caloric Tests

Oculomotor tests

- Calibrate
- Saccades
- Spontaneous
- Gaze
- Pursuit
- OKN

For VENG - do an “intrinsically calibrated” test like saccades and pursuit right away – and analyze it!
Calibration
- Calibration should be performed at start for VNG, and if goggles are repositioned.
- VNG calibrations do not change unless goggles are repositioned.
- The patient will be instructed to follow a moving dot.
- The examiner will “lock in” the calibration when the patient is accurately calibrated.

Calibration
- Poor calibration will result in major errors! Everything is wrong by the % error in the calibration.
- It is important to recognize when the patient was doing fine, but the calibration was off.

Awful Calibration

SaccadeTest
- Purpose:
  - To detect central disorders of saccades
  - Confirm your calibration is good
- Procedures
  - Vision allowed
  - Follow target jumping on screen
  - Horizontal and vertical
- Result
  - Velocity, accuracy, latency

Saccade disorders
- Saccadic disorders are rare
- Too slow
  - Velocity – medication effect or brainstem
  - Latency – lack of cooperation or attention
- Asymmetrical
  - Oculomotor palsy
  - INO
- Inaccurate (overshoot)
  - Cerebellar disorder
  - VNG can’t record – saccadic oscillations

CNS- intranuclear ophthalmoplegia
- Caused by lesion of the MLF between CN3 & CN6 nuclei
- Bilateral > demyelination (MS)
Watch Out!
- Note any drugs the patient has taken and possible effect on the test
- Alerting, especially if the patient is medicated
- Blink artifact

Ocular dysmetria
- Cerebellum controls smooth integration of body muscles in agonist/antagonist relationship
- Cerebellar (or its connections) disease causes defects of limb movements
- The ocular component is dysmetria

Saccades – overshots (hypermetric)

Random Saccade Test

Saccades – undershoots (hypometric)

Caution!
- Superimposed gaze nystagmus
- Superimposed congenital nystagmus
- Drugs (usually dysmetria)
- Inattention/poor vision
- Eye blinks
- Head movement

Saccadic slowing
The eyes can accurately reach the target but do so much slower than normal. This can be symmetric or asymmetric. CALIBRATION errors and drug use must be ruled out for accurate interpretation.
Oculomotor - Tracking

- Tracking (pursuit) test:
  - The patient follows a visual target moving in the horizontal plane.
  - The recording is examined for abnormalities.

Normal Pursuit

Abnormal – saccadic pursuit

- Aka “Cogwheeling” - Eyes fall behind target

Abnormal – saccadic pursuit

- Disorganized and disconjugate
  - Reduced horizontal gaze capacity
  - Disconjugate movement is possible
  - Brainstem/Cerebellar localization

Pursuit Pitfalls

- Drugs disrupt pursuit
- Inattention
- Head movement
- Superimposed gaze nystagmus
- Superimposed congenital nystagmus
- (cross check with other subtests)

Spontaneous Nystagmus Test

- Purpose:
  - To detect vestibular and central nystagmus
- Procedures
  - 20 seconds vision allowed
  - 20 seconds vision denied
- Result
  - Nystagmus or not
  - Effect of vision on nystagmus
Effect of Vision

- Nystagmus with vision allowed which is enhanced with vision denied is usually PERIPHERAL (but can be anything)
- Nystagmus unaffected by vision is usually CENTRAL.
- Horizontal nystagmus which is enhanced with visual fixation (vision allowed) and is reduced or abolished with vision denied is always due to CONGENITAL NYSTAGMUS

Congenital nystagmus

Features: 1/1000 people
- Fixed, genetic developmental brain defect
- Occurs at birth or soon after in an otherwise healthy person so will be obvious and known to patient
- Generally horizontal (rarely torsional or vertical)
- Worse in light when trying to fixate, reduced or abolished in the dark
- Convergence = reduction or abolition
- Null Point – orbital position where nystagmus is minimal

Gaze Test

- Purpose:
  - To detect gaze evoked nystagmus
  - To document ocular range is full
- Vision is allowed
- Procedures
  - Horizontal left and right
  - Vertical up and down
- Result
  - Gaze-evoked nystagmus or not.

Optional Test – Gaze Rebound

- Method
  - Vision denied.
  - Eyes to far right for 10 seconds
  - Return to center for 10 seconds or more
  - Eyes to far left for 10 seconds
  - Return to center for 10 seconds or more
- Output
  - Rebound nystagmus is always central

Gaze testing – method

- 30 degrees in each direction
- Recorded for 20 seconds in each direction
- Vision is allowed
- Compare nystagmus in each condition
Gaze- Rebound

- Nystagmus is present upon returning to center gaze from an eccentric gaze position that is held for 10 seconds.
- The nystagmus beats in the opposite direction of the previously held gaze.
- This is a central finding associated with cerebellar disease.

Optokinetic

- Optokinetic test:
  - The patient follows a series of visual targets moving to the right and then to the left. This provokes optokinetic nystagmus.
  - The recordings are examined for weak nystagmus in one or both directions of the moving target.

Normal variations

- Speed of the eyes should match speed of the stimulus up to 30 deg/sec and then may fall behind stimulus (but should still increase)
- Responses should be symmetric

Abnormal- asymmetry

- OKN asymmetry is rarely encountered
- Congenital nystagmus
- Occasionally indicates CNS abnormality

Look Out!

- Drugs
- Inattention
- Instructions
Recommended Special Tests

- High Frequency Headshake Test – goggles recommended
  - Shake the patient’s head side to side with eyes wide open but vision denied for 10-20 seconds
  - Immediately after stopping, a nystagmus may be seen that beats away from the pathologic ear
- Vibration Test – goggles recommended
  - Apply vibration to each SCM muscle for 10-20 seconds with vision denied but eyes wide open
  - Immediately after vibration, a nystagmus that beats away from the pathologic ear may be seen from both sides.

Headshake

Vibration

Headshake and Vibration Cross-checks on calorics

- Headshake
  - Should match up with caloric asymmetry
  - Beats away from lesion
- Vibration
  - Should match up with caloric asymmetry
  - Beats away from lesion

Positional tests

- The patient is moved into these sets of positions to diagnose positional vertigo
  - Dix Hallpike (head right and left)
  - Supine, head right, head left
- Eye movements are examined in each of these positions for nystagmus.

Special Tests – Cervical
Suggest do as a routine

- Method
  - Vision denied, sitting upright
  - Head to end of Left range for 20 seconds
  - Head center for 20 seconds
  - Head to end of Right range for 20 seconds
  - Head center for 20 seconds
- Pitfall – make sure eyes are in center.
- Output – nystagmus related to head on neck
**Cervical Source**

- May be result of torsion on the neck
- Can be from VBI – rare but dangerous
- Can be from neck pain “spilling over” into the vestibular system
- Can be from a herniated disk (variation – Arnold Chiari malformation)

**Cervical Source**

- Old School “Laterals”
  - If nystagmus is present in head right or head left position, roll patient onto the offending side. If it goes away, it was not really based on the head position but rather, the torsion of the neck.

**Cervical Source**

- New School AKA “Vertebral artery Test”
  - Video Goggles are an invaluable resource for this test
  - Have patient sit upright so that there is no change of orientation of the head relative to gravity.
  - Keep the body perfectly still and rotate the head as far as you can to one side – keeping the eyes in the center of the orbit.
  - Nystagmus may be small but is significant if present.

**BPPV Nystagmus Patterns**

- PC or AC BPPV
  - Vertical and torsional nystagmus
  - Latency
  - Burst
  - Fatigues (and is inconsistent)
- LC BPPV
  - Direction changing nystagmus
  - Geotrophic (beats towards ground)
  - Ageotrophic (beats towards sky)
  - Depends on previous head position

**Central Positional**

This is rare – you shouldn’t be making this call very often!
- Doesn’t fit the BPPV patterns
  - Too consistent (doesn’t fatigue)
  - Doesn’t go away
  - Wrong direction (no torsional component)

**Positional Pitfalls**

- Gaze L or R during positions
- Convergence (can be a problem for monocular goggles)
- Alcohol ingestion (causes positional nystagmus)
Positional/positioning

- Dix-Hallpike
  - Patient’s head is rotated to the side and body is brought back from sitting to laying with head hanging down and to the side.
  - This is done to the right and then to the left.
  - Eyes are observed for nystagmus induced by the change in body position.

Procedure

- Frenzel lenses or video goggles in darkened room - big monitor is nice for this.
- Is typically torsional but may also be horizontal and vertical in rare forms
- Record anyway!

Traditional Dix-Hallpike

- Patient sits on exam table and examiner stands to the side.
- The patient’s head is turned 45 deg. To the left (or right)
- The patient is brought down to a supine position with the head hanging off the edge of the table still to the left (or right)

Dix Hallpike

- The head is supported by the examiners hand and is held in this position for at least 40 seconds.
- If nystagmus appears, hold this position for at least one minute or until the response subsides.
- At this point you may return the patient to a sitting point, if nystagmus is present you may treat the patient with a CRP.
- OR, you may return the patient to a sitting position and look for a possible brief reversal of the nystagmus
- Repeat this maneuver with the head turned to the other direction.
- It is a good idea to start with the suspected uninvolved side.

Normals

- Normals may have a few beats of nystagmus during the downward motion but none otherwise.

Abnormal

- Benign Paroxysmal positioning vertigo
  - Delayed onset
  - Short duration
  - Torsional beats toward undermost ear
  - Fatigable upon repeat trials
  - May reverse direction upon return to sitting
  - Usually accompanied by vertigo

Pick a canal, any canal

- Generally, posterior canal is involved
  - RPC= upward & rightward torsional
  - LPC= upward and leftward torsional
- Less commonly, anterior canal is involved
  - RAC= downward and rightward torsional
  - LAC downward and leftward torsional
- Very rarely, horizontal canal is involved
  - RHC= horizontal geotropic fast phase stronger right ear down
  - LHC= horizontal geotropic fast phase stronger left ear down
Typical PC BPPV

Typical LC BPPV

Calorics
- Each of the patient’s ears is irrigated twice
  - Once with cold stimulus
  - Once with warm stimulus
- Use water unless there is a contraindication
- These stimuli provoke caloric nystagmus
  - COWS: cold-opposite, warm-same
- The eye movement recordings are examined for a weak response in one or both ears.

The procedure
- The head is elevated 30 degrees
- Each canal is stimulated one at a time with a cool and a warm stimulus
  - Water:
    - Warm: 44 degrees C
    - Cold: 30 degrees C
  - Air:
    - Warm: 50 degrees C
    - Cold: 24 degrees C
- The patient has their vision denied and is alerted during the procedure

Patient Instructions
- Inform patient of what is about to happen
- There will be some noise (from irrigator)
- Let them know that the cool stimulus is not cold and the warm stimulus may feel hot but is not really hot enough to burn or hurt them
- Tell them it is common to feel a turning or spinning sensation but it won’t last
- Give them good alerting tasks (name vegetables for example)
Pre-stimulus

- Calibrate
- Let the recorder run to make sure you don’t have any preexisting nystagmus
- Give the patient alerting tasks after calibration

Stimulus

- Place the irrigator tip deeply into the canal.
- Warn the patient it is about to begin and not to pull away
- Begin the irrigation

The stimulus

- Nystagmus and vertigo will commence near the end of the stimulation
- It will build to a crescendo about 30 seconds after stimulation and then taper off
- KEEP ALERTING THE WHOLE TIME!!

Normal

- All four caloric responses should be roughly equal
- Normals (and peripheral) lesions should have normal fixation suppression

Abnormal

- Unilateral weakness
- Directional preponderance
- Bilateral weakness
- Hyperactive responses
- Failure of fixation suppression
- Caloric inversion and perversion

Calculations

- Duration of nystagmus response
  - From beginning of irrigation to end of response
- Peak nystagmus frequency
  - Average frequency of nystagmus beats during 10 second interval when response is most intense
- Maximum SPV during 10 second interval when response is most intense
  - Most widely used
  - Determined by inspection of record

Calculation

- Each response is quantified by the maximum SPV – this is done by the software but it’s good to understand where the numbers are coming from to verify accuracy of results.
- All four responses are compared for the following calculations:
  - Unilateral weakness
  - Directional preponderance
  - Fixation index

Unilateral weakness

- The amount by which 2 responses provoked by right ear stimulation differ in intensity from those provoked by left ear stimulation.
  - Significant finding is >22% difference between ears (Jacobson)
  - Indicates peripheral problem on the weaker side
  - Be careful of asymmetric canal anatomy!

Unilateral weakness formula:

\[(\text{RW+RC}) - (\text{LW+LC})]/(\text{RW+RC+LW+LC}) \times 100\]
Unilateral Weakness

Bilateral weakness

- Caloric response of both ears is very weak or absent
- If all four caloric responses total less than 22 deg/sec (Jacobson), its BW
- Is indicative of CNS or bilateral peripheral lesions
- Ice caloric should be considered.
- Rotatory chair if available

Traces for unilateral weakness

Bilateral Weakness -- Gentamicin

Ice caloric
Always do for “dead Ear”

- Patient closes eyes, turns head and recording is started.
- 2ml of ice water (or more) is squirted into the ear using a big syringe (no needle of course) - “Toomey” is good
- Water remains for 20 seconds and then head is turned to empty the ear.
- Head is brought back to center position.
- This may provoke an opposite beating nystagmus not seen before, (cold-opposite), because much stronger stimulus than air or 7 deg centigrade irrigator
**Ice Calorics -- Prone**

- If you get a response
- Have the patient quickly flip over to see if the response changed direction.
- If the response does not change direction, this indicates that it is not a gravity dependant response and is probably just a latent spontaneous nystagmus - not a true caloric response.
- This is important for case management decisions regarding possible surgical intervention vs. VRT!!

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**Ice caloric Bilateral Weakness -- Gentamicin**

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**Directional preponderance**

- The difference in intensity between the 2 right beating and the 2 left beating responses
- Generally, this is seen with a pre-existing nystagmus
- Sometimes, can be seen without one.
- Useless for clinical diagnosis
- However, it is conventionally reported and is an abnormal finding if >28% (Jacobson)

Directional preponderance formula
\[(RW+LC)-(LW+RC)/(RW+LC+LW+RC) \times 100\]

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**RB directional preponderance**

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**Directional Preponderance and UW**

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**DP technical error**
Fixation
- As the response begins to decline (about 90 seconds after beginning the irrigation) ask the patient to look at the fixation light (if using electrodes, have them open their eyes & look at your finger or a spot on the ceiling)
- Keep looking for about 10 seconds then the light will shut off (or have them close the eyes again if using electrodes)
- The recording should be continued until the nystagmus has tapered off.
- Wait 3-5 minutes before starting the next irrigation.

Fixation Suppression Examples
- Good fixation suppression (peripheral)
- Failure of fixation suppression (CNS)

Fixation Index
- Measure of the effectiveness of visual fixation in suppressing caloric nystagmus.
- Should be calculated for at least one right beating and one left beating caloric response

Fixation index formula:
SPV (fixating)/SPV (not fixating)

Failure of fixation suppression
- Nystagmus intensity with eyes open nearly equals matches or exceeds that with eyes closed
- Fixation suppression will occur in normals and peripheral lesions
- FI greater than .6 is abnormal and indicative of CNS involvement
- Calculated at peak or near end of peak
- Rotatory chair does it better

Hyperactive responses
- Defined as water responses that exceed 50deg/sec for cool's and 80deg/sec for warm's (Jacobson: 99 deg/sec for cool, 146 deg/sec for warm, 221 deg/sec total)
- Usually is due to excellent inner ear function in a nervous young person.
- Rarely can be due to abnormal anatomy (tm perf, mastoidectomy, etc.)
- In absence of this, very rarely it is due to CNS problem (cerebellar).
Hyperactive response (central)

Normal response

Caloric inversion and perversion – usually your error
- Inversion: entire caloric response beats in the wrong direction (anatomically impossible to explain)
- Perversion: vertical or oblique nystagmus in response to caloric stimulation (some physiology here)
- Caloric inversion/perversion is usually caused by a technical error
  - Wrong temperature or head position
  - Alerting bringing out spontaneous nystagmus
  - Too short wait between irrigations
  - Rarely, perversion is brainstem
  - Should have LOTS of other brainstem findings.

The optional ENG tests

Cervical testing
Head Shake
Hyperventilation
Fistula
Rebound nystagmus
Tullio’s
Valsalva
Vibration

We suggest always doing bolded tests and have already discussed in earlier material

Special Tests – HVT (suggest - - on demand)
- Method
  - Record baseline
  - HVT for 30 seconds
  - Record post-HVT
- Output
  - Nystagmus induced, enhanced or reversed by HVT
  - Reversal suggests vest nerve irritability
- Pitfalls
  - None

Special Tests – Fistula (suggest - -on demand only)
- Method
  - Apply positive pressure into the ear canal
- Output
  - Nystagmus associated with pressure
- Pitfall
  - Hard to calibrate pressure
  - Very insensitive

Special Tests – Tullio’s Suggest - -on demand only
- Method
  - Vision denied
  - Loud noise close to one ear
- Outcome
  - Nystagmus correlated with loud noise
  - Suggests SCD
- Pitfalls
  - Insensitive
  - Difficult to calibrate loud noise.
Special Tests – Valsalva
On demand or always

- Method
  - Vision denied
  - Patient takes a deep breath and "strains" – increasing intrathoracic pressure. 5 sec is enough.

- Output
  - Nystagmus provoked by straining
  - Suggests SCD or fistula

- Pitfalls
  - Some people don’t cooperate leading to false negatives

Summary

- ENG consists of 4 groups of studies
  - Oculomotor
  - Positional
  - Caloric
  - Special maneuvers
- Powerful method to detect many ear disorders
- Complex interpretation process