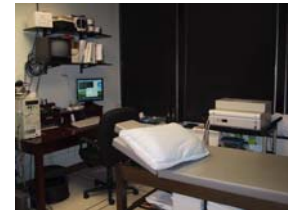
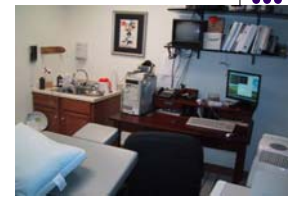


Core ENG Methods

The test suite

- Large enough room
- Exam table
- Foot rest Sink and supply cabinet/storage
- ENG equipment
 - LARGE monitor
 - Computer
 - Air/water calorics
- Examiner's stool
- Display screen
- Telephone

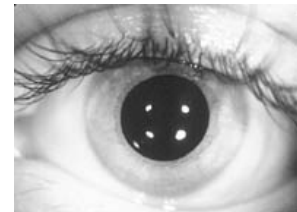


Video Goggles

- Video is preferred to electrodes since you can record and capture the actual eye movements to compare to the graphic recording.
- Goggles can record from one eye or both.
- In a few situations, you may have to use electrodes but the system can accommodate both.



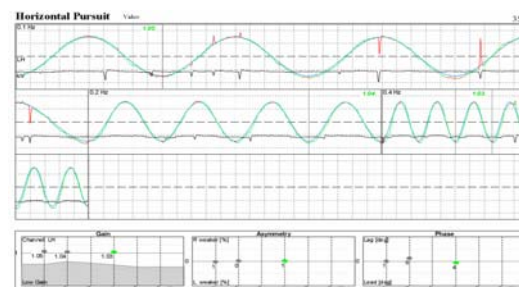
Monitors- the bigger, the better!



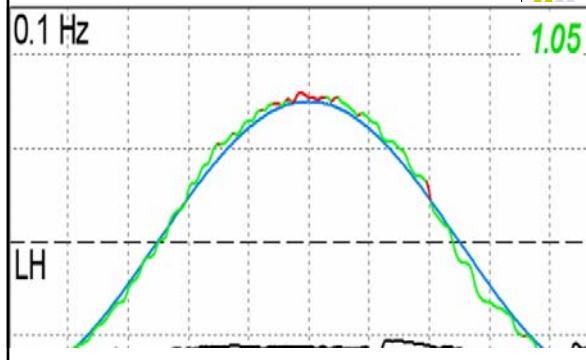
Video can be saved for later review, medical records and educational purposes.



Comparison of video to graphic record allows you to "clean up" the records and interpret findings more accurately.



Look carefully when reviewing the graphic recordings!



Pre test instructions for the patient

- No tranquilizers, sedatives, or vestibular suppressants for at least 48 hours before the test
- No alcoholic beverages for at least 48 hours before the test
- No food before the test (breakfast only is OK if test is after lunch)
- No make up or lotions
- No caffeine before the test
- Patient should bring/wear 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 can be used easily with contact lenses but glasses must be removed.
- If the patient can not see the target without their glasses, consider using electrodes for the oculomotor portion of the test.



Pre-test eye exam

Visual impairment will prevent you from doing SOME but not ALL of the ENG battery.

Obviously, the blind patient can not track a visual target, but can certainly complete positional and caloric tests (except for fixation).



Caution!

- Goggles
 - Very dark eyelashes, eye make up, severe ptosis and eye hemorrhages may all obscure proper video recording.
- Electrodes
 - If blind patient does not have a corneo-retinal potential, electrodes will be useless even for calorics (consider goggles).

Pre-test eye exam

- Look for conjugate eye movement and spontaneous nystagmus in these positions:
 - Eyes right
 - Eyes left
 - Eyes center
 - Eyes up
 - Eyes down



Pre-test eye exam

- Signs of an oculomotor disorder that should be identified prior to performing the ENG
 - one or both of the patient's eyes fail to meet or hold any of the extreme gaze positions
 - one or both of the patient's eyes have nystagmus in any of the extreme gaze positions (Both =OK to proceed)
 - one or both eyes move sluggishly as the patient looks back and forth

Pre-test ear exam

Does the patient have hearing loss?

- If so, the patient will have difficulty following instructions especially during caloric irrigations and any vision denied portions of the test. You may want to review written instructions beforehand and cue them as you go along.



Pre-test ear exam

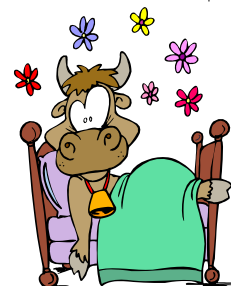
- Tympanic membrane perforation
 - Water caloric irrigation *is* contraindicated
 - Air caloric is OK but comparisons between ears may not be valid
- Abnormal external or middle ear anatomy
 - Water calorics *may* be contraindicated
 - Air calorics are OK but comparisons between ears may not be valid

Pre-test ear exam

- Has the patient had any ear surgery?
 - If so, this could alter the strength of the caloric stimulation.
- Excessive cerumen in the ear canal
 - Cerumen may block the irrigation
 - Should be removed prior to testing
- Narrow ear canal
 - Adequate irrigation may be difficult
 - Caloric responses may then appear weak

Pre-test considerations

- Has the patient reported positional vertigo?
- Be prepared for a reaction on the Dix-Hallpike, if so.



Pre-test considerations

- Does the patient have back or neck problems?
- If so, the Dix-Hallpike may be contraindicated or need to be modified.
- The patient should be evaluated for cervical or vertebral artery involvement prior to testing. ([more on this later](#))

Pre-test considerations

- Has the patient disregarded the instructions and taken vestibular suppressants, tranquilizers or sedatives or consumed alcohol in the last 48 hours?
- If so, there may be a suppression of vestibular nystagmus from the drugs, positional nystagmus from the alcohol or other eye movement abnormalities.

Test instructions to the patient

- Talk to the patient, establish rapport.
- Ask how they feel today – make a note of any sensations they report.
- **Remember to ask about vision, ear/hearing, back and neck problems prior to testing!!!**

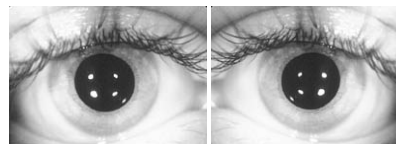
Test Instructions to the patient

- Advise the patient that the test is divided into 3 main segments:
 - Looking at dots
 - Lying in various positions
 - Running cool and warm water (or air) in each ear, one at a time
- Breaks may be given if necessary but it is easiest to do this between segments.
- Advise the patient to report if they feel any spinning, floating or dizziness during the test.

Test instructions to the patient

- Let the patient know that:
 - It is not unusual to feel some spinning or dizziness during certain parts of the test.
 - You are trying to measure the eye movements that occur when you feel this way.
 - It is not unexpected like an attack and will not persist like an attack.
 - 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.)

Patient preparation

- Darken the room to the level at which you will be working. A darker room will dilate the pupil and make it easier to track for the vision allowed portions.
- Check your monitor to make sure that the pupil is centered as much as possible on the screen. (For electrodes, impedance should be under 5kohms.)

Calibration

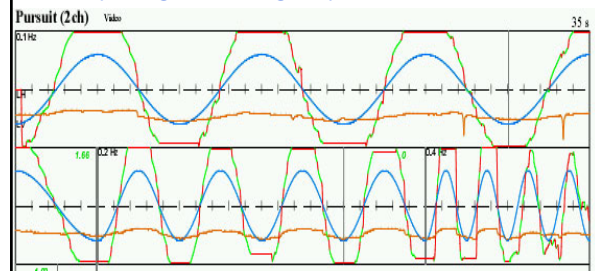
- Calibration should be performed at least between each test segment and, if possible, between each caloric temperature.
- The patient will be instructed to follow a moving dot.
- The examiner will "lock in" when the patient is accurately calibrated.

Calibration

- Poor calibration will result in erroneous recordings.
- It is important to recognize when the patient was doing fine, but the calibration was off.

Calibration

Example of good tracking but poor calibration.



The ENG Test Battery

Gaze
Rebound Gaze
Saccades
Pursuit
Optokinetics
Head Shake
Vibration
Hyperventilation
Fistula
Positional/Positioning
Bithermal Calorics

Test Battery

- Cross check
- Results supported by other findings
- Can help confirm/refute suspicions of history
- Looks at different parts of the system

The test battery

- Looking for nystagmus
- 4 sub groups:
 - Gaze/oculomotor
 - Special Tests
 - Positional/positioning
 - Calorics

Gaze Testing

- Purpose: To detect nystagmus with the head in a single position and the eyes:
 - Primary
 - Horizontal right
 - Horizontal left
 - Up
 - Down
- With vision allowed and vision denied.

Technical Info

- 30 degrees in each direction
- Recorded for 20 seconds in each direction vision allowed and 20 seconds vision denied
- Compare nystagmus in each condition



Is there nystagmus?

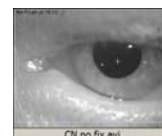
- Horizontal nystagmus with vision allowed which is enhanced with vision denied is PERIPHERAL
- Horizontal nystagmus which is enhanced with visual fixation (vision allowed) and is reduced or abolished with vision denied is a CNS ABNORMALITY

Congenital nystagmus

Features:

- 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 or rotary (rarely vertical)
- Upward gaze= horizontal nystagmus
- Worse in light when trying to fixate, reduced or abolished in the dark
- Convergence = reduction or abolition
- Null Point

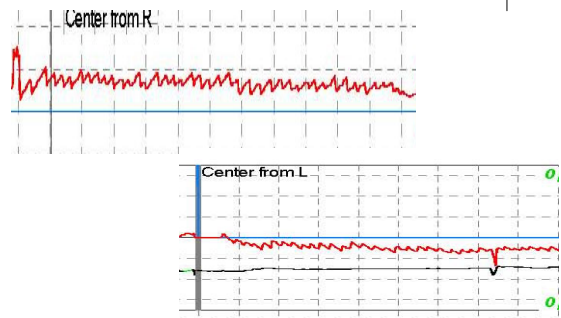
Congenital nystagmus in light with fixation vs. dark (check if these are reversed on website)



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.

Gaze - Rebound



CNS- intranuclear ophthalmoplegia

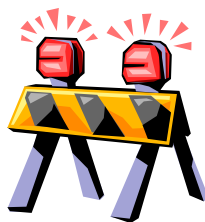
- Caused by lesion of the MLF between CN3 & CN6 nuclei
- Bilateral > demyelination (MS)

INO video



Watch Out!

- Note any drugs the patient has taken and possible effect on the test
- Alerting, especially if the patient is medicated
- Blink artifact



Oculomotor – Saccade Test

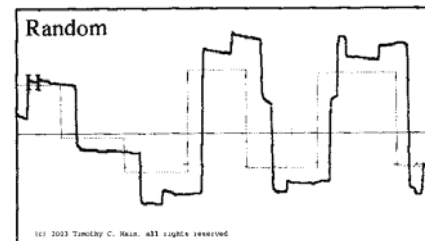
- **Saccade test:**
- Patient looks back and forth at visual targets in the horizontal plane. They will be at random distances and directions.
- The movements are examined for abnormalities.

Ocular dysmetria

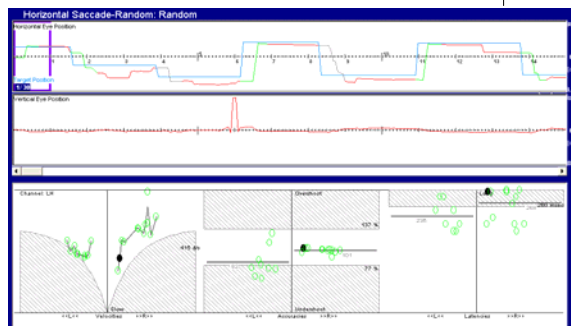
- Cerebellum controls smooth integration of body muscles in agonist/antagonist relationship
- Cerebellar (or its connections) disease causes defects of limb movements
- The ocular component is dysmetria

Saccades – overshoots (hypermetric)

Random Saccade Test

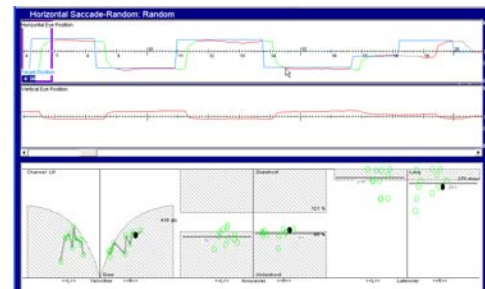


Saccades – undershoots (hypometric)

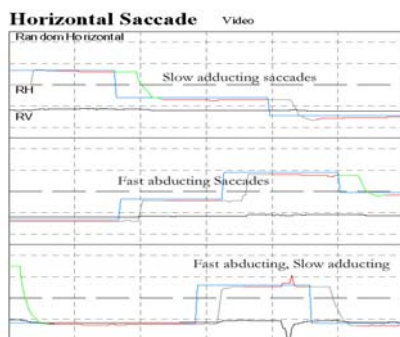


Saccadic slowing

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.

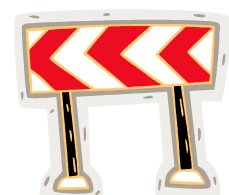


INO evidence on Saccades



Caution!

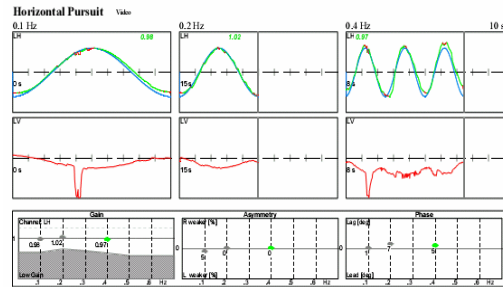
- Superimposed gaze nystagmus
- Superimposed congenital nystagmus
- Drugs (usually dysmetria)
- Inattention/poor vision
- Eye blinks
- Head movement



Oculomotor - Tracking

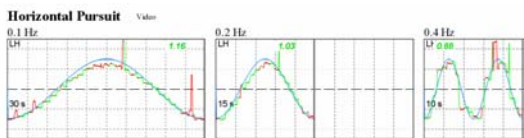
- **Tracking (pursuit) test:**
- The patient follows a visual target moving in the horizontal plane.
- The recording is examined for abnormalities

Normal Pursuit



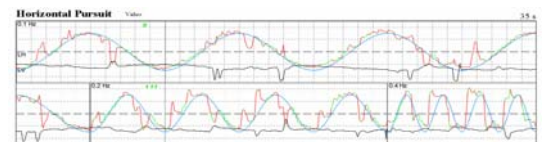
Abnormal – saccadic pursuit

- Aka “Cogwheeling” - Eyes fall behind target



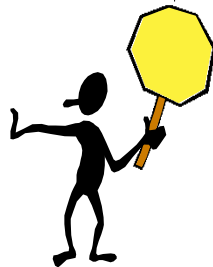
Abnormal – saccadic pursuit

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



Pitfalls

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

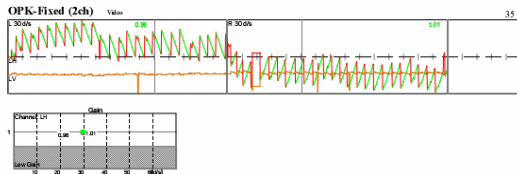


Gaze/Oculomotor

- **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

- Rarely encountered
- Congenital nystagmus
- Occasionally indicates CNS abnormality

Look Out!

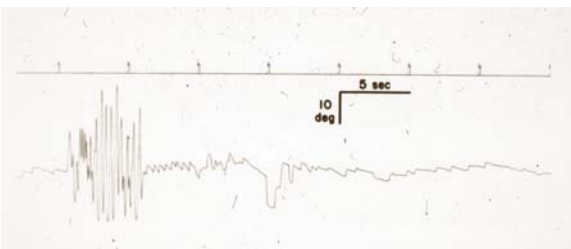
- Drugs
- Inattention
- Instructions



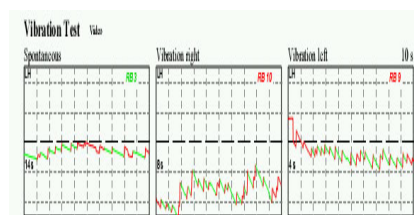
Special Tests

- High Frequency Headshake Test – goggles recommended
 - Shake the patients 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 and vibration



Vibration



Special Tests

- Hyperventilation
 - Have the patient breathe quickly and deeply for about 30 breaths and look for nystagmus.
 - If it beats away from the lesion, this is typical, if it reverses away from the spontaneous direction, then it may be an irritative lesion like an acoustic.
- Fistula
 - Apply positive pressure into the ear canal and observe nystagmus.
 - Patient will likely report feeling dizzy.

Positional/positioning

- The patient is moved into **various positions**.
 - Erect (already covered in gaze testing)
 - Supine
 - Supine, head right
 - Supine, head left
 - Right lateral (optional)
 - Left lateral (optional)
 - Dix Hallpike - head right & left
- Eye movement recordings are examined in each of these positions for nystagmus.

Nystagmus

- Is it present in any head position?
- Does it appear/enhance, reduce/abolish vision allowed vs. vision denied?
- Is the patient reporting any sensations?

Alerting

- Just like with the gaze testing, give the patient mental alerting tasks during the vision denied portion.

Positional - Abnormal Findings

Horizontal nystagmus present during **vision denied** with alerting:

- Direction changing in a single position
- Persistent in 3 or more positions (including Dix-Hallpikes R and L)
- It is intermittent in 4 or more positions (including Dix-Hallpikes R and L)
- SPV of 3 strongest beats is $> 6\text{deg/sec}$ in any head position

Positional - Abnormal Findings

Positional nystagmus present during **vision allowed**:

- Always considered abnormal
- May be peripheral if it is direction fixed and enhanced with vision denied
- Usually it is CNS – may be direction fixed or direction changing
- Depends on orientation of head with respect to gravity

CAUTION - Positional nystagmus present during vision allowed

- Watch out for cervical source.
- If you see it head right or head left, do laterals to confirm or refute.
- Always a good idea to test for cervical vertigo before doing positionals at all.



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.

Positional Pitfalls

- PAN I and II
- Alertness
- CNS depressant drugs
- Gaze L or R during positions



Positional/positioning

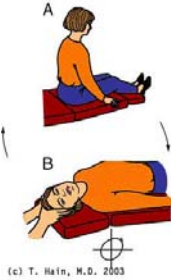
- **Dix-Hallpike**
- Patient's head is rotated to the side and body is brought back from sitting to laying with head hanging down and to the side.
- This is done to the right and then to the left.
- Eyes are observed for nystagmus induced by the change in body position.

Procedure

- Frenzel lenses or video goggles in darkened room - big monitor is nice for this.
- OR just with open eyes if lighting is adequate to observe nystagmus visually
- 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 examiner's 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

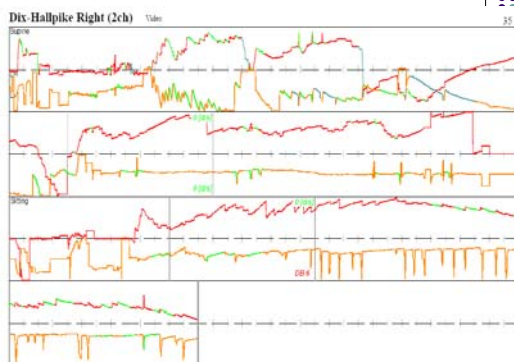
- Normals may have a few beats of nystagmus during the downward motion but none otherwise.

Abnormal

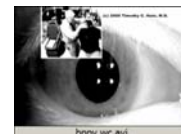
- Benign Paroxysmal positioning vertigo
 - Delayed onset
 - Short duration
 - Torsional beats toward undermost ear
 - Fatigable upon repeat trials
 - May reverse direction upon return to sitting
 - Usually accompanied by vertigo

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
- Can be irrigated with air or water
- 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 may be some noise
- 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

Pre-stimulus

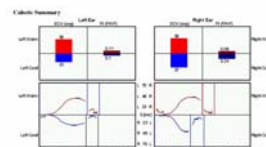
- Calibrate
- Let the recorder run to make sure you don't have any preexisting nystagmus
- Give the patient alerting tasks after calibration

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

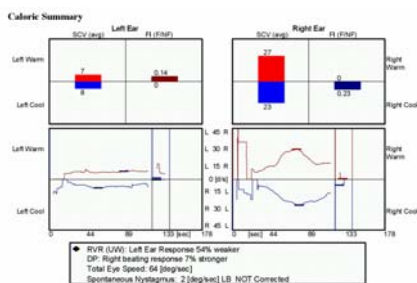
Unilateral weakness

- 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:

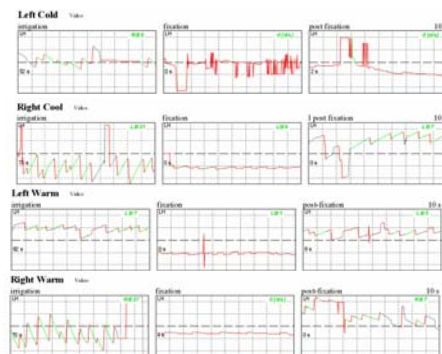
$$(RW+RC) - (LW+LC)/(RW+RC+LW+LC) \times 100$$

Unilateral Weakness



Patient with left sided acoustic neuroma

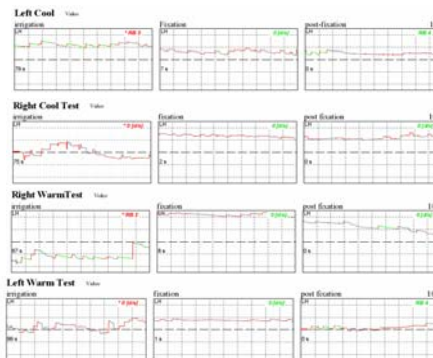
Traces for unilateral weakness



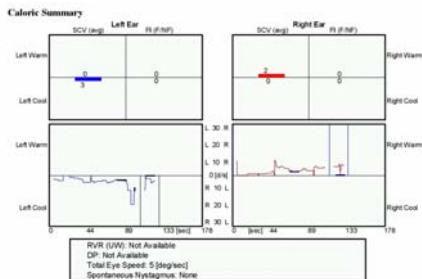
Bilateral weakness

- 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 calorics should be considered.

Bilateral Weakness -- Gentamicin



Bilateral Weakness -- Gentamicin



Ice calorics

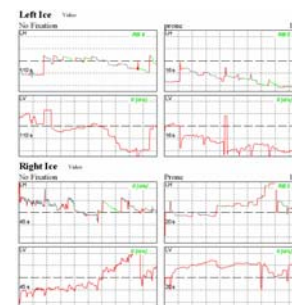


- Patient closes eyes, turns head and recording is started.
- 2ml of ice water is poured into the ear.
- Water remains for 20 seconds and then head is turned to empty the ear.
- Head is brought back to center position.
- This may provoke an opposite beating nystagmus not seen before. (cold=opposite)
- A response should not begin earlier than 10 seconds after the introduction of water.

Ice Calorics

- 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!!

Bilateral Weakness -- Gentamicin



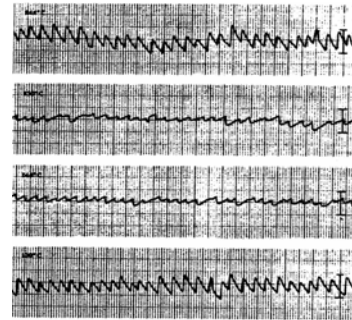
Directional preponderance

- 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.
- Not terribly clinically useful because it can be seen with both peripheral and CNS lesions.
- However, it is considered an abnormal finding if >28% (Jacobson)

Directional preponderance formula

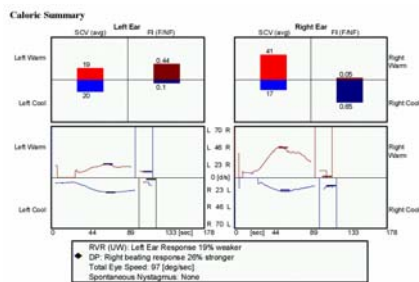
$$(RW+LC)-(LW+RC)/(RW+LC+LW+RC) \times 100$$

RB directional preponderance

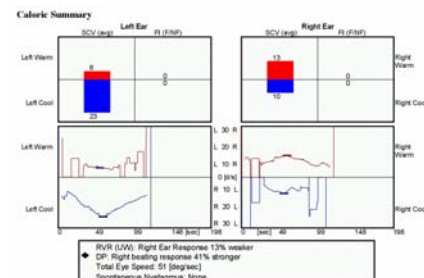


Barber & Stockwell

Directional Preponderance and UW



DP technical error



Fixation

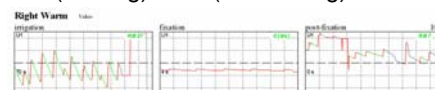
- As the response begins to decline (about 90 seconds after beginning the irrigation) ask the patient to look at the fixation light (if using electrodes, have them open their eyes & look at your finger or a spot on the ceiling)
- Keep looking for about 10 seconds then the light will shut off (or have 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 Index

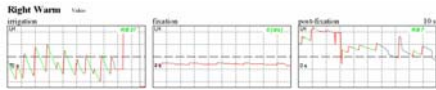
- Measure of the effectiveness of visual fixation in suppressing caloric nystagmus.
- Should be calculated for at least one right beating and one left beating caloric response

Fixation index formula:

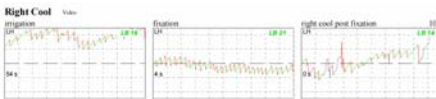
$$SPV \text{ (fixating)} / SPV \text{ (not fixating)}$$



Fixation Suppression Examples



Good fixation suppression (peripheral)



Failure of fixation suppression (CNS)

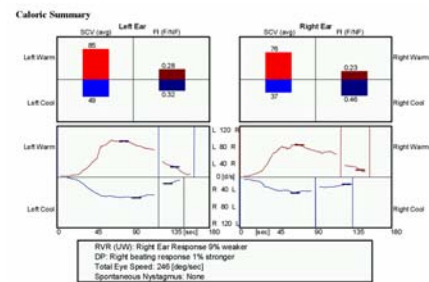
Failure of fixation suppression

- 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

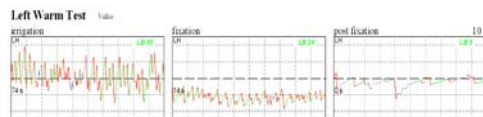
Hyperactive responses

- Occurs when responses exceed 50deg/sec for cools and 80deg/sec for warms (Jacobson: 99 deg/sec for cools, 146 deg/sec for warms, 221 deg/sec total)
- Can be due to abnormal anatomy (tm perf, mastoidectomy, etc.) or nervousness, overalertness, etc.
- In absence of this, likely due to CNS problem (cerebellar)

Hyperactive responses (central)



Hyperactive response (central)



Normal response



Caloric inversion and perversion

- Inversion: entire caloric response beats in the wrong direction
- Perversion: vertical or oblique nystagmus in response to caloric stimulation
- Both are evidence of brainstem disease
- CAUTION: most likely cause of caloric inversion is technical error – wrong temperature!!

Simultaneous Binaural Bithermal Stimulation (Brookler)



- Using a Y-cord, both ears are stimulated simultaneously with warm and then cold water.
- The responses are compared
- Rarely used in common clinical practice