Learner Outcomes

• After this course learners will be able to define the COWS acronym.
• After this course learners will be able to describe the proper procedure for performing caloric irrigations.
• After this course learners will be able to describe the difference between gain asymmetry and directional preponderance.
Introduction

- VNG/ENG is a series of tests designed to evaluate vestibular function
- Standard VNG/ENG test battery:
  - Saccade test
  - Gaze test
  - Tracking/OPK tests
  - Positional tests
    - Dix-Hallpike Maneuver
  - Bithermal caloric tests

Introduction

- Allows independent assessment of responses from right and left lateral semicircular canals
  - Detection of unilateral vestibular abnormalities
- Records eye movements as the temperature is changed in the patient’s ear canals
  - Water or air irrigation
- Equipment needed:
  - Computer
  - VNG/ENG system
  - Caloric irrigator (air or water)
  - Table or reclining chair

This course is presented in cooperation with
Introduction

• Caloric test protocol
  • Right ear, Cool irrigation (RC)
  • Left ear, Cool irrigation (LC)
  • Right ear, Warm irrigation (RW)
  • Left ear, Warm irrigation (LW)
• Record responses in vision denied condition
  • VNG: Eyes open, goggles closed
  • ENG: Eyes closed
• Wait at least 5 minutes between irrigations

Irrigators

• ICS Caloric Irrigator integrates with Chartr 200 VNG/ENG software
  • Select “cool” or “warm” caloric test in software to automatically set up selection on irrigator
• Water (NCI-480) or Air (NCA-200)
• Press the handset or foot pedal once to remotely start recording and stimulation
• Press the handset or foot pedal a second time to start a video recording (VNG) or center the tracing (ENG)
Air vs. Water Irrigation

- Air
  - Less messy for the patient and examiner
  - Takes longer to learn how to use effectively
- Water
  - Easier to get an effective irrigation
  - Messier for the patient and examiner

- NOTE: Both systems require routine inspection and addition of distilled water periodically

Tips for Irrigation

- Examine the ear canal before beginning VNG/ENG testing
  - Perforation? Wax? Ear canal shape?
- Examine the ear canal again once the patient is supine in caloric position
- Pull the pinna up and back to straighten the ear canal for air irrigation
  - Listen for change in turbulence when air stream is positioned optimally
- READ the manual for your irrigator—the temperatures and flow rates differ across manufacturers

This course is presented in cooperation with
Test Procedure

• Position the patient to be supine with head inclined at a 30° angle
  • This positioning places the lateral canal in the vertical plane

Test Procedure

• Describe procedure and expected response to the patient
• Close goggles
• Start collecting response and start irrigation
  • By pressing foot pedal or handset
• Start alerting the patient 20-30 seconds into irrigation
• Allow patient to fixate when you notice that the nystagmus intensity has started to decline
• Collect eye movements until response subsides

This course is presented in cooperation with
Sample Patient Instructions

- I will be putting warm and cool air (water) in each of your ears.
- The goggles will be closed but I need you to keep your eyes open and forward at all times.
- I will start talking to you midway through the test. Please respond to my questions.
- During this test, you may get dizzy. Try to relax and continue to answer my questions.
- When I’m done testing, I will turn on a light in the goggles. Stare at the light when you see it.

Alerting the Patient

- Ask the patient generic questions
  - Tell me a boy’s name that begins with A, B, C, D…
  - Name breeds of dogs, types of cars, names of states, state capitals..
- Engage the patient in a memory task relevant to him/her
  - Name all the states you’ve visited
  - Name all of your grandchildren/nieces and nephews/first cousins
  - Tell me about your last vacation
- Avoid tasks that are too easy or too difficult for the particular patient
  - Judge the difficulty of the task by the quality of the response
Response Waveform (Time 0:00 to 1:00)

Response Waveform (Time 1:00 to 2:00)

This course is presented in cooperation with
Response Waveform (Time 2:00 to 2:18)

- Fo = Fixation light off

Caloric Analysis

- Scroll to where analysis should begin, then click **Begin**
  - Allows analysis for 140 seconds after the “begin” point
- Delete stray data points and measure/insert data points
- Normal responses to caloric stimulation follow the COWS rule
COWS RULE!

Cold
Opposite
Warm
Same

Cold irrigations should produce beating in the opposite direction.

Warm irrigations should produce beating in the same direction.

Caloric Analysis: COWS Example

This course is presented in cooperation with
Caloric Analysis

Caloric Analysis: Waveform

This course is presented in cooperation with
Caloric Analysis

Eye position

Time (seconds)

SPV

Caloric Analysis: SPV graph

Slow Phase Velocity

Time line

Time (seconds)

This course is presented in cooperation with
Pods Display

Pods = SPV graph of the four irrigations

Butterfly Display

If the lines intersect in the box, responses are WNL

This course is presented in cooperation with
A Word about the Baseline…

- A guideline or starting point for comparison
- We assume the starting point for caloric responses is from 0 deg/sec

**HOWEVER...**
- If the patient has spontaneous nystagmus, the starting point has shifted in the direction and at the amplitude of the spontaneous nystagmus

**SO,**
- We have to shift the baseline to account for the patient’s actual starting point

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This course is presented in cooperation with
A Word about the Baseline…

Set Baseline

Shift Baseline Down

This course is presented in cooperation with
Caloric Test Interpretation

- Unilateral Weakness
- Bilateral Weakness
- Directional Preponderance and Gain Asymmetry
- Failure of fixation suppression
- Temperature Effect
- Hyperactive Response
- Tympanic membrane perforation

Unilateral Weakness

- The responses of one ear are weaker than the responses of the other ear
- Right Ear response is RC and RW
  Left Ear response is LC and LW

\[
UW\% = \frac{\text{Total Right Ear} - \text{Total Left Ear}}{\text{Total Right Ear} + \text{Total Left Ear}} \times 100
\]

- Criterion for abnormality
  - UW > 25%
  - Indicates peripheral lesion on the side of weakness

This course is presented in cooperation with
Unilateral Weakness

- The responses of both ears are weak
  - Total Right Ear < 12 deg/sec and Total Left Ear < 12 deg/sec
- Non-localizing: indicates either a central lesion or a peripheral lesion on each side
- Rule out technical errors
- Must recommend additional testing to confirm finding
  - Rotary chair, head shake, head thrust, etc.

Bilateral Weakness

- The responses of both ears are weak
  - Total Right Ear < 12 deg/sec and Total Left Ear < 12 deg/sec
- Non-localizing: indicates either a central lesion or a peripheral lesion on each side
- Rule out technical errors
- Must recommend additional testing to confirm finding
  - Rotary chair, head shake, head thrust, etc.

This course is presented in cooperation with
Bilateral Weakness

TotR < 12 deg/sec and TotL < 12 deg/sec

Bilateral Weakness?

Total responses greater than 12... should they be?

This course is presented in cooperation with
Directional Preponderance

- The responses beat more in one direction than the other
- Right-beating responses are RW and LC
  Left-beating responses are LW and RC

\[
\text{DP\%} = \frac{\text{Total Right-beating} - \text{Total Left-beating}}{\text{Total Right-beating} + \text{Total Left-beating}} \times 100
\]

- Criterion for abnormality
  - DP > 30%
  - Non-localizing: indicates either a central or peripheral lesion

- Usually caused by pre-existing spontaneous nystagmus
- Spontaneous nystagmus has the same direction and same amplitude in every position, with vision denied
- This patient has normal responses with vision and significant spontaneous nystagmus with vision denied

This course is presented in cooperation with
Directional Preponderance

This course is presented in cooperation with
Directional Preponderance and Unilateral Weakness

Directional Preponderance and Bilateral Weakness

Tracing courtesy of Otometrics customer.

This course is presented in cooperation with
Gain Asymmetry

- Directional Preponderance that cannot be explained by spontaneous nystagmus
- The baseline position must be set for this calculation
  *For GA, Peak caloric response = Peak – Baseline Shift

\[
\text{GA}\% = \frac{\text{Total Right-beating}\* - \text{Total Left-beating}\*}{\text{Total Right-beating} + \text{Total Left-beating}} \times 100
\]

- Criterion for abnormality
  - GA > 25%
  - Non-localizing: indicates either a central or peripheral lesion
Gain Asymmetry

\[ \text{DP} = \frac{(9+13) - (29+27)}{9+13+29+27} = 43\% \text{ Abnormal} \]

\[ \text{GA} = \frac{[(9+10)+(13+10)] - [(29-10)+(27-10)]}{9+13+29+27} \]
\[ = \frac{[19+23] - [19+17]}{78} \]
\[ = \frac{42-36}{78} = 8\% \text{ Within Normal Limits} \]

Directional Preponderance compared to Gain Asymmetry

Caloric Analysis

This course is presented in cooperation with
Failure of Fixation Suppression

- Turn fixation light on when response starts to decline
  - Peak of nystagmus usually occurs around 30 seconds after stimulation ends
- Visual fixation should decrease nystagmus by at least half
- Fixation Index > 50% is abnormal
  \[ FI = \frac{SPV_{\text{vision}}}{SPV_{\text{vision denied}}} \times 100 \]
- Indicates CNS lesion

This course is presented in cooperation with
Temperature Effect

• Temperature effect can be calculated with the following formula:

\[
TE\% = \frac{\text{Total Warm} - \text{Total Cool}}{\text{Total Warm} + \text{Total Cool}} \times 100
\]

• Total warm is RW and LW; Total cool is RC and LC
• If it happens once in awhile, don’t worry about it
  • If it happens all the time, get your equipment checked out

\[
TE\% = \frac{(8+8)-(44+27)}{8+8+44+27} = -0.63 \times 100
\]
Hyperactive Response

- Responses of both ears are much more robust than normal responses
- Criterion for abnormality
  - Total Right Ear > 140 deg/sec and Total Left Ear > 140 deg/sec
- Rule out technical error
  - Calibration
  - TM perforation
- Indicates CNS lesion

Perforated or Missing Eardrum

- Get clearance from an ENT to perform calorics
- Only use air calorics, and only cool air
  - Warm air will cool if canal damp, possibly causing caloric reversal
- Irrigate a shorter time
  - Response likely to occur within 5 seconds
  - Stop as soon as a response is apparent
  - If no response after 60 seconds, stop
- **Cannot quantify response**
  - Typical analysis is invalidated if stimulation for each ear is unequal
  - “Patient has response from perforated ear”
  - “Patient has no response from perforated ear”
Effects of Scaling

Look at peak values, not just patterns!

Tracings courtesy of Otometrics’ customers

Troubleshooting Caloric Tests

• No nystagmus present
  • Check the irrigator settings (temperature, air flow, timing)
  • Make sure the air is flowing directly toward the eardrum
  • Using an otoscope, look in the ear canals and check for any blockage such as wax (cerumen) that would interfere with the air flow
  • Was the alerting task too easy/difficult?
  • Did you remember to close the goggles?
• There is no decrease in the nystagmus when the fixation light is activated
  • Ask the patient if he/she sees a light (is it “on”?)
  • Check to be sure the patient is focusing on the light
  • Don’t wait too long after the nystagmus peaks to turn on the light

This course is presented in cooperation with
Considerations

- Alerting a person with hearing impairment
- Otitis Media/Mastoidectomy/Abnormal Anatomy
- Preventing Unhappy Patient Reactions
  - Light meal 2 hours in advance
  - Ventilation
  - Stop if patient indicates severe nausea
  - Stop if response is huge
- Medication Effects
  - Always report medications that patient is taking

Caloric Irrigation vs vHIT vs Rotary Chair

**Caloric Irrigation**
- Ear-specific
- Indirect measurement of function
- Detects in cases of peripheral vestibular loss in Lateral SCC
- Tests at Low Frequencies (~0.025 Hz)
- Stimulus can persist between irrigations especially if not performed properly
- Difficult to impossible for serial testing
- Unpleasant patient experience
- Test time: ~30 minutes

**vHIT**
- Ear-specific
- Obtain absolute measurement of canal function for individual canals
- Detects abnormalities in all 6 semicircular canals
- Can confirm unilateral vs bilateral lesions
- Tests at High Frequencies (4-5 Hz)
- Stimulus does not persist between tests; not taxing on the patient
- Serial testing is possible
- Does not tax patient
- Test time: ~12-15 minutes
- Can test patients with middle ear disorder
- Very small footprint
- Sensitive to common (unilateral) vestibular lesions

**Rotary Chair**
- Used to confirm true, bilateral lesions
- Can test patients with middle ear disorder
- Mid Frequency Stimulus (reliable testing from 0.1 to 1 Hz)
- Canals are tested simultaneously
- Lateral canals only are commonly tested**
- Allows for serial testing
- Requires large physical space
- Mostly insensitive to common vestibular lesions (most unilateral in origin)
- Can be unpleasant
- Test Time ~30 minutes

This course is presented in cooperation with
Caloric Irrigation vs vHIT

Comparing Head Impulse and Caloric Tests
Differences in the Operational Frequency Range

The caloric and vHIT results should be considered complementary because they assess different frequency ranges of the vestibular function.

vHIT vs Calorics

How can one be normal and the other abnormal?

Normal Duct: No local flow, hydrostatic pressure drive retained and Cupula bent.

Hydropic Expansion of Duct: Local convective flow dissipates hydrostatic pressure across Cupula.

What does the head impulse test versus caloric dissociation reveal about vestibular dysfunction in Meniere's disease?

Leigh A. McGarvie, Ian S. Curthoys, Hamish G. MacDougall, and G. Michael Halmagyi

This course is presented in cooperation with
Thank you!

Questions?
Keeley.moore@natus.com
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