

Caloric Testing

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Learning Objectives

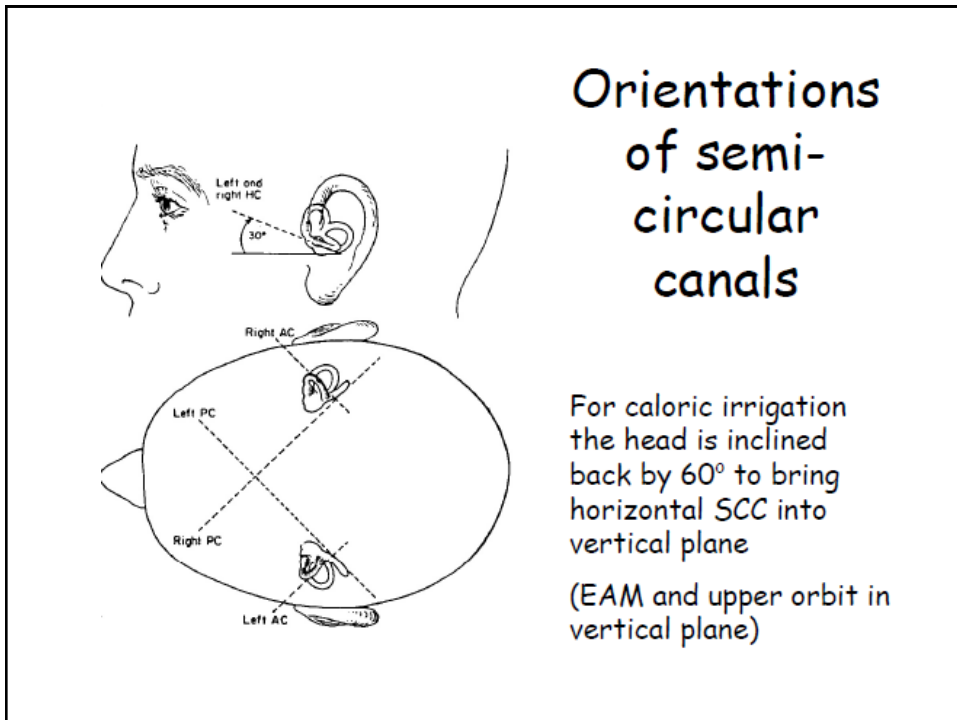
- The physiology of the caloric response
- The clinical setup and protocol for caloric testing
- How to calculate and record results from caloric testing
- The implications of the more common test results

Principal components of vestibular assessment

- Patient interview
- Audiometry & tympanometry
- Eye movement examination
 - Ocular-motor function
 - Positional and positioning tests
 - Caloric irrigation
- Other testing – postural control, VEMPs

Caloric Test

- Short term (2-3 mins) stimulation of horizontal SCC on one side
- Only test where vestibular system can be stimulated unilaterally
- Very useful for confirmation of asymmetric end-organ function
- Also sometimes used for confirmation of residual function (eg cochlear implantation)



Mechanism of caloric response

- Convection current set-up in endolymph stimulates horizontal SCC (warm irrigation produces utriculopetal flow, producing excitation).

Limitations of caloric test

- Test only examines functioning of one part of the vestibular system (horizontal semicircular canal)
- Stimulus equivalent to head rotation of about 0.003 deg/s (almost lowest limit of physiological range)
- Between subjects there is considerable variation in stimulus to SCC due to inter-subject differences in skull morphology, making production of normative data difficult
- Therefore results most useful when comparing L/R sides in one subject

Caloric irrigators

WATER



AIR

Air calorics

- May be used in situations where water calorics contraindicated (eg TM perforation)
- Air is a less efficient thermal stimulus so it is important to ensure it is delivered optimally
 - Flow rate is correct - this is highly determined by the diameter of the tube used to deliver it
 - Placement - is it essential that a view of the TM can be maintained during the irrigations
 - Requires more skill/practice on behalf of the tester

Clinical protocol I

- See BSA recommended procedure
- <https://www.thebsa.org.uk/wp-content/uploads/2014/04/Recommended-procedure-for-the-Caloric-test.pdf>

Clinical protocol II

- Patients often worry about caloric test and often feel disorientated by it, therefore it is usually performed at the end of test battery
- Normally referral should be recent and from medical staff with responsibility for patient
- Audiology staff must, however, be aware of various contraindications for testing

Clinical protocol III Contraindications

- Excessive wax
- Otitis externa
- Middle ear fluid / effusion
- High blood pressure
- History of cardiac problems
- Psychotic / neurotic disorders
- Epilepsy
- TM perforation (may be suitable for air calorics)

Clinical protocol IV

- Otoscopy and tympanometry to check for patency of ear canal, perforations etc
- Explain procedure to patient (stress that turning sensation for 2-3 mins is normal response)
- Skin preparation for electrode placement (ENG)
- Calibration for eye movement (horizontal) at 20°
- Recline patient on bench with head raised by 30°

Clinical protocol V - Irrigation

- Water: 44 or 30°C (± 0.4 °C)
250 \pm 10 cm³ in 30s
- Air: 50 or 24°C (± 0.4 °C)
8 \pm 0.4 litres in 60s
- First irrigation normally right warm
- Commence recording at the start of irrigation

Clinical protocol VI

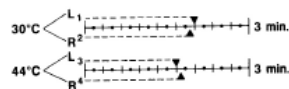
- At end of irrigation ensure patient is in dark, or using light-proof goggles (VNG)
- Instruct patient to keep eyes open and looking forward
- Use mental alerting exercises
- Shortly after maximum response turn lights on for 10s to measure fixation
- Record response for at least 1 min after irrigation
- At end of recording period switch on lights and check for "tympanic flush" using otoscope (warm irrigations only)

Clinical protocol VII

- Allow 5 mins between irrigations
- Re-calibrate between irrigations if using ENG
- Recommended irrigation order (BSA):
 - right warm
 - left warm
 - right cold
 - left cold

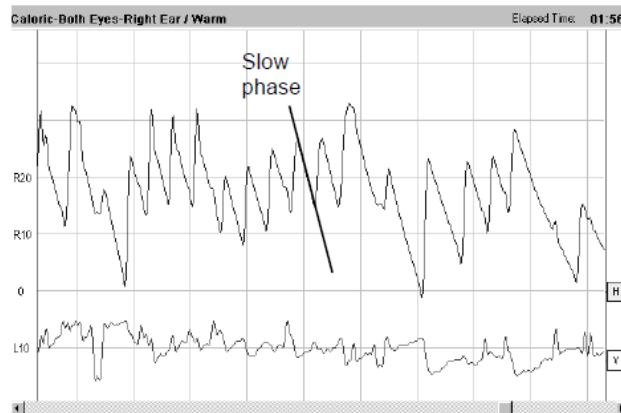
Measurement of caloric response

- Caloric stimulation for typical 30s generates response starting around the end of the irrigation, increasing to a max after about 1 min, then decreasing to zero after another 1-2 mins
- Can be quantified by measuring the duration of induced nystagmus with patient able to fixate (direct observation)



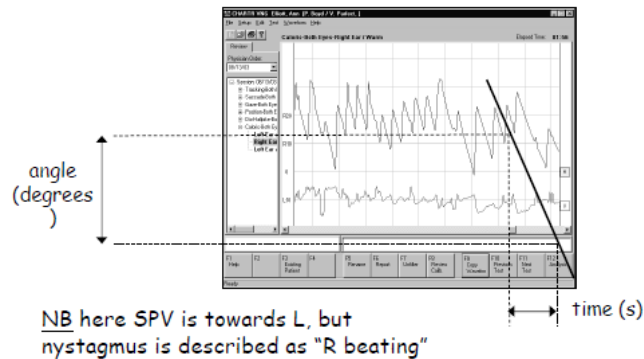
- When using ENG / VNG normal approach is to measure the maximum slow-phase velocity produced

Normal caloric response



Measurement of nystagmus

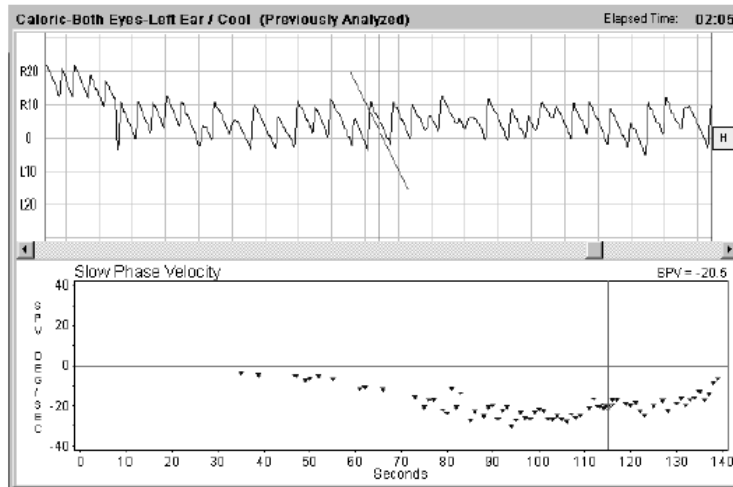
- Measure gradient of slow-phase velocity (i.e. degrees/second)



Manual calculation of caloric response (on chart recorder)

- Inspect recording visually to identify period with maximal SPV (c. 1 min after irrigation)
- Select 3-5 beats in this period and draw lines along slow phase and calculate SPV
- Calculate mean to produce final value

Computerized ENG analysis of response



"COWS"

- Warm irrigation on one side produces excitation, therefore SPV towards opposite side, and beats towards stimulated (same) side.
- Conversely, cool irrigation produces nystagmus beating towards opposite side
- So: "Cold Opposite, Warm Same side"

Analysis of Results – Canal Paresis

- Canal paresis (CP) expresses any relative weakness in the response of one side relative to the other

- Calculated as:

$$CP = \frac{(WR+CR) - (WL+CL)}{WR+WL+CR+CL} \times 100\%$$

(where WR = warm right, CR = cold right etc, in deg/sec)

- +ve value indicates left CP

Analysis of Results – Directional Preponderance

- A directional preponderance (DP) reflects responses which are stronger in one direction than the other

- Calculated as:

$$DP = \frac{(WR+CL) - (WL+CR)}{WR+WL+CR+CL} \times 100\%$$

- +ve value indicates DP to the R

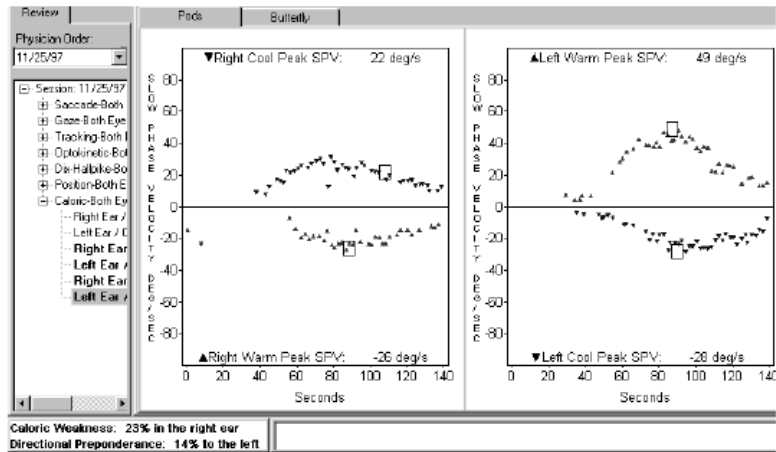
Analysis of results – Fixation Index

- Visual fixation Index quantifies suppression of nystagmus by fixation (often not possible in gaze test)
- Nystagmus magnitude (deg/s) with fixation (V_2) is compared to nystagmus just before (V_1) and after (V_3) fixation period
- $$VFI = \frac{2 V_2}{V_1 + V_3} \times 100\%$$

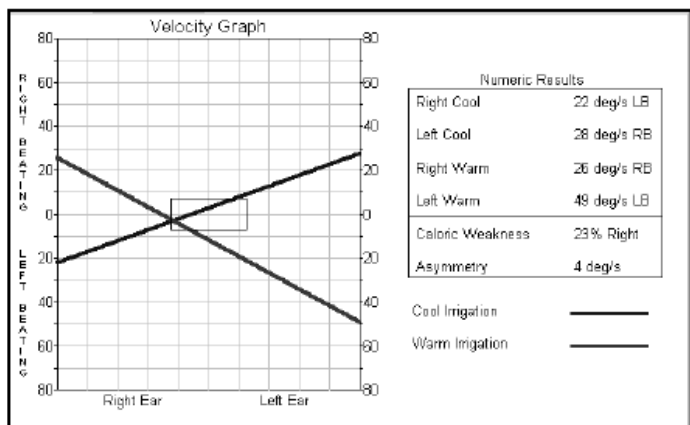
Absolute response values

- Absolute response magnitude very variable, ? due to anatomical variations
- Therefore main comparison is L/R
- Both sides may show hypofunction ($<10^\circ/s$)
- Some central pathology can produced hyperactive responses ($>50^\circ/s$)
- CP and DP calculations invalid if responses $<10^\circ/s$

“Pod” display of caloric results



“Butterfly” display of caloric results



Interpretation of Calorics I

- Ideally normative data produced for individual clinic set-up (normal limits then within 2 SDs of mean)
- In practice most centres use guidelines of 20% CP or DP as significant (Jacobsen et al. 1993)

Interpretation of Calorics II

Unilateral weakness (CP) > 20%

CP relates to peripheral reduced response (end organ (SCC) or neural pathway up to vestibular nucleus)

- ➔ end organ (Meniere's, labyrinthitis, others) - most common
- ➔ neural (acoustic neuroma and CPA, vestibular neuritis, MS, others)

Interpretation of Calorics III

Bilateral weakness ($<5-10^\circ/s$)

- End organ: ototoxicity, certain systemic infections
- Central: hypertension, brainstem degenerative conditions, ocular motor tract disease, many others
- Calculations of CP and DP much less reliable if best response is $< 10^\circ/s$

Interpretation of Calorics IV

Fixation Index FI

- Range of workers have suggested FI normally below 50%
- Mechanism of fixation shares many features with pursuit function
- Failure of fixation suppression (FFS) tends to be produced by disrupted connections between vestibular nuclei and cerebellar flocculus - if bilateral suggests diffuse brainstem / cerebellar disorder
- More significant in presence of e.g. poor pursuit

Screening caloric protocol

- Many clinics employ "screening protocol"
- Carry out warm irrigations on both sides
- Stop test if responses within 10% of each other, as long as no significant spontaneous nystagmus present ($> 3^\circ/s$)
- (Without above it is possible to have sig. CP if there is also a DP)