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Bedside simultaneous cold caloric test

PRODUCT INSIGHTS

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This document presents an in-depth analysis of the bedside simultaneous cold caloric test, which constitutes a simple qualitative tool in acute vestibular syndrome. Central to the discussion is the modular Inventis Nystalyze system, which integrates advanced visualization and recording functionalities aimed at achieving accurate eye movement analysis. The SYNAPSYS VNG module provides a wide range of vestibular and oculomotor tests, ensuring a comprehensive and reliable diagnostic approach. The system's intuitive interface supports audio and video recording, allowing comprehensive and detailed clinical assessments. Furthermore, it uses advanced infrared cameras to instantly capture eye movements without requiring adjustments, even under challenging conditions such as with dark-colored eyes.

Since Bárány first described caloric stimulation in the early twentieth century, caloric testing has represented one of the cornerstones of vestibular assessment. By inducing thermal gradients within the horizontal semicircular canal, the test allows selective stimulation of each labyrinth, thereby enabling independent evaluation of unilateral vestibular function.

The traditional Binaural Bithermal Caloric Stimulation (BBCS) uses warm and cold irrigations to generate endolymphatic convection currents that modulate vestibular afferent activity and induce nystagmus. The elicited responses are then quantitatively analyzed using the Jongkees' formula to calculate vestibular asymmetry, such as Canal Paresis (CP) or Unilateral Weakness (UW). Despite its diagnostic value, the test requires dedicated equipment, is time-consuming, and often causes significant patient discomfort. For these reasons, caloric stimulation has long been neglected in the bedside evaluation of acute vertigo.

In recent years, simplified qualitative cold caloric bedside tests have been reintroduced as rapid alternatives to standard caloric testing. Rather than quantitatively measuring vestibular responses, these methods aim to detect clinically relevant vestibular asymmetries and support the differential diagnosis between peripheral and central vestibular disorders. Among the bedside techniques, simultaneous bilateral cold caloric stimulation represents a particularly interesting application in patients presenting with acute vertigo.

PHYSIOLOGICAL BASIS OF CALORIC STIMULATION

The caloric test is based on thermal stimulation of the lateral semicircular canal, which changes endolymph density and generates convection currents that deflect the cupula and modulate vestibular afferent firing.

Cold irrigation produces inhibitory ampullofugal flow, reducing neural discharge on the stimulated side and inducing contralateral-beating nystagmus. Although Bárány's convection theory remains the accepted physiological basis of caloric testing, additional mechanisms have been proposed, including direct thermal effects on vestibular sensory receptors, particularly during intense cold stimulation.

Caloric stimulation evaluates vestibular function at extremely low frequencies (approximately 0.003 Hz), far below physiological head movements and complementary to high-frequency tests such as the video Head Impulse Test (vHIT).

WHY A "BEDSIDE" CALORIC TEST?

The bedside evaluation of acute vestibular syndrome (AVS) increasingly relies on rapid qualitative protocols such as HINTS, HINTS Plus, and STANDING, none of which include caloric stimulation. However, a simple bedside caloric test can still reveal unilateral vestibular asymmetry in both acute and chronic peripheral vestibular disorders and may provide valuable diagnostic information when differentiating acute unilateral peripheral vestibulopathy from central vestibular syndromes in the acute stage.

The aim of bedside cold caloric stimulation is not to replace conventional caloric testing, but to provide a rapid qualitative assessment of vestibular asymmetry using minimal equipment. These tests are inexpensive, quick to perform, and particularly useful in emergency, bedside, and outpatient settings.

UNILATERAL MONOTHERMAL VS SIMULTANEOUS BILATERAL COLD STIMULATION TEST

The simplest bedside caloric tests currently available are:

a) unilateral monothermal cold stimulation

b) simultaneous bilateral cold stimulation

The former test consists of unilateral cold irrigation performed separately in each ear, thereby allowing a qualitative comparison between the responses generated by the two labyrinths, similarly to conventional caloric testing. Accordingly, bedside unilateral monothermal cold stimulation acts as a simplified qualitative indicator of canal paresis.

The simultaneous bilateral cold test is based on a different physiological rationale. Rather than comparing the responses elicited by each labyrinth separately, simultaneous bilateral cooling transiently alters the tonic vestibular balance between the two vestibular systems. This stimulation may unmask vestibular asymmetry in chronic vestibular disorders and, in acute unilateral vestibular imbalance, may transiently reduce or abolish spontaneous nystagmus by temporarily equalizing vestibular tone. This concept represents the physiological basis of the bedside "ice test" proposed for differentiating peripheral from central causes of acute vertigo.

SIMULTANEOUS BILATERAL COLD STIMULATION: TECHNIQUE

The presence of a clean and patent external auditory canal and an intact tympanic membrane is a prerequisite for performing the test. The simultaneous bilateral cold caloric test can be performed using extremely simple equipment:

- Frenzel googles (or infrared video goggles);
- Two syringes;
- Ice water (approximately 3–5°C);
- Examination couch.

The patient lies supine with the head elevated approximately 30°, thus bringing the lateral semicircular canal into a vertical plane and maximize the responses. After observing (and, if possible, recording) baseline spontaneous nystagmus, both external auditory canals are simultaneously irrigated with approximately 10 mL of ice water. The examiner then continuously observes the modification of spontaneous nystagmus under visual deprivation.

Unlike standard caloric testing, precise quantitative measurements are unnecessary and the test is interpreted qualitatively according to the behavior of nystagmus during stimulation.

CLINICAL INTERPRETATION

Patients without spontaneous nystagmus

Under normal vestibular conditions, simultaneous bilateral cold inhibition does not produce a clinically evident response, as vestibular symmetry remains substantially preserved.

However, simultaneous bilateral cold stimulation may unmask a latent vestibular asymmetry. In such cases, the transient imbalance between the two vestibular systems can induce horizontal nystagmus, suggesting an underlying unilateral vestibular hypofunction. Regardless of the degree of residual vestibular function, symmetrical cold stimulation exerts a greater inhibitory effect on the healthy ear, thereby generating a nystagmus beating toward the affected side (Figure 1).

Patients with spontaneous nystagmus

The greatest clinical utility of the simultaneous bilateral cold test emerges in patients presenting with spontaneous horizontal unidirectional nystagmus (Figure 2).

Peripheral vestibular lesions

In acute unilateral peripheral vestibulopathy, spontaneous nystagmus reflects an asymmetry of tonic vestibular activity between the two labyrinths. Simultaneous bilateral cold stimulation transiently reduces vestibular activity on both sides, partially equalizing vestibular tone and exerting its inhibitory effect predominantly on the healthy labyrinth, which remains more responsive. Consequently, depending on the residual function of the affected ear, spontaneous nystagmus may decrease markedly or transiently disappear. This finding strongly supports a peripheral vestibular origin. In the subacute phase, spontaneous nystagmus may even reverse its direction. This phenomenon is generally interpreted as a sign of ongoing central compensation of a unilateral peripheral vestibulopathy.

Central vestibular lesions

In central vestibular disorders, spontaneous nystagmus is not primarily generated by peripheral tonic vestibular asymmetry. Consequently, bilateral cold irrigation usually fails to modify the nystagmus significantly, which tends to persist substantially unchanged during stimulation. Persistence of spontaneous nystagmus during the test should therefore raise suspicion of central pathology and prompt further neurological evaluation.

The simplicity, low cost, and rapid execution of simultaneous bilateral cold stimulation make it an attractive complementary bedside procedure in acute vestibular syndrome, recently showing strong concordance with the HINTS protocol. However, although particularly useful in emergency settings, it cannot replace standard bithermal caloric testing. Moreover, clinical reality is not always binary: partial reduction of nystagmus, transient modifications, or ambiguous responses may occasionally occur. Therefore, this test should never be interpreted in isolation, but always integrated into the overall bedside neuro-otological examination.

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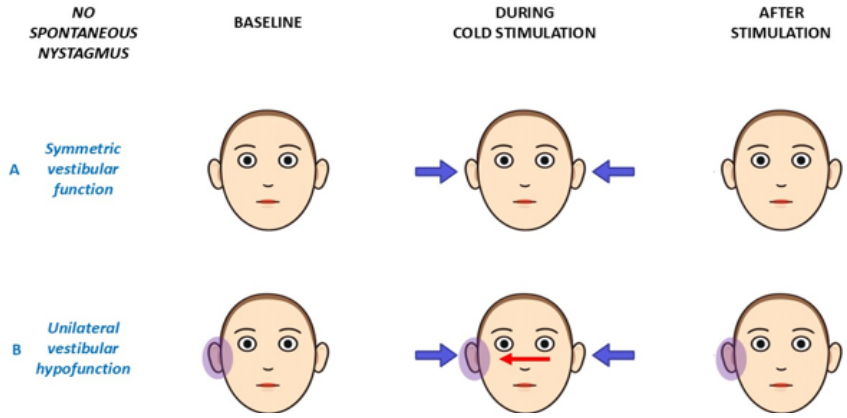

Figure 1. Schematic representation of simultaneous bilateral cold caloric stimulation. In healthy subjects, simultaneous bilateral cold stimulation does not induce nystagmus (A). In compensated or chronic unilateral vestibular disorders without spontaneous nystagmus, the test may elicit nystagmus directed toward the healthy side (B).

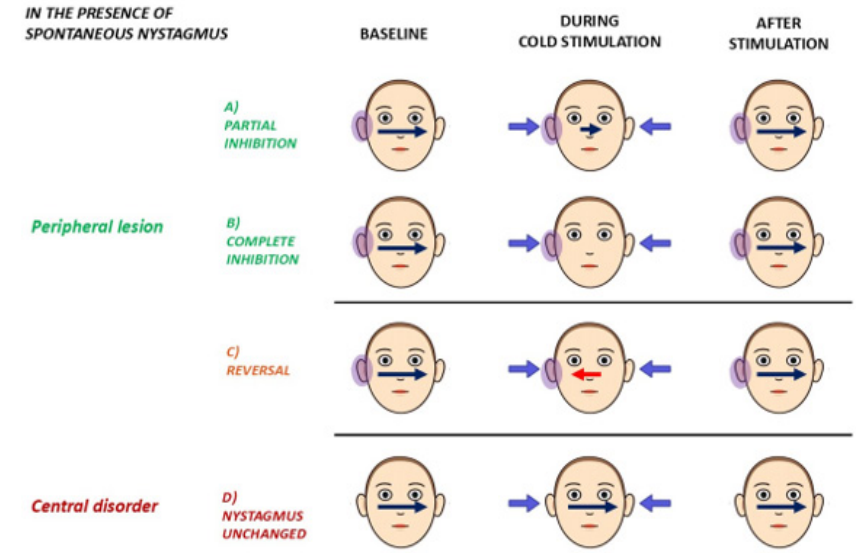

Figure 2. Schematic representation of simultaneous bilateral cold caloric stimulation in the presence of spontaneous left-beating horizontal nystagmus. In acute right unilateral vestibulopathy, simultaneous bilateral cold stimulation may markedly reduce (A), transiently abolish (B) the spontaneous nystagmus depending on the residual function of the affected labyrinth. In the subacute phase, spontaneous nystagmus may even reverse its direction (C). By contrast, in central vestibular disorders, spontaneous nystagmus generally persists substantially unchanged after stimulation (D).

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