Dr. Rahul Bagla ENT Textbook
Ultimate Guide – Makes You Best

Vestibular Function tests.

Vestibular Function Tests. The central nervous system receives information from the vestibular system (inner ear), visual (eye) and proprioceptive sensory inputs (body position sense). The human brain uses all of this information and regulates the equilibrium and body posture by coordinating the eyes, head, and body during movements. The equilibrium and body posture system is like a two-sided push and pull system, which is equal on both sides during the neutral position. As a result, any disruption in these inputs—whether from trauma, disease, or degeneration—can lead to symptoms like **dizziness or vertigo.**

Vestibular function tests are broadly divided into two groups:

1. **Clinical tests (Bedside Examination):** These are simple, quick tests performed in the clinic without specialised equipment.
2. **Laboratory Tests (Instrumental Evaluation):** These quantitative tests use specialised equipment to objectively measure and analyse vestibular system responses, offering precise diagnostic information.

CLINICAL TESTS OF VESTIBULAR FUNCTION

1. Spontaneous Nystagmus

Nystagmus is an important tell-tale sign in the evaluation of vestibular function. Nystagmus is defined as a rhythmical, involuntary, oscillatory movement of the eyes without a cognitive, visual or vestibular stimulus. The direction of nystagmus may be horizontal, vertical or rotatory. Generally, horizontal canal lesions produce horizontal nystagmus, superior (anterior) canal lesions cause rotatory nystagmus, and posterior canal lesions lead to vertical nystagmus.

Mechanism of Vestibular Nystagmus: Vestibular nystagmus comprises two distinct components or phases:

Vestibular nystagmus has a **slow and a fast component**. The ‘slow phase’ is due to the abnormality in the vestibular system, while the ‘fast phase’ is due to the corrective central mechanism that brings the eyes back to the primary position. However, while only the slow phase plays a part in image stabilisation, it is the fast phase that is actually detected, and hence by convention, the direction of the nystagmus is attributed to that of its fast phase.

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For example, in acute right-sided vestibular failure, the slow phase is towards the right (the weak side), but the fast phase will be to the left, thus causing left-beating nystagmus. However, crucial for interpretation, the patient’s past-pointing and falling will still occur towards the slow component, indicating the side of vestibular weakness (i.e., towards the right in this example).

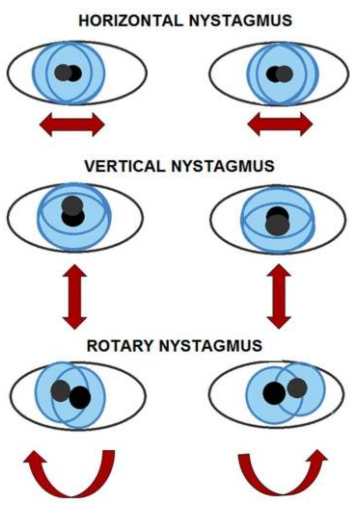

Diagram: Types of Nystagmus

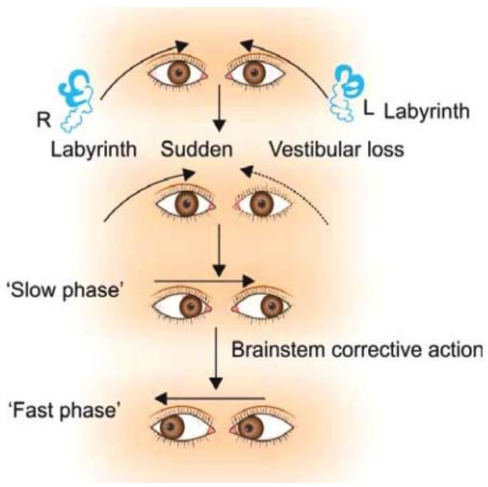

Diagram: Showing mechanism of nystagmus

Degrees of nystagmus. Intensity of nystagmus is indicated by its degree.

1st degree	It is a weak nystagmus and is visible only when the patient looks in the direction of the fast phase
2nd degree	It is stronger than 1st degree and is visible even when the patient looks straight ahead.
3rd degree	It is stronger than 2nd degree and is visible even when the patient looks in the opposite direction of the fast phase

**These degrees of nystagmus are according to Alexander’s law and may not hold true in case of nystagmus of central origin.*

How to look for nystagmus.

Patient is asked to sit on the examination chair or may lie supine on the bed. The clinician keeps his finger about 30 cm centrally in front of the patient's eyes. The clinician moves his finger in all four directions (up, down, left, right) and asks the patient to follow his finger. The finger should not move beyond 30 degrees from the initial central position, as it will induce physiological "gaze-evoked nystagmus," which is not indicative of pathology. The presence of spontaneous nystagmus strongly suggests an organic lesion. Differentiating its origin (peripheral vs. central) is paramount for diagnosis and management.

Table: Differentiating Peripheral vs. Central Nystagmus

Feature	Peripheral Nystagmus	Central Nystagmus
Lesion Site	Labyrinth or Vestibulocochlear nerve (VIIIth CN)	Central neural pathways (vestibular nuclei, brainstem, cerebellum)
Fatiguability	Fatiguable (decreases with repeated testing)	Non-fatiguable (persists with repeated testing)
Reproducibility	Reproducible (can be elicited again)	Non-reproducible (variable or inconsistent)
Optic Fixation	Suppressed by optic fixation (looking at a fixed point); Enhanced in darkness or with Frenzel glasses (+20 dioptre, abolish optic fixation).	Not suppressed by optic fixation.
Direction	Unidirectional (fast phase always beats in one direction); Typically horizontal or horizontal-rotatory.	Often multidirectional (vertical, purely torsional, or changing direction with gaze).
Associated Symptoms	Severe vertigo, nausea, vomiting, hearing loss, tinnitus.	Milder vertigo; often associated with other neurological signs (e.g., ataxia, diplopia, dysarthria).
Specific Patterns	- Irritative lesions (e.g., serous labyrinthitis) cause nystagmus towards the lesion side. - Paretic lesions (e.g., purulent labyrinthitis, VIIIth nerve section) cause nystagmus towards the healthy side.	- Torsional nystagmus (lesion of the brainstem/vestibular nuclei); - Downbeat nystagmus (craniocervical junction, cerebellar degeneration); - Upbeat nystagmus (pons/medulla junction); - Pendular nystagmus (congenital, MS); Disconjugate nystagmus.

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2. Corneal reflex (Blink reflex).

Normally there is an involuntary bilateral blinking (closure) of the eyelids elicited by touching the cornea.

The reflex is mediated by:

- **Afferent pathway:** via the ophthalmic branch (V1) of the trigeminal nerve (CN V) sensing the stimulus on the cornea only.
- **Efferent pathway:** via the facial nerve (CN VII) initiating the motor response (efferent fiber) to oculi orbicularis
- **Center:** (nucleus) is located in the pons of the brainstem.

Method. A small wisp of cotton wool is touched on the cornea on the lateral aspect without touching eyelashes and conjunctiva while the patient is asked to look forward and straight. Look for blinking and tearing in both the eyes.

Interpretations. The corneal reflex may be slowed or absent in disorders that affect the trigeminal nerve, facial nerve, or brain stem nuclei, such as posterior fossa and cerebellopontine angle tumours, such as acoustic neuroma.

3. Fistula test

The **fistula test** identifies an abnormal communication (fistula) between the middle and inner ear. Normally, pressure changes in the external ear canal do not transmit to the labyrinth.

Principle. If a fistula exists, pressure changes applied to the external auditory canal transmit to the labyrinth, stimulating it and inducing nystagmus and vertigo.

Method. The test is performed by applying intermittent pressure on the tragus or by using Siegel's speculum, in order to produce pressure changes in the ear canal. If there is existence of an abnormal communication between the middle and inner ear, the pressure changes are transmitted to the labyrinth. Stimulation of the labyrinth results in nystagmus and vertigo. The direction of nystagmus is observed. The direction of nystagmus will be to the opposite side in positive fistula test.

Interpretations.

(i) Negative test (i.e. No fistula).

1. Normally the pressure changes in the external auditory canal cannot be transmitted to the labyrinth
2. When the labyrinth is dead (non-functioning), no nystagmus will be elicited even with a fistula.

(ii) Positive test (i.e. fistula present). Common causes include:

1. Erosion of the horizontal (lateral) semi-circular canal (e.g., due to cholesteatoma) or a surgically created window in the horizontal semi-circular canal (e.g., following fenestration operation).
2. Abnormal opening in the oval window (post-stapedectomy fistula) or the round window (rupture of round window membrane).

In another way, a Positive fistula also implies that the labyrinth is still functioning.

(iii) False negative fistula (i.e. negative fistula test but fistula is present) test is seen when fistula is there but is covered by cholesteatoma or granulation tissue and does not allow pressure changes to be transmitted to the labyrinth.

(iv) False positive fistula test (i.e. positive fistula test without the presence of a fistula) is seen in

1. **Congenital syphilis.** Annular ligament is lax and mobile, causing the stapes footplate to be hyper-mobile.
2. 25% cases of **Meniere's disease.** It is due to the fibrous bands connecting the utricular macula to the stapes footplate.

This false positive phenomenon is also known as **Hennebert's sign**.

Tullio's Phenomenon: This refers to giddiness or vertigo produced by loud noise rather than pressure. It is typically associated with labyrinthine fistula and can occur after fenestration surgery.

4. Romberg's Test and Sharpened Romberg Test

These tests assess static balance by challenging proprioceptive and vestibular inputs, especially when visual input is removed.

Method:

- The patient removes shoes and stands with feet together, arms by their side. The examiner must stand close by for safety.
- First, the patient stands quietly with **eyes open**. This allows visual compensation.
- Then, the patient stands with **eyes closed**. With visual input lost, the vestibular and proprioceptive systems are put to a greater test.
- If the patient can perform this without significant sway, proceed to the **Sharpened Romberg Test:** The patient stands in a heel-to-toe position (tandem stance), with one foot directly in front of the other. Arms are folded across the chest.

Interpretations:

- **Peripheral Vestibular Lesions:** The patient sways and tends to fall towards the side of the lesion, especially with eyes closed. Inability to perform the sharpened Romberg test strongly indicates vestibular impairment.
- **Central Vestibular Disorders:** Patients often exhibit swaying or instability even with their eyes open, indicating a more profound and often multi-sensory balance deficit.
- A "wooden soldier" fall (straight backward without correction) is frequently non-organic or psychogenic.

5. Gait Test

Method. The patient is asked to walk along a straight line in normal speed for 5 metres to a fixed point, first with eyes open and then closed. The examiner walks alongside to prevent the person from falling over and hurting himself.

Interpretation. In the case of recent vestibular hypofunction, with eyes closed, the patient tends to deviate to the affected side.

6. Tandem Gait Test

Method. The patient is asked to take 10 heel-to-toe steps in a straight line in normal speed with arms folded on the chest, first with eyes open and then closed. The examiner walks alongside the patient for safety reasons and looks out for deviation towards the side of the lesion.

With the eyes open, this primarily tests cerebellar function as the visual components compensate for chronic vestibular and proprioceptive deficits. However, tandem walking with closed eyes is a good test of vestibular function, assuming that the visual and proprioceptive functions are intact.

Interpretation.

- **Peripheral Vertigo:** Patients may exhibit some impaired balance but can usually still walk.
- **Central Vertigo:** Patients with central lesions often cannot walk or even stand without falling, highlighting a more severe imbalance.

7. Unterberger Stepping Test (Fukuda Stepping Test)

This test identifies the tendency of patients with vestibular imbalance to turn while walking, indicating the side of the lesion.

Method. The patient is asked to march on the spot 50 times with the arms extended and eyes closed. Repetition of the test is essential for consistency.

Interpretation.

- A positive test is indicated by rotational movement of the patient towards the side of the lesion by more than 30-45 degrees or displacing forward/backwards by more than 50cm.
- Patients having unilateral paralytic labyrinthitis will rotate to the side of the lesion.

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- Patients having active irritative lesions will not be able to perform the test

8. Past-pointing Test

Past pointing means the movement of a pointing finger that goes beyond the intended mark. This is called overshooting and is a manifestation of dysmetria (inability to control the range of motion).

Method. The patient stands in front of the clinician. The clinician extends his arms and points both of his index fingers approximately 15cm (6 inches) apart. The patient is asked to lift both arms over the head and then bring the arms down to touch his index fingers to the clinician's index fingers.

Interpretation.

- **Normally,** the patient can perform the test without difficulty.
- **Vestibular Disease:** Patients have difficulty lining up with the clinician's fingers and will consistently "past-point" (overshoot) towards the side of the vestibular lesion.
- **Clinical Correlation:** Importantly, the direction of **past-pointing, falling during Romberg, the slow component of nystagmus, and the turn in the Unterberger test** all point towards the **side of the vestibular lesion**.

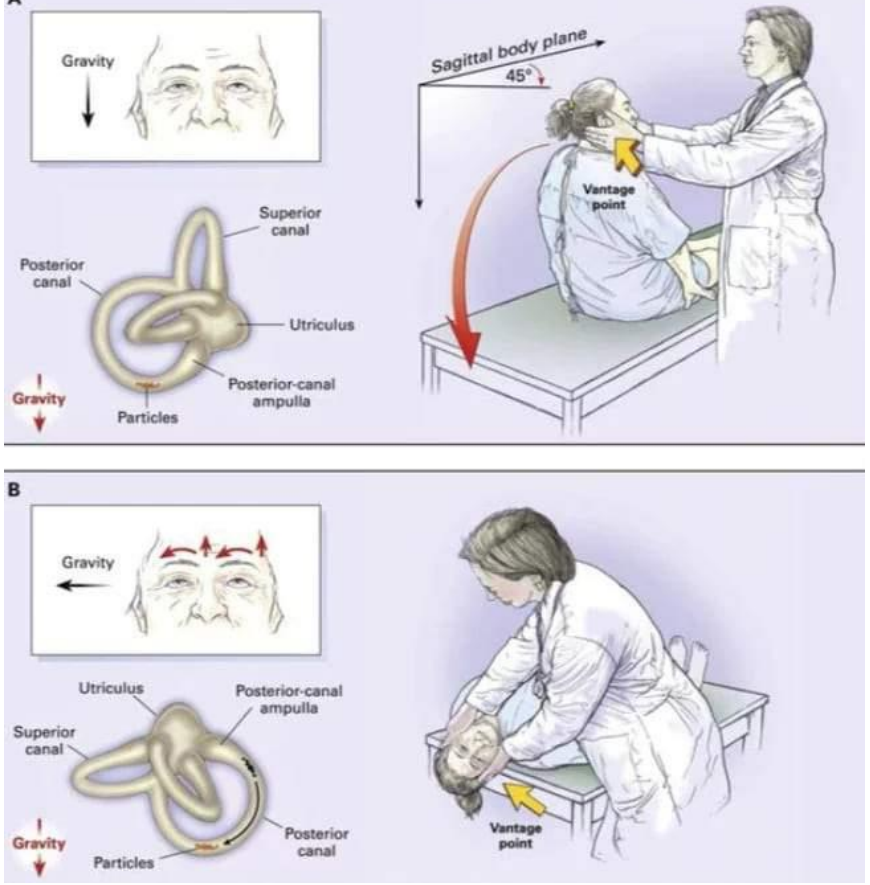
9. Dix-Hallipke Manoeuvre (Positional Test)

This manoeuvre is critical for diagnosing **Benign Paroxysmal Positional Vertigo (BPPV)** and differentiating peripheral from central positional vertigo. This test should be conducted when the patient complains of vertigo provoked by specific head–neck movements or in certain head positions. Typical symptoms are brief intense spells of rotatory vertigo which usually precipitates during an abrupt change in head position, getting out of bed, turning over in bed, bending over, looking up or when extending or flexing the neck.

Dix-Hallpike Manoeuvre test is done to elicit vertigo, and the patient should be informed and warned beforehand. Careful examination of the patient's eyes is essential during the test. It also helps to differentiate a peripheral from a central lesion.

Table: Differentiating Peripheral vs. Central Positional Nystagmus (Dix-Hallpike Findings).
Positional nystagmus in peripheral and central lesions of the vestibular system. Positional nystagmus is elicited by the Hallpike manoeuvre.

Feature	Peripheral	Central
Latency	2–20 s	No latency (immediate onset)
Duration	Less than 1 min	More than 1 min
Direction of nystagmus	Direction fixed, towards the under-most ear	Direction changing
Fatiguability	Fatiguable (decreases or disappears with repeated testing in the same position)	Non-fatiguable (persists with repeated testing)
Accompanying symptoms	Severe vertigo	None or slight
Intensity of vertigo	Severe	Mild
Reproducibility	Non-reproducible	Reproducible
Incidence	Common	Rare



Method.

- The patient sits on the examination couch with legs extended.
- The examiner holds the patient's head, turns it to approximately 45° horizontally to the right.
- During the complete procedure patient is required to keep his eyes open and should look at one point on the examiner's face (i.e. the nose or bridge of the nose).
- Then the patient is guided into a supine position so that his head hangs over the edge of the couch, approximately 30° below the horizontal.
- Keep the patient in the head-down position for a few (20-30) seconds
- Observe the patient's eyes for nystagmus, and ask about the onset and intensity of vertigo.
- Gently help the patient return to the sitting position. Allow them to recover before repeating the test.

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- Repeat the entire procedure with the head turned to the left.
- If both sides are negative, perform the test with the head in a straight-hanging position (testing the superior semicircular canals, though BPPV commonly affects the posterior canal).

Four parameters of nystagmus are observed to differentiate peripheral (typically BPPV) from central positional nystagmus:

1. **Latency:** The delay between assuming the provocative position and the onset of nystagmus/vertigo.
2. **Duration:** How long does the nystagmus and vertigo last?
3. **Direction:** The characteristic beating pattern of the nystagmus.
4. **Fatiguability:** Whether the nystagmus and vertigo diminish with repeated testing in the same position.

Laboratory Tests for Vestibular Functions.

These tests help to confirm the diagnosis and allow objective and quantitative evaluation of peripheral vestibular function and the vestibular-ocular reflex.

1. Caloric Test

The **caloric test** checks how well **each ear's balance system (labyrinth)** is working by making changes in temperature in the external auditory canal through hot or cold water. The **caloric test** induces **nystagmus** (involuntary eye movements). The advantage of the test is that it evaluates **each ear separately,** unlike rotational tests (which test both ears together). If the induced vertigo is similar to one patient's experience, it proves the labyrinthine origin of vertigo. However, some patients may not tolerate the induced vertigo and discomfort.

Principle: Irrigation with water at 30 or 44°C (37 ± 7°C) for 40 seconds is the standard procedure. A 5-minute interval between consecutive irrigations allows the temporal bone temperature to normalize.

- **Hot Water (44°C):** Heats the endolymph in the horizontal semicircular canal. The heated endolymph becomes less dense, rises, and **creates a flow towards the ampulla**, deflecting the cupula. This simulates a head rotation to the irrigated side (same side), producing nystagmus with the **fast phase to the irrigated side**.
- **Cold Water (30°C):** Cools the endolymph, making it denser. It sinks, **creating a flow away from the ampulla.** This simulates a head rotation to the opposite side, producing nystagmus with the **fast phase to the opposite side**.

Mnemonic: COWS (Cold Opposite, Warm Same)

- **C**old water/air induces nystagmus with a fast phase to the **O**pposite side.
- **W**arm water/air induces nystagmus with a fast phase to the **S**ame side.

Methods. The caloric test is typically performed using one of three primary methods.

- Modified Kobrak Test
- Fitzgerald-Hallpike Bi-thermal Caloric Test
- Cold-air Caloric (Dundas Grant's) Test.

A. Modified Kobrak Test (Quick Office Procedure)

The Modified Kobrak Method is a quick in-office procedure that precisely controls temperature to stimulate the ear, typically using a small volume of water or air for a localised effect.

Method.

- The patient sits with their head tilted 60 degrees backwards. This position places the horizontal semicircular canal in a vertical orientation.
- The ear is irrigated with **ice water** for 60 seconds, starting with a small volume and gradually increasing it if there's no response:
- Begin with 5 mL of ice water.
- If no response, increase to 10 mL, then 20 mL, and finally 40 mL.

Interpretation.

- Normal Response: A normal response is the presence of nystagmus (involuntary eye movements) beating toward the opposite ear when 5 mL of ice water is used.
- Hypoactive Labyrinth: If nystagmus is only observed with increased volumes of water (between 5 mL and 40 mL), it suggests the labyrinth (inner ear balance organ) is hypoactive (underactive).
- Dead Labyrinth: If there is no nystagmus even after irrigating with 40 mL of ice water, it indicates a dead labyrinth.

B. Fitzgerald-Hallpike Bi-thermal Caloric Test:

Method.

- The patient reclines on the couch at 30 degrees (so that horizontal SCC comes in a vertical position).
- Examine both ears for wax or tympanic membrane (TM) perforations. (If TM is perforated, use air instead of water).
- Alternatively, irrigate each ear with water at 30°C and 44°C for 40 seconds.
- Observe and record the nystagmus (duration, amplitude, frequency) using electronystagmography (ENG) or videonystagmography

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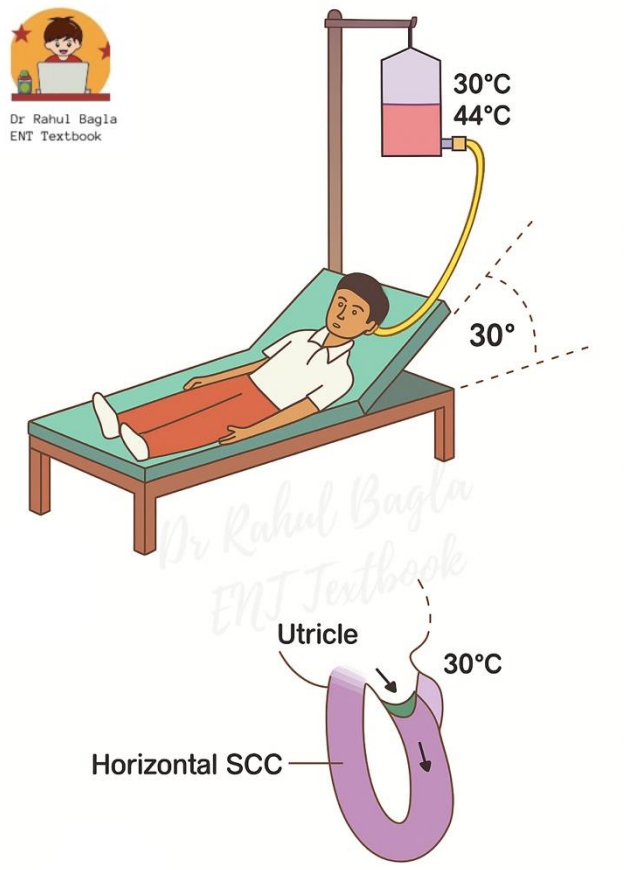
(VNG). The total time is recorded from the start of irrigation to the end of nystagmus and charted on a ***calorigram.***

- If no nystagmus is elicited, repeat the test with 20°C water for 4 minutes before concluding a "dead labyrinth."



Fitzgerald–Hallpike test.

Interpretations (Most Common Findings): Both canal paresis and directional preponderance must be greater than 15-20% to be clinically significant.

- **Canal Paresis (CP): One ear is weaker**
- **Definition:** The response (measured as nystagmus duration) to both cold & warm is much less on one side than on the opposite side. It reflects the weak function of the ipsilateral labyrinth, vestibular nerve, or vestibular nuclei.
- **Calculation:**

$$\% \text{ CP} = \frac{[(RC + RW) - (LC + LW)]}{(RC + RW + LC + LW)} \times 100$$

where R/L = Right/Left ear, C/W = Cold/Warm irrigation response).

- Commonly seen in Meniere's disease, vestibular schwannoma, post-labyrinthectomy, or vestibular nerve section.
- **Directional Preponderance (DP): Nystagmus is stronger in one direction**
- **Definition:** The total duration of nystagmus beating in one direction is significantly greater than the nystagmus beating in the opposite direction.
- **Calculation:**

$$\% \text{ DP} = \frac{[(RW + LC) - (LW + RC)]}{(RC + RW + LC + LW)} \times 100$$

(where R/L = Right/Left ear, C/W = Cold/Warm irrigation response for respective beating direction).

- **Clinical Significance:** This can be seen in both central and peripheral lesions. DP towards the side of a central lesion, and away from the side of a peripheral lesion (due to an irritative lesion). Further investigations (e.g., BERA, CT/MRI) are required for differentiation and localisation. If nystagmus is 25–30% or more on one side, it indicates directional preponderance.
- **Specific Patterns:**
- CP + Contralateral DP**:** Commonly seen in **Meniere's disease**.
- CP + Ipsilateral DP**:** Often seen in **acoustic neuroma**.
- No nystagmus at all: Indicates a dead labyrinth or bilateral hypofunction

C. Cold-air Caloric (Dundas Grant's) Test. Cold air is introduced into the ear by pouring ethyl chloride in the Dundas grant tube, which is a coiled copper tube wrapped in cloth. This test is used when there is perforation in the eardrum.

2. Electronystagmography.

It detects and records spontaneous or induced nystagmus that is not seen with the naked eye. A pair of disposable surface electrodes is placed around the orbit, which records the difference in potential between the cornea and the retina (corneoretinal potentials). It is a relatively easy, non-invasive test and allows a proper, permanent, documented record of nystagmus for future reference and medicolegal cases. It cannot record torsional eye movements.

3. Optokinetic Test

This test is used to diagnose a central lesion.

Principle. In response to repetitive visual patterns, such as a series of moving stripes or a large striped curtain in front of our eyes. The eyes follow one object with a slow-phase movement. The eyes are reset in the orbit by a fast component. This sequence of slow ipsilateral and fast contralateral eye movements forms optokinetic nystagmus.

Method. Patient is instructed to look straight ahead rather than follow a series of vertical stripes on a drum or open magazine moving slowly in both directions, and the results are analysed.

Interpretation.

- Normal nystagmus. Nystagmus with a slow component in the direction of moving stripes and a fast component in the opposite direction.
- Abnormal nystagmus. It is usually seen in brainstem and cerebral or other central disorders.

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4. Rotational Tests

The rotational chair is used for analysing horizontal canal vestibulo-ocular reflex (VOR).

Method. The patient is asked to sit in a motorised and computer-controlled chair (Barany's revolving chair) without optical fixation. The revolving chair delivers the desired velocity and rotational waveforms. The patient's head is comfortably immobilised and kept in a tilted 30° forward position. The chair is rotated in either direction and is stopped suddenly, and the resulting nystagmus is carefully monitored and recorded using either ENG or VNG. Normally, nystagmus lasts for 25–40 s. The test is useful as it can be performed in cases of congenital abnormalities where the ear canal has failed to develop, and it is not possible

Further, it can be performed in two ways.

1. **Sinusoidal rotation stimulation.** The chair is rotated sinusoidally over a range of frequencies, e.g. from approximately 0.05Hz to 1Hz, while the peak velocity of the stimulus is kept constant
2. **Velocity step or 'impulsive' rotational test.** There is an abrupt increase in chair velocity, say from a stationary position to 60 or 90 degrees per second, measuring the per- and post-rotation responses to clockwise and anti-clockwise. This complete procedure is then repeated in the opposite direction.

These tests are generally available in higher centres and provide a less provocative alternative to the caloric test. This test provides an alternative to the caloric test and is tolerated well by children. However, both labyrinths are tested simultaneously and do not give information about the site of the lesion and are relatively expensive.

Interpretation. There are three main abnormalities seen.

Response	Disorder
Bilateral reduced or No Response	Seen in bilateral vestibular failure, ototoxicity, post-meningitis and idiopathic.
Asymmetric response or Directional preponderance.	Seen in vestibular system disorder.
Loss of VOR suppression	Seen in central disorder.

5. Cupulometry

6. Galvanic test

7. Posturography

8. Vestibular Evoked Myogenic Potentials (VEMP)

Cerebellar Function Tests

1. **Asynergia** (abnormal finger-nose test). The patient touches the tip of his nose with his forefinger and then touches the clinician's finger, held within the reach of the outstretched arm of the patient. The test is repeated as fast as the patient can. The position of the clinician's finger can be changed to make the test more sensitive. Patients having cerebellar dysfunction will not be able to touch the nose on the first attempt (dysmetria). The reason is that intention tremors are more pronounced as the hand approaches the face.
2. **Dysmetria** (inability to control range of motion). i.e. movements are incorrect in range, direction and force. The movements may overshoot their intended mark (hypermetria) or fall short of it (hypometria).
3. **Adiadochokinesia** (inability to perform rapid alternating movements). e.g. supination and pronation of the forearm or patting the palm of one hand to the palm and back of the other hand.
4. **Rebound phenomenon** (inability to control movement of extremity when opposing forceful restraint is suddenly released). When the patient attempts to do a movement against resistance, and if the resistance is suddenly removed, the limb moves forcibly in the direction towards which the effect was made. This is called the rebound phenomenon. It is due to the absence of the breaking action of antagonistic muscles.

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