10.5005/jp-journals-10003-1084
REVIEW ARTICLE

Videonystagmography

Bachi T Hathiram, Vicky S Khattar

ABSTRACT

The goals of any test that evaluates balance function are manifold; primarily to determine the presence of a true balance disorder and to topographically locate it. Secondarily, to determine the extent of residual functional abilities of the patient as regards the 'deficit' caused by the disorder, and evaluate the possibility of recovery. Thirdly, and most importantly, to determine whether the individual is likely to benefit from some therapeutic modality, whether single or combined, based on the results of the tests.

Testing for vertiginous patients involves eliciting a detailed history, followed by a clinical evaluation. Investigations include the audiological, radiological and computerized tests. Computerized vestibular testing includes various computerized modules, such as: Electronystagmography (ENG), videonystagmography (VNG), rotational testing, computerized dynamic posturography (sensory organizational test—SOT; motor control testing—MCT) and vestibular evoked myogenic potential (VEMP) testing.

VNG is thus only one of the computerized tests and should always be interpreted in conjunction with the others mentioned above. This, however, does not mean that VNG should be performed in all patients complaining of vertigo. It is thus, prudent to understand the indications and possible information that may be obtained from a VNG evaluation and its application to clinical science. Analysis is often carried out by a technician and the results presented to the surgeon or physician. The analysis is often carried out automatically, or at least semi-automatically by a computer, where the automatic artefact rejection is usually poor, or in the least, suboptimal. These potentially 'weak links' in the chain can often mislead the clinician, and lead to errant diagnosis, such as 'central vestibular disorder', either due to an artifactual recording, or poor interpretation! It is thus, extremely important, that the ENG/VNG results are correlated with the clinical evaluation of the same tests, which may be done with the naked eye or in the least, using Frenzel's glasses.

Keywords: Vertigo, Computerized, Vestibular testing, Nystagmus.

How to cite this article: Hathiram BT, Khattar VS. Videonystagmography. Int J Otorhinolaryngol Clin 2012;4(1): 17-24.

Source of support: Nil

Conflict of interest: None declared

INTRODUCTION

Why is the Examination of the Eyes Important?

In many balance disorders, except for during the acute phase, the ENT and neurological evaluations are inconclusive; in continuation, performing a contrast enhanced magnetic resonance imaging (MRI) scan for a patient who may be suffering from benign paroxysmal positional vertigo (BPPV) would also be an 'overkill,' of sorts. Nystagmography can detect subtle ocular motility abnormalities which may be spontaneous or induced, and reflect the effect of the balance disorder on the ocular system, due to its intricate connections with the vestibular apparatus. It has thus been said repeatedly that, 'the eyes serve as a window to the vestibular system'.

ENG *vs* VNG

VNG has recently developed over the past couple of decades. Prior to that, it was the ENG which routinely performed for evaluating the same functions. The ENG was certainly more cumbersome, time-consuming and had a higher probability of errors than the VNG. This is not to say that the VNG is bereft of errors; but comparing the two, and given the advantages of the latter, it has gained popularity over the former. The distinct advantages of VNG over ENG are outlined below:

1. It is less time consuming—while a standard ENG test could well take over an hour, the VNG test is routinely complete within 25 minutes. The only time consuming test which is a part of both the procedures is the caloric test, which takes an equal amount of time in both ENG as well as VNG.
2. The ENG test relies on the corneoretinal potential to detect changes in eye position, while the VNG uses infrared cameras to record eye movements directly—thus, while ENG is an indirect evaluation of the ocular motility, VNG is a direct one; in addition, VNG also has the option of a visual recording and archiving facility, which allows for playback and slow-motion evaluation of the ocular movements.
3. While the ENG needs to be performed in darkness, the VNG eye goggles serve the dual purpose of isolating the patient's visual environment from the surroundings, making it completely dark, as well as recording the movements of the eyes through the infrared cameras that are mounted on the goggles. The VNG has the distinct advantage of being able to record torsional movements, which are not possible with the ENG.
4. VNG tracings are 'cleaner', with fewer artifacts than in ENG, such as those caused by muscle twitches, electrical noise, oily skin, perspiration, etc.
5. Since during the VNG recordings, the eyes are constantly visible, instructions may be given to the patient to make adjustments, keeping his/her eyes open at all times from

time to time so that optimal recordings may be made. In ENG, the tracing is usually visible after the recording is over, and hence in case any adjustments are to be made, the entire test may have to be repeated.

6. Otolithic function assessment is possible with VNG
7. Dysconjugate eye movements are better appreciated with VNG recordings.

On the other hand, ENG too has certain advantages over VNG such as:

1. The equipment is less expensive as compared to the VNG, which is usually thus preferred only in specialized clinics, teaching institutions and academic and research centers.
2. Patients who have had cataract surgery with lens implants, or those with prosthetic eyes, and in fact, even application of mascara can confuse the sensitive VNG recordings. The same problem has also been observed with patients having ptosis or long eyelashes. This is because the infra red cameras pick up the darkest spot on the eye (pupil) and any other dark object will confuse the recordings since it will interfere with 'pupil-traking' (El-Kashlan and Handelsman, 2008).[1]
3. The goggles are heavy and uncomfortable for many, and usually only one size is available for all, which can prove to be difficult to wear for certain patients as they keep slipping off.

So do all Patients with Balance Issues Warrant a Formal detailed Nystagmographic Evaluation?

Of course not!

There was a time when radiology was not as freely and easily available as today, where nystagmography would play an important role to help screen patients with suspected 'central' vestibular disorders. That was also the time when sophisticated laboratories providing computerized testing of complicated functions, such as otolothic functions were not available—at such times ENG formed a vital component of the balance testing armamentarium.

And then, there is today, when we have state-of-the art computerized facilities, to not only evaluate balance function in vertigo clinics, but also with provisions for the assessment of balance under simulated conditions, including for space travel!

Nevertheless, VNG still retains its place. It may not be very valuable in the detection of easily diagnosed conditions, such as large vestibular schwannomas, Meniere's disease, etc. but it may help in predicting the prognosis, documenting objectively their presence and effect on the balance system, and more importantly monitoring the progress of improvement after treatment.

On the other hand, it is valuable to detect and confirm unilateral/bilateral vestibular hypofunction, spontaneous nystagmus, otolithic function, etc. Thus, oculographic evaluation is helpful in formal vestibular testing, to understand the waveform, when there is a spontaneous nystagmus, and to determine whether the same is congenital or acquired or, when the clinical evaluation leaves no doubt that there is a potentially significant abnormality in the balance system. Thus, conditions such as BPPV, Meniere's disease, vestibular schwannomas do not necessitate oculographic recordings except:

- When the response to treatment is poor
- When there is presence of complications
- For presurgical evaluation
- Evaluation of the healthy labyrinth
- Need for objective measurements on follow-up.

The goals of the VNG are:

- To apply to vestibular system well-defined stimulations in direction, amplitude and frequency
- To measure the response on the oculomotor tract (i.e. nystagmography), using infrared video goggles and record the same using digital technology
- To analyze the results with a facility for reviewing them.

MATERIALS AND METHODS/TECHNIQUE

The VNG Armamentarium

VNG comprises a series of subtests which are designed to assess the function of the vestibular end organs, the central vestibulo-ocular pathways and oculomotor processes. The various tests available are:

1. Spontaneous nystagmus
2. Gaze nystagmus
3. Positional nystagmus
4. Saccade testing
5. Smooth pursuit test
6. Optokinetic nystagmus
7. Head-shake test for posthead shake nystagmus
8. Vibration-induced nystagmus
9. Caloric testing
10. Rotational testing
11. Ocular counter roll
12. Dynamic visual acuity/visual vestibulo-ocular reflex
13. Subjective visual vertical/horizontal.

Calibration

Calibration is performed using a normal subject:

- Free from any cervical pathology
- Average size
- Use the head fixation device

- Carefully measure distance from eye to central target
- For more accuracy measure the average distance with several normal subjects.

Once hardware calibration is done, be sure that nobody will modify the distance from chair position to the screen.

Precautions to be taken before the Patient is Tested

- As the patient wears the goggle use the target frame to check proper head orientation
- Check head stability and give instructions
- Instruct the patient to quickly follow the target when moving and to keep alert always
- Instruct the patient to continuously focus on the target and keep eyes open when the target remains steady.

It is important to keep in mind that calibration strongly depends on the patient's compliance.

Spontaneous Nystagmus

It is the nystagmus that appears in darkness, in the head-upright position and at least 3 feet away from any kind of stimulus.

It occurs due to the process of dynamic central compensation, following a vestibular 'insult', but recorded under static conditions. Often the spontaneous nystagmus following a recent vestibular imbalance is proportional to the patient's symptoms.

While in ENG recordings a spontaneous nystagmus of 5 to 10° per second may be accepted as normal, any spontaneous nystagmus that appears on VNG is considered pathological. It is recorded in degrees/second.

'Central' spontaneous nystagmus: This is usually associated with other 'central' signs and symptoms, such as headaches, may be seen in the vertical planes or may be 'direction-changing', and is usually amplified (or may remain the same) with visual fixation.

'Peripheral' spontaneous nystagmus: Has a constant direction, usually decreases in intensity with visual fixation, is proportional to the patient's symptoms and follows Alexander's law (which states that the intensity of the nystagmus increases with the gaze in the direction of the fast phase).

Slow phase velocity (SPV): The velocity of the 'slow phase' is used to quantify the amplitude of the nystagmus. When the velocity of the slow phase of the nystagmus increases beyond 10°/sec in a peripheral vestibular pathology, the patient perceives subjective rotatory vertigo. In addition to the feeling of rotatory vertigo (which is a vestibulocortical sensation), the patient may also perceive vestibulospinal symptoms such as instability, vestibulo-vegetative symptoms such as nausea, sweating and vestibulo-ocular symptoms such as visual fixation difficulties.

Direction: The spontaneous nystagmus in a vestibular pathology, usually beats toward the direction of the normal ear except in the acute/irritative phase of the pathology. By definition, spontaneous nystagmus thus depends only upon itself, and this independence should be confirmed. The only exception to this rule is in cases of anterior or lateral canal cupulolithiasis, wherein a 'permanent' nystagmus may appear in the upright position in darkness.

Congenital nystagmus: A large horizontal nystagmus in a patient with no significant vestibular or neurological symptoms should always raise the possibility of congenital nystagmus (Dell'Osso, 2002).[3]

Gaze Nystagmus

The nystagmus which is evoked when the patient is made to look in a particular direction is termed as gaze-evoked nystgmus. The patient is made to look front, left, right, up and down at angles of 15° and the nystagmus is recorded.

Horizontal gaze–evoked nystagmus can be indicative of either: Unilateral acute vestibular loss (nystagmus toward normal ear) or cerebellar pathology and the two can be differentiated by visual fixation.

Vertical gaze–evoked nystagmus is usually central, and commonly downbeat (rarely upbeat)—commonly due to posterior fossa abnormality.

Direction-changing gaze nystagmus is usually central, e.g. Brun's nystagmus.

Positional Nystagmus

Positional tests are performed in the seated and supine positions. The head is placed in the central position and then turned to the right and left. All positions are tested with the eyes open and eyes closed. Nystagmus is displayed and recorded in each individual position of the head. The nystagmus may be:

- Direction changing; seen in either central pathologies or horizontal canal BPPV
- Direction fixed; usually seen in uncompensated unilateral vestibular pathology.

To assess canalolithiasis, the canal to be checked should be in the vertical plane:

- The bent-over position mainly checks both lateral canals, partially the others, but weakly the two posteriors because of the position of their ampullae

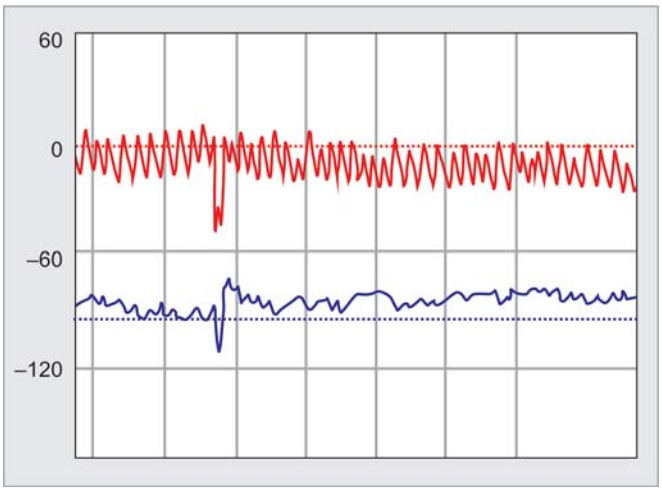

Fig. 1: The VNG tracing seen in horizontal canalithiasis

- Supine position checks both lateral canals vertically, and the four vertical each at 45°
- Hallpike checks the posterior canal of the lower ear and the anterior canal of the opposite (upper) ear, and also both lateral canals at 45°.

For assessing cupular density dysfunction, the checked cupular plane should be in the horizontal plane. Invert the suspected plane at 180° to check nystagmus inversion.

However, it is good to remember that alcohol may induce a bilateral density dysfunction involving all the cupula simultaneously for more than 12 hours.

With the patient supine, and head turned to one side, a direction changing nystagmus may be indicative of:

- *Horizontal canal BPPV* (Fig. 1): the nystagmus and symptoms are intense and duration is long
- *Central pathology*: symptoms are less severe and there may be a vertical component to the nystagmus.

Adaptation of Recording Duration

Minimal duration of observation should be at least for 20 seconds (some canalolithiasis may need such a latency). Total duration of observation is the function of the velocity evolution profile. There may be three possibilities:

- Velocity which increases: Wait
- Stable during 2 minutes: Stop and conclusion of permanent nystagmus
- Decreasing velocity: Wait until return to initial conditions or stop recording after 3 minutes.

Predefining the recording duration is not suggested.

Principles for Interpretation of Results

The stimulation of lateral canal alone gives a purely horizontal nystagmus. The stimulation of only a posterior or anterior canal always involves a torsional component. In case of the vertical canals, the proportion between the vertical and torsional components depends on eye position (vertical component increases on temporal gaze, while torsional increases on nasal gaze). In any position, a purely vertical nystagmus will thus never suggest a unilateral vertical canal origin.

A three-dimensional recording, if available, quantifies the evolution of the torsional component but is not essential for diagnosis. Sometimes, head shaking is not enough to elicit a nystagmus, in such cases, debris mobilization can also be facilitated by applying a vibrator on the mastoid.

In case of lateral canalolithiasis, the head positionis 60° bent forward. This helps to bring the lateral canal in vertical position with the ampulla down. Observe the absence of any synchronic vertical or torsional component (purely horizontal nystagmus). The observed nystagmus and symptoms in horizontal canal BPPV can vary from 30 seconds to 3 minutes.

Characteristics of a 'Central' Nystagmus

- Nystagmus changing direction with eye position
- No latency
- Purely vertical nystagmus associated with other central signs
- Loss of suppression with visual fixation
- Disproportionality between nystagmus and vertigo intensity

A central positional nystagmus does not have a torsional component, and moreover it is not inhibited by fixation.

Saccade Testing

The ability to keep the images of objects in the periphery of the visual field on the fovea and prevent retinal slip is a function of the saccade system.

In this test, the patient is made to sit in the VNG chair which is at a fixed precaliberated distance from the VNG monitor and asked to follow the movements of the object on the screen. A stimulus randomly appears on the screen at the edge of the visual field in both horizontal and vertical directions and the patient is asked to follow the stimulus only with his eyes keeping his head stable.

The eye movements are displayed and recorded. The computer analyses the results. Normal saccades will be symmetrical (Figs 2 and 3).

The various factors to be measured are:

Amplitude of the Saccade

The saccade is considered to be of large amplitude if its size is 30° or more. And of small amplitude if the size is 10° or less.

Fig. 2: The saccade testing being performed. Note the stimulus (white dot) at the periphery of the field (but within the visual range)

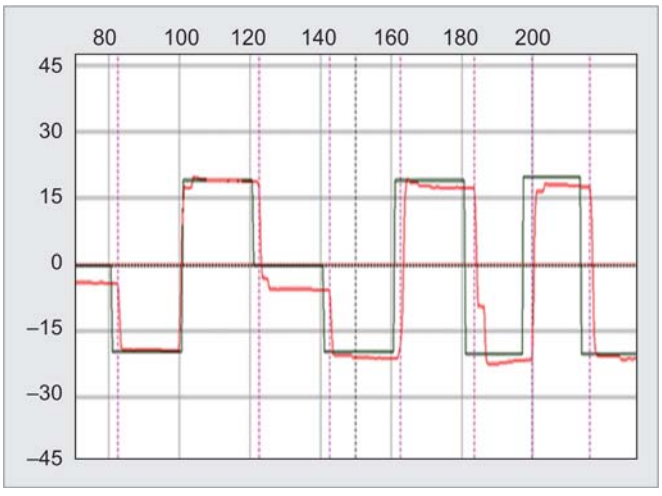

Fig. 3: Normal symmetrical saccades recorded in a normal individual

Latency of the Saccade

Latency is the delay between onset of target movement and initiation of eye movement. A latency consistently more than 260 to 270 msec is considered abnormal (Fig. 4).

Precision/Accuracy

Precision is the amplitude of the eye movement relative to the target. Up to 10 to 15% hypometria and 15 to 20% hypermetria is considered normal (Fig. 5).

Velocity

Velocity is the time taken to complete the saccade once it has been initiated. This should be less than 430°/sec for large amplitude and less than 200°/sec for small amplitude saccades.

Symmetry of the Saccades

In a normal individual, the saccades will be symmetrical. Asymmetry indicates abnormality.

Variations and Abnormalities

Symmetrically, inaccurate/slow saccades could be due to old age, poor cognitive status, inattention to task, poor visual

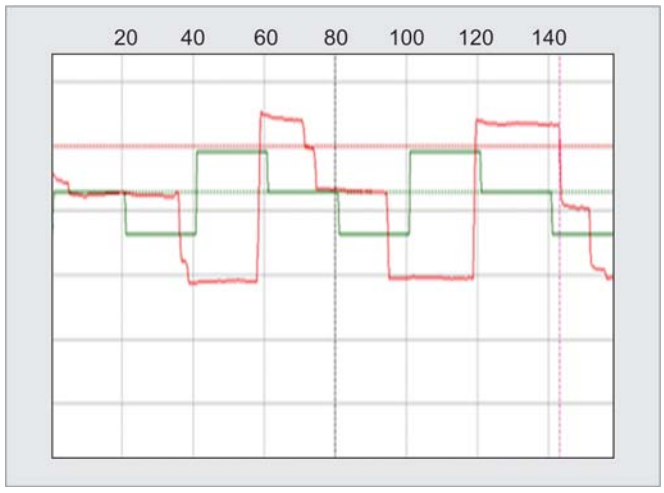

Fig. 4: Excessive latencies. These can interfere with the caliberation

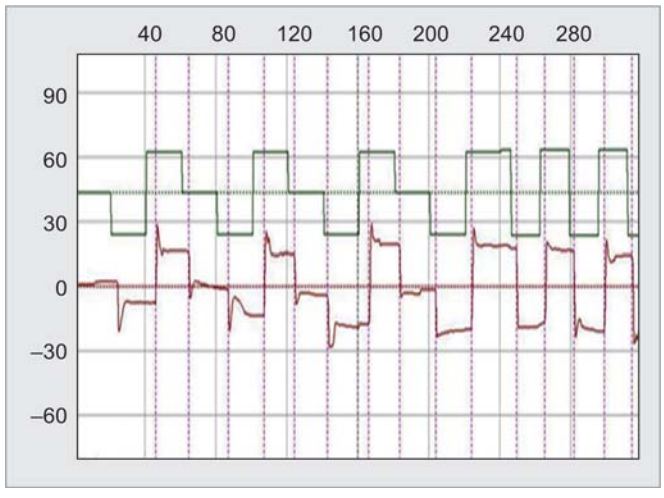

Fig. 5: Hypermetric saccades

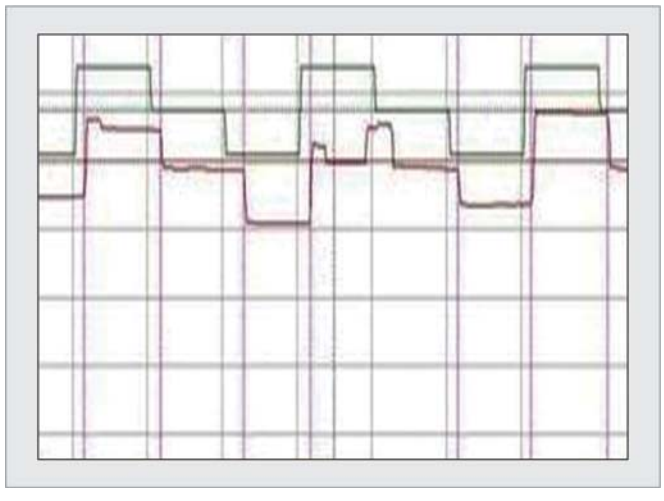

Fig. 6: Inconsistent saccades

acuity, sedation, sleep deprivation, poor comprehension level, medications (Figs 6 and 7). The saccades seen in a patient with internuclear ophthalmoplegia will have a slow velocity for adduction and fast velocity for abduction. Long latencies are seen for both eyes in both directions. Saccades

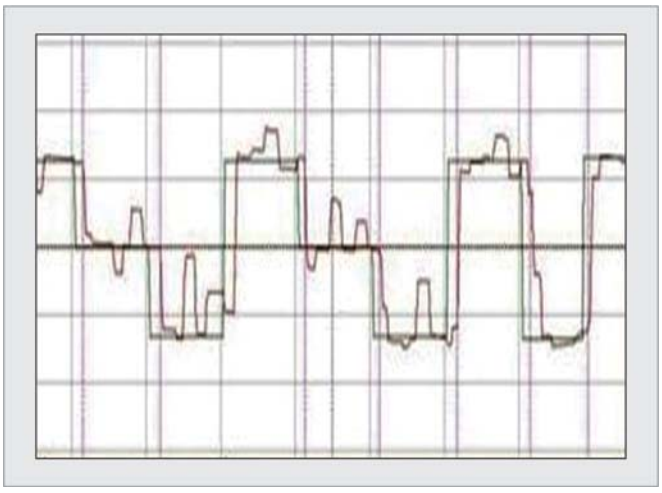

Fig. 7: The saccades recorded in a nervous patient

Fig. 8: The Optokinetic test in progress. Note the multiple targets on the screen

seen in patients with cerebellar disorders are dysmetric, commonly overshooting the target. Patients with parapontine disorders and those with reticular formation disorders usually show an abnormal slowing of saccades. In disorders of the basal ganglia hypometric, slow saccades are usually seen.

Smooth Pursuit Testing

The ability of the eye to keep the image of an object moving slowly across the visual field on the fovea, thus preventing a 'retinal slip' is a function of the smooth pursuit system.

It is tested by asking the patient to keep looking at a target that moves across the screen in the horizontal plane in either direction (left/right). The movement of the eye is displayed and recorded. In a normal patient, the eye should be able to track the target smoothly. It is tested in several velocities of target movement (0.1, 0.2, 0.4, 0.9 Hz).

Abnormalities

Symmetrically inaccurate/slow saccades could be due to old age, poor cognitive status, inattention to the task, poor visual acuity, sedation, sleep deprivation, poor comprehension level and medications.

The patient's eyes must 'follow' the target and not 'lead' it. If the patient appears to be predicting the movement of the target, instruct the patient not to do so and repeat the test. Pursuit can be saccadic/jerky toward the side if the lesion is a cerebellar, brain stem or parietal lobe lesion.

Symmetrically impaired pursuit maybe a nonspecific 'central finding' but, nonsymmetrically impaired pursuit is suggestive of a unilateral hemispheric or asymmetrical posterior fossa lesion.

Optokinetic Nystagmus Testing

The ability of the eye to keep multiple moving objects (the entire visual field) on the fovea and prevent a retinal slip is a function of the optokinetic system.

The patient is asked to track multiple moving targets across the screen (Fig. 8). These are moved first toward the right and then toward the left.

Many laboratories propagate the use of full field testing for optokinetic nystagmus as it is believed that a peripheral vestibular asymmetry can occasionally bias small field optokinetic testing but, not full field optokinetic testing (Mossman et al, 1992).[4]

Abnormalities

Cerebral and cerebellar lesions produce ipsilateral directional preponderance. Brain stem lesions produce contralateral directional preponderance. Since, the smooth pursuit and optokinetic systems are intricately connected, abnormalities of one usually reflect on the other.

Testing the Vestibulo-ocular Reflex

The vestibulo-ocular reflex (VOR) tests the movement of the eyes in relation to that of the head. It can be performed at various frequencies of motion and in opposite directions. The VOR is what allows us to see clearly when we walk, run or turn our heads. It does so by generation slow-phase eye movements of an almost equal velocity, but opposite in direction to head movement (Bronstein, 2008).[2]

Three different stimuli may be given and the resultant nystagmus is checked:

- The head impulse test
- The head-shake nystagmus test
- The vibration-induced nystagmus test.

The Head Impulse Test

Patient is in the sitting position. The patient's head is turned passively by the examiner in the yaw plane, then in the pitch plane with head turned to an angle of 30° to the center. All

semicircular canals are thus checked individually. Normal response is characterised by the eyes following the head even at high velocities. In case of canal paresis, the eyes will lag behind the head followed by a corrective saccade to realign the two. This is described separately in another article in this same journal.

The Head-Shake Nystagmus Test

It is an objective test for documentation of an uncompensated, unilateral, vestibular deficit (Fig. 9). It is thus a latent manifestation of, or an increase in the intensity of a pre-existing spontaneous nystagmus.

The patient is seated with head bent down by 30°. The head is then shaken in the yaw-plane for 30 seconds. The response recorded consists of two components:

- Passive dolls-eye movement (PDE)
- Post head-shake nystagmus (PHSN) initially away from the affected ear and later recovery nystagmus toward the same side.

Inference

- In unilateral vestibular loss, PDE may be poorly seen in the direction of the loss but, PHSN will be seen to the opposite side.
- In bilateral vestibular loss PDE will be poor on both sides. There may (only mild) or may not be any PHSN.
- In central lesions the nystagmus may show a vertical component.

The Vibration-induced Nystagmus Test

The rationale is similar to a head-shake nystagmus test however, the frequency of the stimulus used is much higher. A 100 Hz vibrator is applied to each mastoid process and if a nystagmus appears which has a velocity of >3°/sec, it is indicative of a unilateral vestibular loss.

Fig. 9: The head-shake nystagmus test being performed

The Caloric Test

This is a test to evaluate the VOR. A low frequency (0.003-0.006 Hz) stimulus is given to test the VOR . The lateral SCC is tested in the 30°, propped-up supine position to make the canal vertical. The stimulus is thermal using either water or air. Water caloric is of two types open-loop or closed-loop (using a latex balloon).

The caloric test is the only test which enables us to examine one labyrinth at a time. Both ears are successively tested for warm (44° for water and 48° for air) and cold (30° for water and 24° for air). Warm irrigations stimulate and cold irrigation inhibit the ipsilateral labyrinth.

Water irrigations are performed for 40 seconds each, while air irrigations for 90 seconds. A gap of 5 minutes is allowed between any two irrigations. Canals are tested as left cold, right cold, left warm, right warm (Cawthorne et al[5] 1942). Right warm is the strongest stimulus and hence tested last. Nystagmus and tracings are recorded from the initiation of irrigation, till 2 minutes. Maximum slow phase velocity (SPV), directional preponderance (DP) and canal paresis (CP) are the commonly measured parameters.

Inferences

All parameters are highly variable. A canal paresis of more than 20% is considered abnormal/hypoactive. A directional preponderance of more than 25% is considered abnormal and is suggestive of a peripheral vestibular lesion. A unilateral canal paresis suggests a peripheral vestibular lesion on the side of the paresis. Intrasubject variability has been seen up to 25% when the same test was repeated 10 times in the same subject. When all responses are slow, or absent, then ice caloric irrigation has been recommended, and prone positioning increases the sensitivity of the test. Common 'missed' diagnosis are an 'irritative' labyrinth and 'bilateral vestibular loss'. A bilateral canal paresis suggests a central/bilateral peripheral vestibular lesion.

A hyperactive caloric response suggests a central lesion, except for 'acute irritative' stages of peripheral lesions.

The Rotation Test

Involves stimulating the vestibular system about a vertical axis, in a sinusoidal, pseudorandom, or constant velocity fashion. It uses a quantifiable physiologic stimulus of frequencies more closely approximate to those that occur normally (0.1 to 0.64 or 1.28 Hz). Two types of rotation testing is possible—sinusoidal testing and step rotation testing (Bronstein, 2008).[2]

Dynamic Visual Acuity

It is a test of comparison of visual acuity when the head is at motion and at rest. It can be done with the VNG, by

displaying a letter/alphabet on the screen and altering its size and orientation. The result is calculated as the minimum size of the image, which can be correctly seen with the head in motion and at rest. Also comparisons between motion of the head to the right and left is made.

The advantage of coupling this test with the VNG is that the speed of head movement can be calibrated and only one visual stimulus is presented at a time. Comparison of the static and dynamic visual acuity is made, with respect to three parameters, i.e. gain, phase and symmetry.

Subjective Visual Vertical

The perception of verticality relates to the otolith organs since they are linear acceleration or gravity sensors (Fig. 10). However, inputs from vision and proprioception also play a certain role. The patient is asked to align an illuminated light bar in darkness to the perceived vertical and the angle of deviation from the true vertical is calculated. Acute unilateral vestibular lesions produce an ipsilateral subjective visual vertical (SVV) tilt which may be 10° or even more, but gradually disappearing in a few months. Lesions involving the vestibular nuclei (central vestibular lesions) produce ipsilateral SVV tilt with an ocular tilt reaction, the lower eye being ipsilesional. Upper brain stem lesions produce contralateral SVV tilts. Recent studies have shown that SVV is a combined function of otolith organs and vertical canals.

Eventually, at the end of this article, we need to evaluate, what difference does the VNG actually make to the test battery for a vertiginous patient?

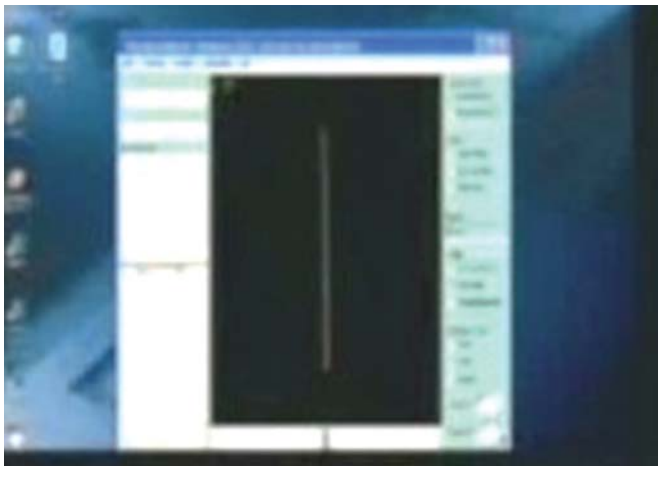

Fig. 10: The light-bar seen on the screen that needs to be subjectively oriented to the vertical as perceived by the patient

The VNG differentiates central from peripheral vertigo, making testing objective and quantifiable. One labyrinth can be tested at a time (calorics). Otolith function can be tested and quantified (partially). Testing can be done for various 'physiological' frequencies of head movement.

Hence, it is important to understand that the VNG is but one of the methods which is used to evaluate the vertiginous patient and should be interpreted with reference to other tests as well as clinical evaluation.

ACKNOWLEDGMENT

The author is thankful to the Dean, TN Medical College and BYL Nair Charitable Hospital for granting permission to publish this article.

REFERENCES

1. El-Kashnan HK, Handelsman JA. Comuterised vestibular testing. In vertigo and disequilibrium: A practical guide to diagnosis and management. Peter C Weber (Ed). Thieme Medical Publishers Inc NY, USA 2008;4-14.
2. Bronstein AM. Evaluation of balance in Scott-Brown's otorhinolaryngology. Head and Neck Surgery (7th ed). Michael Gleeson et al (Eds). Hodder Arnold, UK 2008;3:3706-47.
3. Dell'Osso LF. Development of new treatments for congenital nystagmus. Annals of the NewYork Academy of Sciences 2002;956:361-79.
4. Mossman SS, Bronstein AM, Hood JD. Optokinetic nystagmus in response to different stimulus modalities. Neuro-ophthalmology 1992;12:63-72.
5. Cawthorne TE, Fitzgerald G, Hallpike CS. Observation on the directional preponderance of caloric nystagmus resulting from unilateral labyrinthectomy. Brain 1942;65:138-60.

ABOUT THE AUTHORS

Bachi T Hathiram

Professor and Head, Department of ENT and Head and Neck Surgery Topiwala National Medical College and BYL Nair Charitable Hospital Mumbai, Maharashtra, India

Correspondence Address: Flat No. 2, Ground Floor, MN Banaji Building, Forjett Street Cross Lane, Mumbai-400036, Maharashtra, India Phone: 91-9323699192, 91-9920499192, e-mail: bachi.hathiram@rediffmail.com, orlclinics@gmail.com

Vicky S Khattar

Assistant Professor, Department of ENT and Head and Neck Surgery Topiwala National Medical College and BYL Nair Charitable Hospital Mumbai, Maharashtra, India