Diagnostic value of nystagmus: spontaneous and induced ocular oscillations

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Research over the past 20 years has provided a clearer understanding of the pathogenesis of most forms of nystagmus and other ocular oscillations. To the clinician, these advances translate into greater accuracy of nystagmus as a diagnostic sign. However, to capitalise on these advances, it is important to systematically examine eye movements and interpret the findings with reference to pathophysiology. In this review we describe a scheme for examining the patient with nystagmus and interpreting common ocular oscillations; some examples are provided as video clips.

Enough is now known about nystagmus to make it a valuable clinical finding, provided that it is characterised systematically, and interpreted in the context of the general neurological evaluation. Nystagmus may be defined as repetitive, to and fro, involuntary eye movements that are initiated by slow drifts. Nystagmus may consist mainly of sinusoidal slow phase oscillations (pendular nystagmus) or, more commonly, of an alternation of slow drift and corrective quick phase (jerk nystagmus). Common waveforms are schematised in figure 1. Thus, each slow phase takes the eye away from the preferred direction of gaze and the corrective quick phase (a saccade) brings the eye back towards the visual target. Although nystagmus is often described by the direction of its quick phases (for example, downbeat nystagmus), it is the slow phase that reflects the underlying disorder. Nystagmus should be differentiated from saccadic intrusions and oscillations, in which rapid movements (saccades) take the eye away from the target (fig 1).

Modern classifications of nystagmus are based on current knowledge of the neurobiology of eye movements, and disorders of the three mechanisms that normally hold gaze still (visual fixation, the vestibulo-ocular reflex, and the eccentric gaze holding mechanism). However, at the bedside, the clinician must rely on the observed characteristics of nystagmus and a systematic examination of eye movements to deduce the significance of any ocular oscillations. Here we describe how to elicit nystagmus and saccadic oscillations, and then summarise the observed characteristics of nystagmus and a systematic examination of eye movements to deduce the significance of any ocular oscillations. Research over the past 20 years has provided a clearer understanding of the pathogenesis of most forms of nystagmus and other ocular oscillations. To the clinician, these advances translate into greater accuracy of nystagmus as a diagnostic sign. However, to capitalise on these advances, it is important to systematically examine eye movements and interpret the findings with reference to pathophysiology. In this review we describe a scheme for examining the patient with nystagmus and interpreting common ocular oscillations; some examples are provided as video clips.

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ophthalmoscope. Repeat each of these observations as the eyes are brought into right, left, up, and down gaze, and during sustained convergence.

A description of the direction of rotation of the nystagmus in each gaze angle will often indicate the coordinate system to which the nystagmus conforms. Thus, nystagmus that appears horizontal in the straight ahead position of gaze but torsional on looking far up is rotating around a rostral-caudal axis relative to the head, characteristic of vestibular nystagmus. However, if on upward gaze the nystagmus still appears “horizontal” to the observer, then the eye is rotating around an eye fixed axis, characteristic of congenital nystagmus (see video “Congenital_Nystagmus”).

Always examine the effect of nystagmus of removing fixation; nystagmus attributable to peripheral vestibular imbalance may only be apparent under these circumstances. The best way is to observe the nystagmus behind Frenzel goggles (high positive lenses with small lights), which prevent fixation of objects and also provide the examiner with a magnified, illuminated view of the patient’s eyes. If not available, another technique consists of transiently covering the fixating eye during ophthalmoscopy in an otherwise dark room, and noting the effects on retinal motion in the eye being viewed.

Evaluation of nystagmus is incomplete without a systematic examination of each functional class of eye movements—vestibular, saccades, smooth pursuit, and vergence; selective defects may indicate the nature of the underlying disorder. For example, dissociated nystagmus (greater in the abducting eye) on looking to the right occurs when the adducting left eye cannot be put on target because of an internuclear ophthalmoplegia. It is also important to note the effects of each type of eye movement (such as convergence) on the nystagmus, as well as a 15 second period of head shaking in the horizontal or vertical planes (observe the nystagmus after head shaking through Frenzel goggles). Placing the patient into head hanging positions may increase some forms of nystagmus (for example, downbeat). Nystagmus that is present only when induced by positional testing is a feature of benign paroxysmal positional vertigo, which is discussed elsewhere.

It is possible to induce nystagmus in normal subjects with optokinetic or vestibular stimuli. Under natural circumstances, visual (optokinetic) and vestibular nystagmus acts to hold images steadily on the retina during self rotation. In clinical practice, it is convenient to induce nystagmus with an “optokinetic” drum or tape, which presents a moving pattern of stripes. This stimulus mainly tests smooth pursuit tracking (slow phases) and automatic saccades (quick phases). The patient is instructed to follow the stripes as they move either horizontally or vertically. The clinician looks for an asymmetry of responses. For example, with an infarction of right posterior cerebral cortex that affects secondary visual areas concerned with motion processing, the response will be reduced as the stripes move to the patient’s right (impaired ipsilateral smooth pursuit) and less corrective quick phases will be triggered—that is, there will be less nystagmus as the stripes move to the patient’s right compared with moving to the left.

Nystagmus can also be induced with vestibular stimuli. A simple method is to rotate, by hand, the patient in an office chair for 45 seconds, then stop the chair so that induced nystagmus can be viewed. Vestibular nystagmus can also be induced by irrigating the external auditory canal with cool or warm water, which produces a convection current in the endolymph of the labyrinth. In clinical practice, the minimal ice water caloric test is most convenient. After verifying that the tympanic membrane is intact, the patient’s head is elevated 30 degrees relative to earth horizontal, to place the lateral semicircular canal in a vertical position. Ideally, eye movements should be observed behind Frenzel goggles. A normal response, consisting of a nystagmus beating away from the stimulated ear, can be elicited with as little as 0.2 ml of ice cold water. The caloric test is a sensitive indicator of loss of unilateral vestibular function.

**INTERPRETATION OF FINDINGS**

**Nystagmus occurring when the eyes are close to central position**

An important first step is to determine whether removing visual fixation increases the nystagmus. Mixed horizontal-torsional jerk nystagmus that suppresses with fixation is usually attributable to a peripheral vestibular imbalance and is accompanied by vertigo (for example, viral labyrinthitis). Peripheral vestibular nystagmus (fig 1A) commonly beats away from the side of lesion, and increases when the eyes are turned in the direction of the quick phases (Alexander’s law). Horizontal nystagmus (jerk or pendular) that is accentuated by the visual effort of fixation, as well as by attention or anxiety, is commonly congenital. Congenital nystagmus usually remains horizontal in all gaze angles, may be suppressed during convergence (see video, “Congenital_Nystagmus”), and is sometimes associated with anomalous head positions, head oscillations and strabismus. A characteristic sign of congenital nystagmus is that during testing with a horizontal optokinetic stimulus, the quick phases may be directed in the same direction as drum motion—“optokinetic inversion.” Horizontal nystagmus that changes direction when the eyes are alternatively covered (beating away from the covered eye) is usually “latent nystagmus”, which is associated with lack of normal binocular development (absent stereopsis), and childhood strabismus (see video, “Latent_Nystagmus”). Latent nystagmus is often manifest when neither eye is occluded, because the patient chooses to fixate with one eye. These congenital variants of nystagmus are usually evident from the
Nystagmus induced by moving the eyes to an eccentric position—gaze evoked nystagmus

The commonest form of nystagmus encountered in clinical practice occurs only when the eyes are moved into eccentric gaze, especially in lateral and up gaze (fig 1B). This gaze evoked nystagmus has quick phases that are directed away from central position (see video, “Gaze&Rebound_Nystagmus”). Holding the eyes in such eccentric positions requires a tonic contraction of the extraocular muscles, which is achieved by a sustained discharge of motoneurons.7 This ability is impaired by cerebellar and brainstem disorders as well as a number of intoxications.2 Thus, the finding of nystagmus on lateral or up gaze may be clinically important. Firstly, however, it is important to differentiate between pathological gaze evoked nystagmus and its variant, called end point nystagmus, frequently reported in normal subjects. The latter is characterised by low frequency and amplitude, and not accompanied by other ocular motor abnormalities. Pathological gaze evoked nystagmus may be attributable to a peripheral process,7 being a sign of extraocular muscle weakness, for example, in patients with myasthenia gravis (“fatigue nystagmus”). It also occurs as a result of central disorders that involve the gaze holding neural network, which includes the nucleus prepositus hypoglossi and medial vestibular nucleus for horizontal gaze,11 the interstitial nucleus of Cajal for vertical gaze,11 and the vestibulocerebellum, which optimises gaze holding. Structural lesions affecting this gaze holding network may cause gaze evoked nystagmus, because the eyes tend to drift back to central position (fig 1B). Most commonly, gaze evoked nystagmus is encountered as a side effect of medications, including sedatives and anticonvulsants, or with drug intoxications (for example, alcohol). When patients with gaze evoked nystagmus attempt to hold eccentric gaze for a number of seconds, and then return their eyes to the central position, a transient rebound nystagmus, with quick phases opposite to the direction of the prior eccentric gaze, may occur (see video “Gaze&Rebound_Nystagmus”). Such rebound nystagmus is prominent in patients with disease affecting the vestibular cerebellum.12

When nystagmus on lateral gaze is greater in the abducting eye, the cause may be internuclear ophthalmoplegia, and saccades should be tested, looking for slowing of the adducting eye. In most cases, dissociated nystagmus is a manifestation of the brain’s attempt, with a series of saccades, to put the fovea on the target.12

Nystagmus induced by upgaze is convergence-retraction nystagmus. It occurs with dorsal midbrain lesions (for example, pineal tumours). Convergence-retraction nystagmus may be elicited either by asking the patient to make an upward saccade, or by using a handheld optokinetic drum or tape, moving the stripes down. In some cases the convergence movements appear to be opposed vergence movements,21 but in others it consists of opposed, asynchronous saccades.21

Nystagmus (either jerk or pendular, binocular or monocular) occurs commonly in patients with visual impairment or loss, who cannot accurately direct their gaze. In such patients, both horizontal and vertical components are present, and the
direction of nystagmus fluctuates during a period of observation. Their nystagmus probably reflects an uncalibrated ocular motor system."

Saccadic intrusions and oscillations
Several types of inappropriate saccadic movements may intrude upon steady fixation; more common variants are square wave jerks (fig 1E–G). Because saccadic intrusions are rapid and brief, it is usually necessary to measure eye and target position and eye velocity to identify accurately the saccadic abnormality. Square wave jerks (fig 1E) occur in healthy subjects, but are a prominent finding in progressive supranuclear palsy and some spinocerebellar atrophies (especially Friedrich’s ataxia). They are small, conjugate saccades, ranging from 0.5 to 5.0 degrees in size, which take the eye away from the fixation position and then return it there after a period of about 200 ms. They may be most evident during smooth pursuit, and are easily detected during ophthalmoscopy. Macrosaccadic oscillations (fig 1F) usually consist of horizontal saccades that occur in bursts, building up and then decreasing in amplitude, with intersaccadic intervals of about 200 ms. These oscillations are usually induced by a gaze shift. They are a sign of midline cerebellar disease (affecting the fastigial nucleus), including spinocerebellar degenerations (see video, "Macrosaccadic oscillations"), but have also been reported with pontine lesions.

Saccadic pulses are brief intrusions that take the eye movement away from the fixation position, with a rapid drift back. They are reported in patients with internuclear ophthalmoplegia. There is a continuum between saccadic pulses and saccadic oscillations without an intersaccadic interval (fig 1G). The latter may occur in the horizontal plane, ocular flutter, or may consist of saccadic oscillations with horizontal, vertical, and torsional components, opsonolus (see video, “Opsonolus”). The frequency of oscillations is usually typically 10 to 15 cycles per second, being higher with smaller size movements. Flutter and opsonolus are often brought out by eye lid closure or during gaze shifts between far and distant targets. Most cases of flutter and opsonolus conform to four main diagnostic groups: parainfectious brainstem encephalitis (including multiple sclerosis), paraneoplastic syndromes, metabolic-toxic states, or idiopathic. Differentiation between these disorders depends on the general neurological findings and laboratory testing.

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REFERENCES