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Short Communication

ASSESSMENT OF VESTIBULAR FUNCTION BY VIDEONYSTAGMOSCOPY

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□ **Abstract — Videonystagmoscopy has been used to subjectively observe the responses of the vestibular system in a population of patients with vestibular deficits. These results were compared with those of a control group of healthy, age-matched volunteers. The videonystagmoscopy device is made of one or two CCD cameras mounted on lightproof goggles, allowing a subjective observation of ocular movements on a video monitor. The eye movements, as well as the position of the head in space, can be recorded on videotape. The eyes are illuminated by infrared light emitting diodes placed on each side of the camera lens. The subjects are seated on a manually driven Barany chair. Subjects went through a protocol of passive roll head tilt on each side, followed by a slow, whole body rotation of 180° amplitude, clockwise and counterclockwise, and then a head shaking test (HST). The eyes were subjectively observed, and we focussed on: torsional eye movements during head tilt, nystagmus when the rotation had stopped, and nystagmus induced by HST. With this simple and noninvasive examining procedure, screening of vestibular function at the bedside or during E.N.T. clinical investigations is possible.**

□ **Keywords — videonystagmoscopy; rotation; torsional nystagmus; vestibular function.**

Introduction

Time between the onset of disorders due to a vestibulopathy and the beginning of the medical treatment is usually quite long. Our experience in this field pointed out that the shorter was the time between the vertigo spell and the start of an association of medications and vestibular rehabilitation program, the better was the recovery. In order to let the clinician diagnose the disorder as fast as possible in a noninvasive manner, we worked out a protocol using a video device in complete darkness: videonystagmoscopy.

Based on the knowledge that visual cues alter reflexive eye movements, we observed eye movements in complete darkness by means of a video camera. The eyes were illuminated by infrared light-emitting diodes (LEDs). The investigation of vestibular function takes no more than 5 min and gives even more information than caloric test. This protocol can be used at the bedside as well as routinely at the clinician's facility. Our 2 years of experience is hereafter presented.

Patients and Methods

Patients

Reflexive eye movements were subjectively observed in a population of 170 patients with:

- unilateral vestibular deficit: 60 sudden vestibular loss (vestibular neuronitis), 30 pa-

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tients following vestibular neurectomy, 20 patients after surgery for acoustic neuroma, 20 Meniere's disease.
- bilateral vestibular loss according to caloric tests: 40 patients who had been submitted to aminoglycoside treatment for severe infections.

A control group of 30 asymptomatic, age-matched healthy volunteers drawn from the hospital employees and colleagues was used to determine normative data.

Videonystagmoscopy Device

The video cameras are mounted on light-proof goggles (Figure 1). The cameras are facing the eye and placed on the optic axis. The CCD cameras (Sony) work in daylight as well as in an infrared illuminated environment. Two infrared LEDs are placed on each side of the camera lens. The radiated power of the LEDs can be adjusted in order to have the best compromise: minimum light, maximum contrast on the control monitor. The camera lens has an adjustable focus to have the sharpest picture on the control monitor. A third daylight camera is mounted on a helmet fixed to the head and placed such that the camera is on the forehead and faces straight ahead of the patient. The signals from these cameras go to a video monitor through a picture-in-picture system in order to have the choice between two eyes on the screen, and one eye and the picture of the surrounding which gives the head movement (Figure 2).

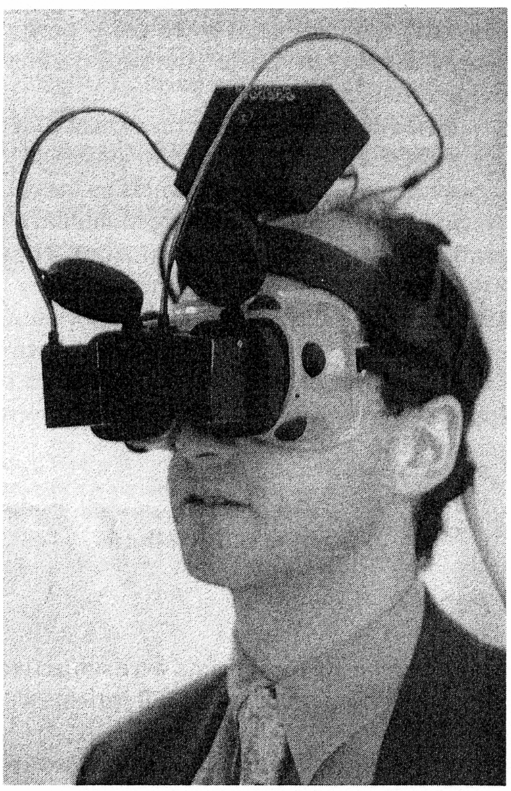

Figure 1. Subject wearing the goggles with cameras mounted, one for each eye, and the upper one for the visual surround.

Procedure

The patients and the subjects were seated on a Barany chair. The protocol to assess peripheral vestibular function was as follows:

- Subjective observation of spontaneous nystagmus and gaze nystagmus. In the absence of visual cues, the patient was asked to look in a specific direction; nystagmic eye movements could be observed subjectively. It was necessary to wait about 20 s to be sure that this nystagmus was pathological.
- A passive head tilt (45°) in frontal plane (roll) at a velocity of $15 \pm 3°/s$ is performed. In normal subjects, tilting the head toward the right shoulder generates a few beats of torsional nystagmus beating clockwise. When the roll head tilt is to the subject's left side, the direction of the torsional nystagmus is counterclockwise.
- Passive horizontal constant velocity whole-body rotations of 180° amplitude provided by a manually driven Barany chair during 5 s in one direction, with observation of the induced nystagmus during the rotations and after it had ceased. When a nystagmus was noted at the cessation of the rotations, the clinician waited until it stopped. Then a horizontal whole body rotation was done

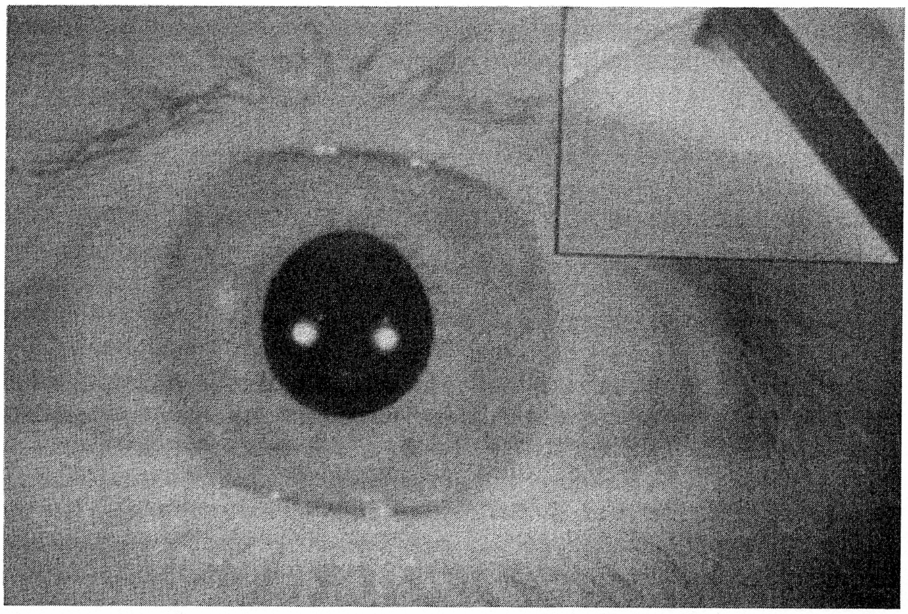

Figure 2. View of the video monitor showing the picture-in-picture view of the left eye and the wall of the room in front of the subject.

with the same velocity in the opposite direction. We estimate that the acceleration at the onset and cessation of the rotations was $200°/s^2$ and that the velocity of rotation was $30 \pm 5°/s$. The shape of the chair movement velocity profile is a step of acceleration, constant velocity, then a step of deceleration.

These rotations were done at first with the head in standard position, then repeated with the head roll-tilted to the shoulder (45°).

- Body rotation with respect to the fixed head to assess the cervicoocular reflex. This test was performed when all the rotational tests previously described did not provoke any responses.
- Post-head-shaking (HS) nystagmus. This test was performed by having the patient's head passively shaken in the horizontal plane as fast as possible for approximately 10 cycles (1). The eyes of the patient were closed during the test. Then, the eyes were opened. HS should not provoke any nystagmus. When a nystagmus is subjectively observed, the quick phases tend to beat toward the side with the highest reflexive value (2).

The results of the videonystagmoscopy protocol were compared with the results of the classical otoneurological tests. The bithermal caloric test was performed as follows: irrigation of each ear for 30 s with a constant flow rate of water at 44°C and 30°C. A resting time of 5 min was observed between the end of the previous response and the next stimulus. The same procedure was performed using irrigations of both ears simultaneously, according to Aubry and Pialoux (3). This simultaneous irrigation should not provoke any nystagmus, or a few beats (less than 10 for both stimulations) in normal subjects.

Results

Normal Subjects

Torsional eye movements were seen during roll head tilts in both directions. No nystagmus could be subjectively seen at the cessation of the rotations, while the nystagmus subjectively observed during the rotations seemed to be symmetric. Rotating the body with respect to the fixed head did not induce any response. These results are shown in Table 1. Results of the classical otoneurological tests were normal, especially for the caloric test.

Unilateral Labyrinthine-Defective Patients

Compensated Patients (Table 2). These patients were said to be compensated because they no longer complained of balance disorders and did not demonstrate either spontaneous nystagmus or head-shaking nystagmus.

A complete unilateral canal paresis was seen at the caloric test while recordings of smooth pursuit and saccades and dynamic posturography (CDP) were normal.

Torsional eye movement induced by head tilt was asymmetric in most of these compensated patients, with a smaller or no torsional nystagmus induced by tilting the head to the side of the lesion.

At the cessation of the horizontal constant velocity whole body rotations toward the affected side with the head in standard position, a nystagmus was subjectively observed, while there was no nystagmus at the cessation of the rotations toward the intact side. At the cessation of the horizontal whole body rotations with constant velocity toward the intact side with the head roll-tilted on the shoulder, the patients demonstrated a nystagmus while no response was subjectively observed after the rotations toward the affected side.

Patients seen at the acute stage (Table 3). The same population had been seen a few days (2 to 7) after surgery or, for those with vestibular neuritis, a few days (2 to 4) after the acute vertigo. These patients had a spontaneous nystagmus with quick phases away from the lesioned side. The caloric test demonstrated quite complete unilateral canal paresis with directional preponderance according to the spontaneous nystagmus. Smooth pursuit and saccade recordings were normal. CDP equilibrium scores were reduced to 0 in conditions 5 and 6 (4).

No torsional eye movement could be subjectively observed when the head was tilted toward the affected side, while the torsional nystagmus induced by tilting the head toward the intact side was normal or increased. In the few days following the vestibular loss, the spontaneous nystagmus was superimposed onto the responses at the cessation of the rotations in both directions.

While compensation was taking place, asymmetry of torsional nystagmus was seen with a smaller torsional eye movement when the head was roll-tilted toward the affected side, and a smaller nystagmus was observed at the cessation of the whole body constant velocity rotation (head in standard position) toward the intact side.

Bilateral Labyrinthine-Defective Patients

These 40 bilateral caloric areflexive patients complained of oscillopsia and had a history of previous aminoglycoside treatment. They did

Table 1. Torsional and Rotation Test Results in Normal Subjects

Spontaneous Nystagmus: 0	Gaze Nystagmus: 0 Left Side	Head Shaking Nystagmus: 0 Right Side
Torsional nystagmus	+	+
Nystagmus following the 180° rotations (head in standard position or roll-tilted on the shoulder)	0	0

+: presence; 0: absence.

Table 2. Torsional and Rotation Test Results in Compensated, Unilateral Labyrinthine Defective Patients

Spontaneous Nystagmus: 0	Gaze Nystagmus: 0 Intact Side	Head Shaking Nystagmus: 0 Affected Side
Torsional nystagmus	+	0
Nystagmus following the 180° rotations (head in standard position)	0	+

+: presence; 0: absence.

not demonstrate any response at the caloric test, but smooth pursuit and saccade recordings were normal. CDP demonstrated equilibrium scores in conditions 5 and 6, which were reduced to 0.

These patients demonstrated neither torsional nystagmus during the roll head tilt nor nystagmus at the cessation of the horizontal constant velocity rotations. Rotating the body with respect to the fixed head induced a nystagmus mimicking a vestibuloocular response (Table 4).

Discussion

With our procedure, normal subjects did not have any nystagmus at the cessation of the horizontal constant velocity whole body rotations. The cessation of the rotation toward the affected side, in fact, is a brief angular acceleration toward the intact side. All the unilateral labyrinthine-defective patients, even compensated in classical ENT vestibular tests, demonstrated a nystagmus after a rotation toward the affected side when the head was in standard position, and a nystagmus at the cessation of a rotation toward the intact side when the head was tilted on the shoulder. These results are similar to those obtained after bithermal (30°C and 44°C) irrigations of both ear simultaneously. For unilateral labyrinthine-defective patients, even compensated patients, irrigation of both ears simultaneously induced a nystagmus. The side of the lesion in indicated by the direction of the quick phases of the nystagmus induced by the cold irrigation (3).

With this procedure, a complete loss of vestibular function can be defined as follows:

- no response after roll head tilt
- no response at the cessation of the horizontal constant velocity whole body rotations
- no response in the head shaking test
- nystagmus mimicking a vestibuloocular response while rotating the body with respect to the fixed head

The slow phase of torsional nystagmus or, ocular counterrolling (OCR), is a torsional movement of the eyes, and it is evoked in the

Table 3. Torsional and Rotation Test Results in Unilateral Labyrinthine Defective Patients in the Acute Stage

Spontaneous Nystagmus: 0	Gaze Nystagmus: 0 Intact Side	Head Shaking Nystagmus: + Affected Side
Torsional nystagmus	+	0
Nystagmus following the 180° rotations (head in standard position)	0	+

+: presence; 0: absence.

Table 4. Torsional and Rotation Test Results in Bilateral Labyrinthine Defective Patients

Spontaneous Nystagmus: 0	Gaze Nystagmus: 0 Intact Side	Head Shaking Nystagmus: 0 Affected Side
Torsional nystagmus	0	0
Nystagmus following the 180° rotations (head in standard position)	0	0
Rotation of the body with respect to the fixed head	+	+

+: presence; 0: absence.

opposite direction to that of the head movement, even in darkness (5). The static OCR is considered to be caused by the utriculus, but the very small changes in eye position cannot be studied with videonystagmoscopy. The dynamic component of OCR is said to involve stimulation of otolith organs, vertical canals, and neck receptors.

Conflicting results have been reported following a unilateral neurectomy. It appears that there is no clear relationship between the side of the neurectomy and OCR (6,7,8). In some cases of our population, an absence of torsional nystagmus during passive roll head tilt was noted, while these patients behaved as normal subjects according to their responses following the horizontal rotations. Shortly after a unilateral vestibular neurectomy, patients still demonstrate a spontaneous nystagmus with quick phases directed toward the intact side. When the head of the patient is roll-tilted toward the intact side, the spontaneous nystagmus is superimposed onto the torsional induced nystagmus. After section of the vestibular nerve, the torsional nystagmus induced by head tilt was not subjectively observed when the head of the patient was tilted to the side of the lesion.

Apart from the great help in the definition of reflectivity of the vestibular system, this protocol is very useful to follow the fluctuating reflectivity of an hydrops. It has been demonstrated that in hydrops, there is a direction changing of the nystagmus in relation to the spinning vertigo crisis. After a crisis, the responses could be very challenging: there is a nystagmus at the cessation of the rotation toward the intact side and a smaller one after rotation toward the affected side. It looks as if the diseased ear had a better response than the good one, but the head shaking test still indicates the bad ear.

Perilymphatic fistulas, which are so controversial in the diagnosis and challenging because of the near normal responses to the usual tests, can readily be studied objectively with videonystagmoscopy. "Valsalva" induces a slow torsional eye movement without a quick phase. The direction of the torsion changes in relation to the pressure-depression of the Valsalva.

Vestibular disorders of central origin can be differentiated from peripheral ones by the high frequency of the nystagmic responses as well as the duration of the responses at the cessation of the rotations, which is much longer than for peripheral disorders. This particular population needs a larger number of observations.

Conclusion

Videonystagmoscopy allows screening of vestibular function at the bedside. In any conditions with this procedure, the presence of a nystagmus at the cessation of the horizontal constant velocity whole body rotation is abnormal; an asymmetry of the responses reveals a vestibular deficit. These are preliminary results, and a further study using videonystagmography is in progress to measure this behavioural asymmetry.

This simple, cheap, fast procedure can be used by any clinician. Cost effectiveness of health care can be dramatically reduced by such a procedure and by starting treatment in the very short period following the onset during which compensation takes place, thus avoiding expensive investigations and decreasing the no-work time.

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