Original Contribution Kitasato Med J 2017; 47: 105-109

Detection of nystagmus in the eyes-closed condition using electronystagmography

Susumu Obata,[1] Junko Suzuki,[2] Mayumi Murayama,[2] Naomi Shimokawa,[2] Naohito Ishii,[3] Shinichi Munekata,[1,2] Hideaki Naganuma,[4] Yuhsaku Kanoh[1,2,5]

[1] Department of Clinical Laboratory, Kitasato University Hospital
[2] Department of Clinical Laboratory, Kitasato University East Hospital
[3] Kitasato University School of Allied Health Sciences
[4] Division of Neurotology, Department of Advanced Medicine, Research and Development Center for New Medical Frontiers, Kitasato University School of Medicine
[5] Department of Laboratory Medicine, Kitasato University School of Medicine

Objectives: Video-oculography (VOG) is widely used because it is non-invasive. However, eye movements in the eye-closed condition cannot be recorded using VOG. Thus, we investigated the detection the incidence of nystagmus in the eye-closed condition using electronystagmography (ENG).
Methods: We investigated 3,564 cases in a total of 3,505 patients who underwent ENG at the Kitasato University East Hospital, from April 2012 through November 2015. We recorded the incidence of nystagmus in the eye-closed condition of these patients.
Results: The present study was comprised of 1,459 (40.9%) cases of nystagmus. Among these, 9 patients (0.3%) had nystagmus in the eye-closed condition, and 73 (2.1%) had nystagmus in the eye-closed condition during mental arithmetic calculations. When we compared the detection of nystagmus according to the observation condition, 700 (19.6%) cases of nystagmus were detected in the eye-closed condition during mental arithmetic calculations, which had a higher incidence compared to that in other conditions.
Conclusions: While using VOG or Frenzel's glasses, we should carefully observe patients with nystagmus because it is not usually detected using these methods. Furthermore, it is desirable to perform VOG in the blindfolded condition during mental arithmetic calculations because nystagmus has a high incidence of detection during this condition, similar to that in the eye-closed condition.

Key words: electronystagmography, video-oculography, eyes-closed condition, blindfolded condition, nystagmus

Introduction

Recording of abnormal ocular movements is useful in the diagnosis and treatment of equilibrium disorder.[1-3] Electronystagmography (ENG) and video-oculography (VOG) are widely used for objectively recording abnormal ocular movement.[4-6] Because ENG requires expensive equipment, it is carried out only in hospitals equipped with the appropriate facilities.[4] Contrarily, VOG is used at many hospitals because of its simple procedure compared with that of ENG. VOG does not require the attachment of any electrodes and imposes few burdens on the patient compared with those using ENG. However, VOG does have a drawback in that it cannot record eye movement under the eyes-closed condition (EC). On the other hand, ENG cannot record pure rotatory nystagmus, but it can record ocular movement under the EC. Further, ENG is also particularly sensitive in its detection of ocular movement information.[6] In this study, we investigated the incidence of nystagmus under the EC using ENG in patients who underwent examinations at our clinical laboratory.

Material and Methods

This study was approved by the Kitasato University

Received 23 February 2017, accepted 4 April 2017
Correspondence to: Susumu Obata, Department of Clinical Laboratory, Kitasato University Hospital
1-15-1 Kitasato, Minami-ku, Sagamihara, Kanagawa 252-0375, Japan
E-mail: susumu-o@kitasato-u.ac.jp

institutional review board for observation and epidemiological study. We investigated 3,564 cases in a total of 3,505 patients who complained of dizziness and underwent ENG at Kitasato University East Hospital, from April 2012 through November 2015. We recorded the incidence of nystagmus in the EC of these patients using ENG. The patients underwent inspections of ENG multiple times, when there were inspection results of more than 1 year after the first inspection, all of the results were collected for analyses. To conduct ENG, we used the nystagmus inspection unit (Figure 1), which connected the electronystagmograph NY-50 (Rion Co., Ltd., Tokyo), the visual sense stimulation presentation device CR-58 (Nagashima Co., Ltd., Tokyo), and the rotary pendulum chair S-2 (Nagashima). The protocol for ENG assessment is shown in Figure 2. In the ENG examination at our hospital, we first perform the gaze nystagmus test and then the non-gaze nystagmus test under the eyes-closed and blindfolded conditions. For each non-gaze nystagmus test, mental arithmetic is added. The placement of the electrode was based on the standard method determined by the Japanese Society for Equilibrium Research. Ocular movement was recorded in the vertical and lateral directions, the normal waveform with a time constant of 3.0 seconds and the speed waveform with a time constant of 0.03 seconds. The ocular 10° calibration was recorded before starting ENG. Dark goggles were attached to the patients' eyes for ENG during the non-gaze nystagmus test so that light did not leak through. After the medical technologist fill in the laboratory findings, the neurotologists make the final judgement of the results.

Results

Incidences of nystagmus

The number of cases and the incidences of nystagmus for ENG are shown in Table 1. During the study period, 3,564 cases were assessed, and 1,459 (40.9%) of those cases were determined to have nystagmus. Abnormal ocular movement other than saccadic nystagmus was detected in 2 cases, both of which showed congenital horizontal pendular nystagmus and an inversion pattern in the optokinetic pattern.

Clinical backgrounds of the patients who underwent an ENG examination

Using the classification system[7] of the Department of Otorhinolaryngology (previous), Kitasato University School of Medicine, we classified the clinical backgrounds of the target patients into five disease groups: peripheral vestibular disorders (P), central nervous system disorders (C), generalized disorders (G), diagnosed from symptoms (S), and undetermined (U). Further, we classified the number and age distribution into groups (Table 2). The P group, including disorders such as Meniere's disease, made up of 2,173 (61.0%) cases, was the largest group. The S group, including patients who had made complaints such as dizziness, was comprised of 1,319 (37.0%) cases. Finally, the C, G, and U groups were comprised of 43 (1.2%), 17 (0.5%), and 12 (0.2%) cases, respectively.

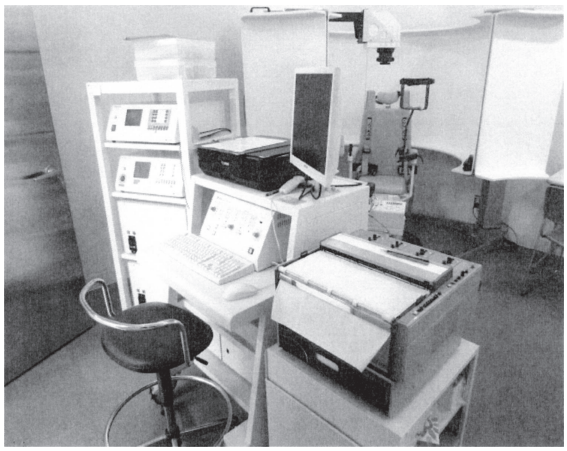

Figure1. Nystagmus inspection unit

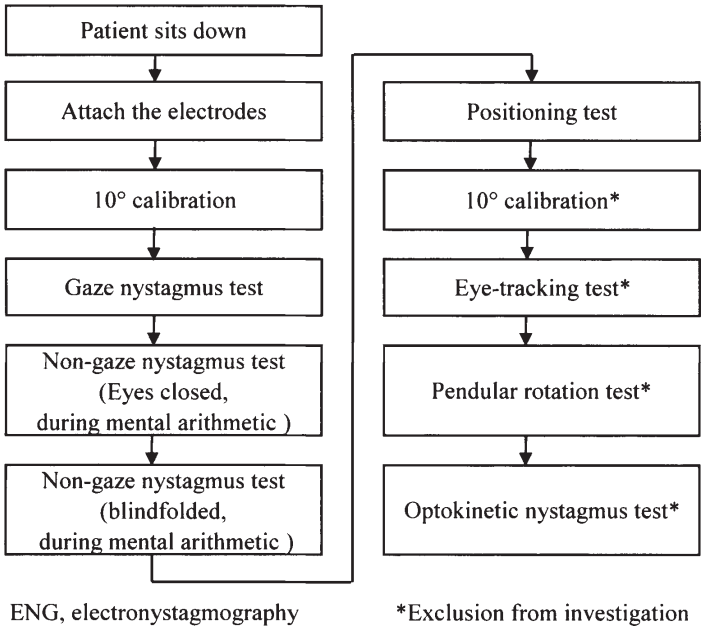

Figure 2. The protocol for ENG assessment

Incidence of nystagmus under the EC for ENG

Table 3 shows the total incidences of nystagmus under each observation condition. Nystagmus was detected in 700 (48.0%) cases under the mental arithmetic calculations (MAC)-EC, and it was detected in 507 (34.3%) cases under the blindfolded with eyes-opened condition during MAC. On the other hand, fixation nystagmus was detected in about 1% of the cases assessed using ENG.

Table 4 shows the number of nystagmus cases detected using ENG under only the EC and eyes-closed during MAC-EC. Of the 1,459 patients who had nystagmus, 123 (8.4%) cases had nystagmus under the EC without fixed nystagmus. Specifically, 9 (0.6%) cases had nystagmus under only the EC, 73 (5.0%) cases had nystagmus only under the MAC-EC, and 41 (2.8%) cases exhibited nystagmus under both conditions. In these 123 cases, 72 cases (58.5%) were patients with Meniere's disease, 22 cases (17.9%) had positional vertigo including benign paroxysmal positional vertigo (BPPV), 22 cases (17.9%) had a diagnosed symptom of dizziness, and 9 cases (7.3%) were patients from the undetermined group.

Table 5 shows the direction of nystagmus in the 123 cases determined to have nystagmus under only the EC. Of these, many were horizontal nystagmus cases; however, a few cases were vertical nystagmus.

Incidence of nystagmus detected using an infrared charged-coupled device (CCD) camera under the EC

Of the 123 cases determined by ENG to be nystagmus in only the EC and MAC-EC, 15 cases were assessed by neurotologists using an infrared charged-coupled device (CCD) camera (Sony; Lantana, FL, USA) during the ENG inspection. Of those 15 cases, the infrared CCD camera did not detect nystagmus in 12 cases (80.0%) but did in 3 cases (20.0%).

Table 1. Cases and incidences of nystagmus for ENG

	Inspections	Nystagmus cases	Abnormal eye movement cases
Male	1,117	422	0
Female	2,447	1,037	2
Total	3,564	1,459	2

ENG, electronystagmography

Discussion

The observation of abnormal oculomotor behavior has often been conducted using equipment such as ENG or VOG exclusively.[1-3] Since Henriksson first reported an ENG measurement in 1955,[8] ENG has been widely used as a method to record abnormal oculomotor responses.

Table 2. Classification of number and age distribution

Clinical backgrounds	Age							
	Total	Total (%)	<20	20−29	30−39	40−49	50−59	>59
Peripheral vestibular disorders	2,173	61.0	2.6	6.9	11.6	19.6	14.6	44.7
Central nervous system disorders	43	1.2	2.3	7.0	7.0	9.3	18.6	55.8
Generalized disorders	17	0.5	23.5	5.9	5.9	23.5	17.6	23.6
Diagnosed from symptoms	1,319	37.0	4.0	3.6	9.3	12.7	12.3	58.1
Undetermined	12	0.3	66.7	0.0	8.3	16.7	8.3	0.0

Table 3. Incidences of nystagmus according to observation condition

	Gaze nystagmus test					Non-gaze nystagmus test				Positoning nystagmus test				
						Eyes closed		Blindfolded		Head inclinaton directon				
	Left	Mid	Right	Up	Down	Eyes closed	During mental arithmetic	Blindfolded	During mental arithmetic	Left	Standard	Right	Up	Down
Total	31	14	39	18	28	362	700	484	507	341	430	410	407	527
%	2.1	1.0	2.7	1.2	1.9	24.8	48.0	33.2	34.7	23.4	29.5	28.1	27.9	36.1

Table 4. Nystagmus in eyes-closed and blindfolded conditions

	Eyes closed	Eyes closed during mental arithmetic	Both
Male	1	25	10
Female	8	48	31
Total	9	73	41
	Blindfolded	Blindfolded during mental arithmetic	Both
Male	4	7	5
Female	8	10	11
Total	12	17	16

Note: Excluding the blindfolded condition while positoning the nystagmus test

Table 5. Direction of nystagmus in cases determined to have nystagmus in only the eyes-closed condition

Conditon	Direction of nystagmus										
Eyes closed	ND	ND	Right	ND	Down	Various	Various	Left	Up	ND	Other
Eyes closed during mental arithmetic	Right	Left	Right	Down	Down	Left	Right	Left	ND	Up	Other
Total (n = 123)	39	22	12	5	4	4	4	3	1	1	28

ND, not detected

Endo et al.[9] reported that the incidence of nystagmus recorded using ENG was 34.2 times higher than that recorded with Frenzel's glasses and 13.5 times higher than that recorded with an infrared CCD camera. On the other hand, because of its ease of use, various types of VOG have been developed, and their use has become widespread.[5,10] However, because VOG cannot record ocular movement with the eyes closed, a nystagmus diagnosis may be missed in patients when only using VOG for assessment. Except for central nystagmus, spontaneous nystagmus is suppressed by one-point gazing; and non-gaze nystagmus tests such as in the EC and blindfolded condition is performed for the ENG inspection. As the level of consciousness decreases, spontaneous nystagmus becomes increasingly more difficult to detect. Therefore, in such cases, the patient is asked to perform mental arithmetic during the test.

In the present study, nystagmus was detected in 8.4% of the cases only when the eyes were closed, suggesting the utility of ENG for observation when the eyes are closed. When nystagmus was assessed using an infrared CCD camera, the incidence decreased compared with that found in the same group of patients assessed using ENG. Thus, the infrared CCD camera should be used in combination with ENG, which has a high incidence of detection. When the incidences of detection of nystagmus were compared according to the test conditions under which they were observed, the MAC-EC revealed more cases of nystagmus than did any other observation conditions. Because there is a large number of detections of nystagmus in the blindfolded with eyes-opened condition, as well, regarding carrying out inspections under the MAC-EC, it was reconfirmed as a useful inspection method to detect nystagmus.

In the present study, of the 123 cases in which nystagmus was detected under the EC, for those classified by diagnosis, the most common disease was Meniere's disease, of which there were 72 cases. Secondly, positional vertigo such as benign paroxysmal positional vertigo (BPPV) was recognized in 22 cases. The reasons that patients with Meniere's disease were the most common among those who had nystagmus, were as

follows. 1) The number of patients having Meniere's disease was large. As a new treatment for Meniere's disease, hydration therapy has been developed in the Department of Neurotology, at Kitasato University East Hospital,[11] where many patients with Meniere's disease have been successfully treated. 2) The observation of nystagmus using ENG was conducted in a short period from the patient's first visit or a Meniere's disease attack.

Recently, BPPV accounts for most cases of dizziness, and there are reports that BPPV has a higher incidence of detection at clinics compared with that at university hospitals.[10] Not only were many cases of pure rotatory nystagmus, which are undetectable by ENG, observed in BPPV but also direction-changing rotatory-type of positional nystagmus and direction-changing-type of positional nystagmus, which is detectable in ENG, were observed in patients with BPPV.[12-15] Furthermore, it was again realized that ENG, which can accurately detect nystagmus, was effective as a clinical examination tool. In the present study, the nystagmus that was detected under only the EC had been missed in cases of BPPV; therefore, we should carefully assess for nystagmus using more sensitive tools, because nystagmus is often not detected using only VOG or Frenzel's glasses. Furthermore, it is also desirable to perform VOG in the blindfolded condition while the patient is doing mental arithmetic calculations, because nystagmus has a high incidence of detection under this condition, similar to that under the EC.

Acknowledgments

This study was supported by the Department of Clinical Laboratory, Kitasato University Hospital and the Department of Clinical Laboratory, Kitasato University East Hospital.

References

1. Naito R, Imai C, Sugasawa K. Abnormal eye movement in patients with spinocerebellar ataxia type 3 (Machado-Joseph disease). *Equilibrium Res* 2014; 73: 512-20 (in Japanese with English abstract).
2. Iwasaki S, Nozue M, Mori Y, et al. Clinical assessment of direction changing positional nystagmus. *Nihon Jibiinkoka Gakkai Kaiho* 1992; 85: 699-705 (in Japanese with English abstract).
3. Itoh A. Diagnostic significance and test methods of electronystagmography (ENG). *Equilibrium Res* 2010; 69: 401-11.
4. Matsunaga T. Routine of the equilibrium function test. *Equilibrium Res* 1986; 45: 285-301 (In Japanese).
5. The Japanese Society for Equilibrium Research. Manual of Positional nystagmus and positional changing nystagmus by infrared CCD/C-MOS camera. *Equilibrium Res* 2012; 71: 284-6 (In Japanese).
6. The Japanese Society for Equilibrium Research. *Illustration - The inspection of dizziness*. Shindan To Chiryo Sha, Inc.; 2009; 40-83 (in Japanese).
7. Tokumasu K, Kawano R, Tashiro N, et al. A report on patients with vertigo or ataxia seen at the Nero-Otological Clinic of Kitasato University Hospital during a seven-year period. *Equilibrium Res* 1979; 38: 269-75.
8. Henriksson NG. An electrical method for registration and analysis of the movements of the eyes in nystagmus. *Acta Otolaryngol* 1955; 45: 25-41.
9. Endo M, Sakata E, Ohtsu K, et al. Comparison of nystagmus-detection rates with Frenzel's spectacles, infrared CCD-camera and ENG. *Equilibrium Res* 1995; l54: 236-41.
10. Ichimura A. Clinical survey of vertiginous outpatients at an ENT clinic. *Equilibrium Res* 2015; 74: 274-81 (in Japanese with English abstract).
11. Naganuma H, Kawahara K, Tokumasu K, et al. Water may cure patients with Meniere disease. *Laryngoscope* 2006; 116: 1455-60.
12. Sekine K, Sato G, Takeda N. Incidence of vertigo and dizziness disorder at a university hospital. *Nihon Jibiinkoka Gakkai Kaiho* 2005; 108: 842-9.
13. Matsuyoshi H, Minoda R, Miwa T, et al. Clinical statistics of recent vertigo and dizziness cases at Kumamoto University Hospital. *Equilibrium Res* 2009; 68: 208-13.
14. Uno A, Moriwaki K, Kato T, et al. Clinical features of benign paroxysmal positional vertigo. *Nihon Jibiinkoka Gakkai Kaiho* 2001; 104: 9-16.
15. Iida M. Diagnosis for benign paroxysmal positional vertigo (BPPV). *Nihon Jibiinkoka Gakkai Kaiho* 2007; 100: 1032-3 (in Japanese).