Caloric Eye-Tracking Pattern Test: Visual Suppression and the Possibility of Simplified Differential Diagnosis Between Peripheral and Central Vertigo

Eiji Sakata and Kyoleo Ohtsu

Center for Vertigo, Disequilibrium, and Tinnitus Diseases, Tokyo, Japan

Abstract: During the examination of patients who complain of vertigo or who have equilibrium disorders, often identifying the etiology of the disorders is difficult (i.e., determining whether it is dependent on a peripheral or a central vestibular disorder). To attempt to determine the etiology in these cases, we devised a new method: the caloric eye-tracking pattern test. In normal subjects and in patients with peripheral disorders, as is well-known, caloric nystagmus has little influence on the eye-tracking pattern. In contrast, in patients with central vestibular disorders, caloric nystagmus evoked abnormalities in the eye-tracking pattern, either superimposed or as saccades, despite the fact that the eye-tracking pattern before caloric stimulation was normal. These findings result from the visual suppression mechanism to vestibular nystagmus. We can conclude that the visual suppression to vestibular nystagmus is evoked more strongly by pursuing a moving visual stimulus than by gazing at a stationary target. These results are interesting, not only from the physiological viewpoint but from the clinical viewpoint. The differential diagnosis should include both peripheral and central vertigo.

Key Words: central vertigo; differential diagnosis; peripheral vertigo; visual suppression

During the examination of patients who complain of vertigo or who have equilibrium disorders, often identifying the etiology of the disorders is difficult. This is especially true in cases that are called *vertiginous attack without cochlear sign*. We cannot be sure whether these disorders depend on peripheral or on central defects. The patients have attacks of vertigo with nausea and other autonomic nervous signs. However, these patients do not complain of tinnitus; their audiological examination and caloric test results are normal. Therefore diagnosing the disorders as inner-ear dysfunction is problematic. Moreover, no disorders of the central nervous system are disclosed either in their medical histories or in their neurological examination results. We cannot diagnose their conditions with confidence, for instance, as vertebral basilar artery insufficiencies. To attempt to determine the etiologies in these cases, we devised a new testing method.

Spontaneous nystagmus of peripheral origin is well-known to have little influence on the eye-tracking pattern (ETP) [1]. In contrast, spontaneous nystagmus of central origin has an influence on the ETP, for instance, as the congenital nystagmus is superimposed on the ETP [1–4]. In normal subjects and in patients with peripheral disorders, even if vestibular asymmetry is revealed by the caloric test, only a slight influence is evoked on the ETP [5]. In patients with central disorders, however, caloric nystagmus evoked abnormalities on the ETP, either superimposed or as saccades, despite the fact that the ETP before caloric stimulation was normal. These results suggest to us the possible differential diagnosis of both peripheral and central disorders. We named our new test method the *caloric eye-tracking pattern (CETP)* test.

Reprint requests: Dr. E. Sakata, Nishishinjuku 1-7-1, Shinjukuku, Tokyo 160-0023, Japan. Phone: 0081-3-3340-1751; Fax: 0081-3-3340-1750.

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MATERIALS AND METHODS

Seventeen normal subjects and 161 patients were tested. The latter group included 33 patients with peripheral disorders, such as Ménière's disease and benign paroxysmal positional nystagmus, and 128 patients with central disorders (e.g., vertebral basilar artery insufficiency, cerebellar infarction, organic solvent intoxication, and Wernicke's encephalitis). The cases of central disorders were limited to those patients whose ETP before caloric stimulation was normal or borderline. Initially, we administered the eye-tracking test using a target that moves horizontally at 0.3 cycles/sec. Pursuit eye movements were recorded with the aid of electronystagmography (ENG), which results in a sinusoidal curve tracing for the horizontal component. Next, we performed the caloric test on the right ear, using 20 ml of ice water for 10 sec. During the evoked caloric nystagmus, we administered the eye-tracking test, and the ETP was recorded for 20 seconds beginning 50 seconds after the start of the ice-water injection. This procedure was repeated on the left ear. The results in each case were presented as three patterns of ENG recording: pattern A obtained before caloric stimulation, pattern B obtained during caloric testing of the right ear, and pattern C obtained during caloric testing of the left ear. We call the pattern while the caloric nystagmus is evoked the *caloric eye-tracking pattern*.

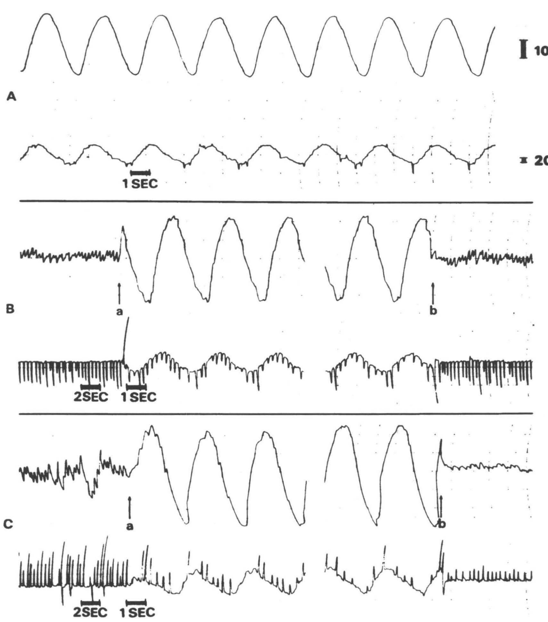

Figure 1. Normal subject. (A) The eye-tracking pattern (pattern A) before caloric stimulation shows a sinusoidal curve without saccades. The upper trace is the electronystagmogram (ENG) of the horizontal component of the eye movement (time constant, 3.0 msec), and the lower trace is the differentiated ENG of the upper trace (time constant, 0.03 msec). Calibrations are shown by the vertical bars on the right end of the tracings: 10 degrees for the eye movement (upper bar); 20 degrees/sec for the eye velocity (lower bar). The target of the eye-tracking test moves horizontally at 0.3 cycles/sec. (B) The caloric eye-tracking pattern (CETP) (pattern B) of the right side. During the evoked caloric nystagmus, the eye-tracking test is administered. The eye-tracking pattern is recorded for 20 seconds, beginning 50 seconds after the start of the ice-water injection. The *a* marks the beginning of the eye-tracking test, whereas the *b* marks its end. The middle part of the eye-tracking pattern is deleted and indicated by the breaks in the curves. Even after the eye-tracking test is stopped, caloric nystagmus is observed. (C) The CETP (pattern C) of the left side revealed and presented as in pattern B.

RESULTS

The results obtained on a normal subject are shown in Figure 1 and are typical of the findings of the 17 normal subjects tested. Notable is that even after the eye-tracking test is stopped, caloric nystagmus is observed. The results from the normal subjects, as shown in Figure 2, illustrate the well-known fact that nystagmus of peripheral origin has little influence on the ETP. The eye movement (upper traces of patterns B and C) is affected only slightly by the caloric nystagmus; we can say that this is a case of borderline recording. Concerning the eye velocity (lower traces of patterns B and C), the change of speed is slight, as the figure shows. We administered this test to 33 patients who had peripheral vestibular disorders. Figure 3 shows the results obtained in a case of left-sided Ménière's disease, which is representative of this group. The CETPs are normal, just as they are for the normal subjects (as illustrated in Figure 2). We studied 128 patients with central vestibular insufficiency by means of this test. The results demonstrated that 121 of 128 cases had obvious superimposed nystagmus or saccades.

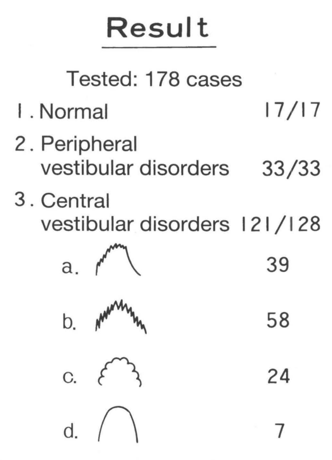

Figure 2. Result from normal subject (1) and from pathological subject (2 and 3).

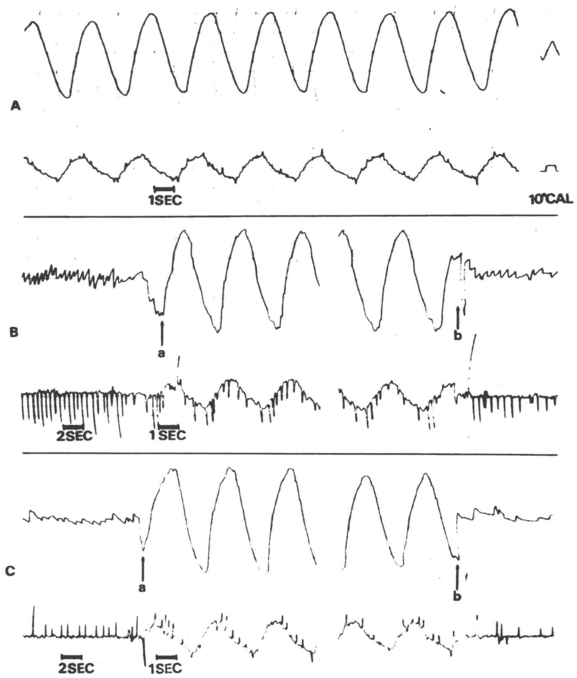

Figure 3. Left-sided Ménière's disease. The caloric eye-tracking patterns are normal, just as they are in Figure 1.

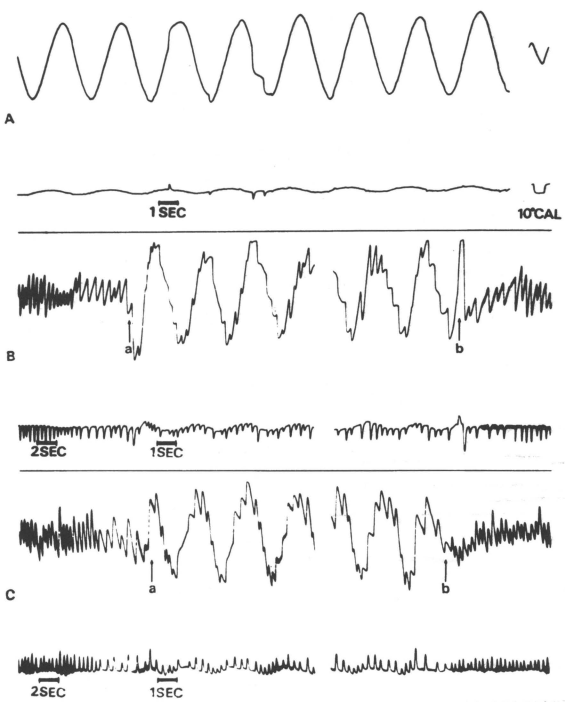

Figure 4. Result of caloric eye-tracking pattern test in Patient 1. Pattern A is normal, but in patterns B and C it is seen that the caloric nystagmus is superimposed on both the quick and slow phases. These results are obviously quite different from those illustrated for normal subjects and for patients with vestibular peripheral disorders. (See Figure 1 for explanation of symbols.)

CASE REPORTS

Patient 1

During 3 years prior to his first visit, a 32-year-old male patient had monthly attacks of rotatory vertigo without cochlear sign. However, he had hand tremor, diplopia, motor weakness, and "glove-and-stocking" paresthesia during these attacks. A diagnosis of vertebral basilar artery insufficiency was made. The result of the CETP test is shown in Figure 4. Pattern A is normal, but patterns B and C demonstrate the caloric nystagmus superimposed on both the quick and slow phases. These results are obviously fairly different from those illustrated for normal subjects and for patients with vestibular peripheral disorders.

Patient 2

During a period of 2 months, a 52-year-old female patient presented with a rotatory vertigo with alternating, fluctuating glove-and-stocking paresthesia, tremor, hoarseness, dysphagia, and motor weakness of the lower extremities. However, she displayed no cochlear signs. The diagnosis in this case also was vertebral basilar artery insufficiency. On the CETP test, pattern A is normal, but patterns B and C demonstrate superimposed caloric nystagmus (Fig. 5).

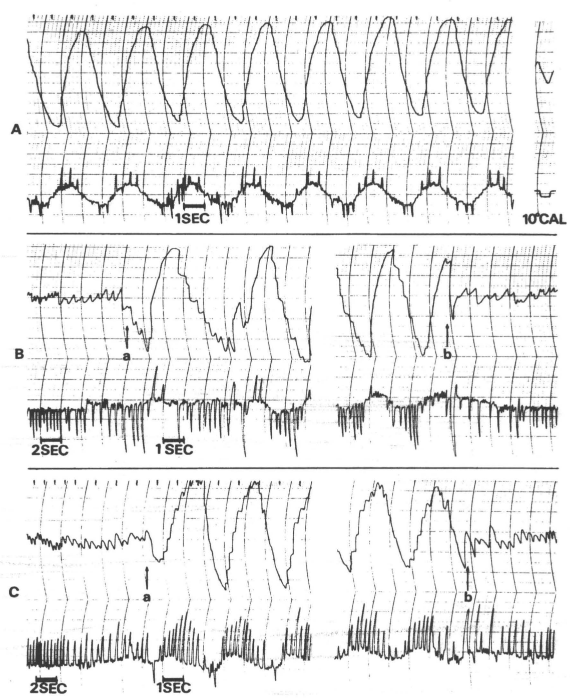

Figure 5. Result of caloric eye-tracking pattern test in Patient 2. On the caloric eye-tracking pattern test, pattern A is normal but, in patterns B and C, it is seen that the caloric nystagmus is superimposed. (See Figure 1 for explanation of symbols.)

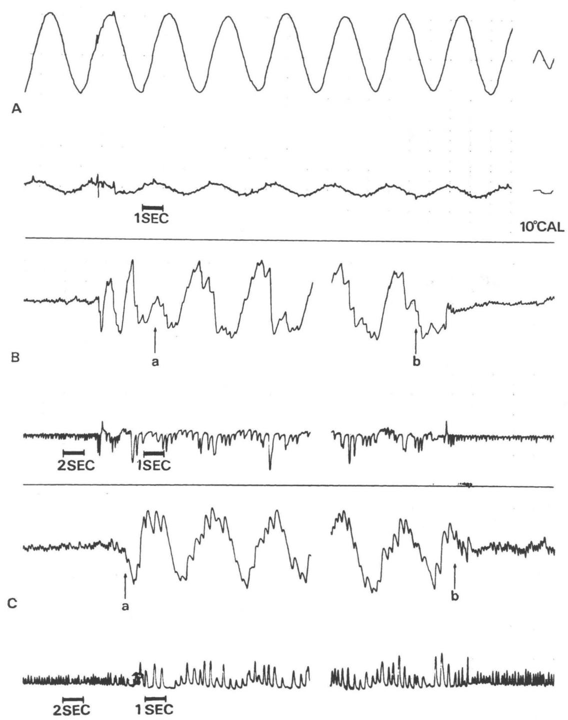

Figure 6. Result of caloric eye-tracking pattern test in Patient 3. Pattern A is normal. In patterns B and C, however, it is obvious that the caloric nystagmus is superimposed on the eye-tracking pattern, although its amplitude is very small. (See Figure 1 for explanation of symbols.)

Patient 3

A 33-year-old female patient had severe rotatory vertigo with laryngeal paralysis, hoarseness, seesaw nystagmus, crossed sensory disturbance, and Horner's sign, but no cochlear sign. She was believed to have typical Wallenberg's syndrome of the right side. One year after the onset of the attack, the CETP examination was carried out. At that time, neither seesaw nystagmus nor neurological signs were evident, but she complained of slight dizziness. Pattern A was normal. In patterns B and C, however, obviously the caloric nystagmus is superimposed on the ETP, although its amplitude is very small (Fig. 6).

DISCUSSION

The method described in this report—three patterns of ENG recording—is presented as a basis for diagnosis. In normal subjects, pattern A is normal, and caloric nystagmus has little influence on the ETP. Similar results are obtained from patients with peripheral disorders. In contrast, in central vestibular disorders, 121 of 128 patients exhibited abnormalities on the ETP. One question that arises is whether the amplitude of the calorically induced nystagmus has an influence on the ETP. As the amplitude of caloric nystagmus is small in patients with peripheral vestibular disorders, it may not be superimposed on the ETP. Conversely, in central vestibular disorders, because caloric nystagmus has a large amplitude, it may be superimposed on the ETP. The records that were obtained from a patient with Wallenberg's syndrome would seem to answer this question. Pattern A was normal. In patterns B and C, however, obviously the caloric nystagmus is superimposed on the ETP, although its amplitude is very small.

Obviously, normal subjects and patients with vestibular peripheral disorders exhibit no oculomotor disorders. The visual suppression mechanism operates normally. Therefore, even if vestibular asymmetry is revealed by the caloric test, the superimposed nystagmus is not remarkable. In some cases of central disorders, if the disorder of the oculomotor system is slight, the ETP is normal. However, once the vestibular asymmetry is shown by the caloric test, the caloric nystagmus is superimposed clearly on the ETP. These changes result from the disorder of the visual suppression mechanism. In conclusion, we can say that the visual suppression to the vestibular nystagmus is evoked more strongly by pursuing a moving visual stimulus than by gazing at a stationary target. Moreover, this CETP test seems to afford the possibility of a simplified differential diagnosis between peripheral and central disorders and the ability to judge the results of treatment over time.

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