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Clinical Study on the Combined Galvanic Test

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Abstract The galvanic nystagmus test and the galvanic body sway test have been used for detecting retrolabyrinthine disorder. Sekitani(1988) reported on the "Combined galvanic test", developed for simultaneous recording of both galvanic eye movement and galvanic body sway.

To investigate patients with retrolabyrinthine disorder by the Combined galvanic test, eleven cases with vestibular neuronitis were studied with the caloric test and the Combined galvanic test successively. It was determined that the findings of the caloric test corresponded to the findings of the galvanic eye movement test, but did not always correspond to those of the galvanic body sway test. We therefore suggest that the galvanic body sway test reflects abnormality in a different system from the one reflected in the galvanic eye movement test and the caloric test. It is agreed that the caloric response mainly originates from the semicircular canal system. Thus we assume that the galvanic eye movement test reflects mainly abnormality in the semicircular canal system, while the galvanic body sway test reflects abnormality in the otolithic system. The Combined galvanic test could be useful for differentiating between disorders of the semicircular canal system and of the otolithic system.

Key Words: Galvanic eye movement test, Galvanic body sway test, Vestibular neuronitis.

Introduction

The galvanic nystagmus test and the galvanic body sway test (GBST) are galvanic tests designed to assess equilibrium function. Galvanic nystagmus[1] was initially reported by Hitzig and employed as a clinical test by Neumann. Thereafter, Pfaltz[2)-5)] and Takashima[6] reported that galvanic nystagmus test

helped to diagnose retrolabyrinthine disorder. As for GBST, Mashida[7] introduced a galvanic test based on vestibulo-spinal response and Sekitani[1] has developed and reported the Computer Galvano-Acceleration registrogram (ARG), measuring galvanic body sway response more quantitatively. Tanaka, et al,[8] described abnormal GBST findings in the case of retrolabyrinthine disorder. So far, the galvanic nystagmus test and the GBST have been performed individually. However, Sekitani developed a galvanic test system which records galvanic eye movement (GEM) and galvanic body sway (GBS) simultaneously by eye mark recorder and stabilometer, and named the "Combined galvanic test (CGT)"[9),10)].

The purpose of this study is to investigate patients with vestibular dysfunction. especially with retrolabyrinthine disorder, by using CGT and to evaluate the significance of this test for clinical diagnosis.

Table 1 Details of the eleven cases.

case	age	sex	affected side	Period after the onset	
				initial examdnation (days)	final dxamination (months)
1	49	F	R	6	11
2	36	M	R	29	16
3	26	F	R	24	8
4	53	M	R	13	39
5	24	M	R	3	32
6	54	F	R	9	24
7	30	F	L	14	27
8	29	F	L	5	11
9	53	M	L	22	14
10	22	M	L	6	45
11	38	M	L	30	6
(mean)	37.6			14.1	21.2

Subjects

The subjects were eleven cases with vestibular neuronitis, six males and five females, aged 22 to 54 (mean age 37.6)(Table 1). The diagnosis was made on the basis of the criteria of the Vestibular Disorder Research Committee of the Ministry of Health and Welfare of Japan.

The cases were successively studied with the CGT at least three times. The initial examination was performed within one month of the onset of the vertigo. The observation periods varied from 6 months to 39 months (mean 21.2 months).

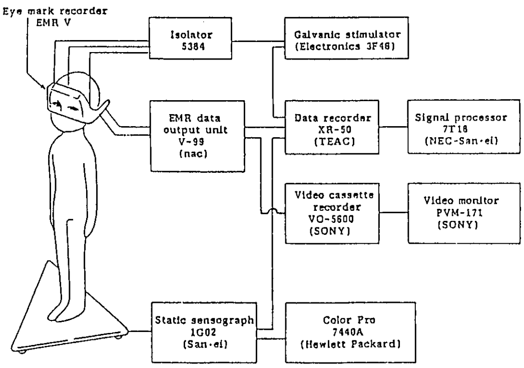

Fig. 1 Block diagram of the Combinend galvanic test (CGT).

Method

The GEM was measured with an eye mark recorder (Eye mark recorder Vmanufactured by nac Co.). The GBS was measured with a stabilometer (SAN-EI SOKKI static sensograph 1G02). The GEM and the GBS were simultaneously recorded with a data recorder (TEAC recorder XR50).

The examination was performed in a dark room. The subject stood on a stabilometer in Romberg posture wearing the eye mark recorder. The face was covered by a blindfold, A block diagram of the system is shown in Figure 1.

An electrical stimulator (NEC SAN-El 3F46, equipped with an isolator 5384) was used as a galvanic stimulator. An electrode for electrocardiography (NEC SAN-EI SILVER/SILVER CHLORIDE MONITORING ELECTRODE, No. 1002) was used. The electrode is of 20 mm diameter and about 314 mm^2 in area, and an adhesive for the electrode is contained in the sponge. The stimulation electrode was placed on the retroauricle of each ear and the indifferent electrode was placed on the forehead. The galvanic stimulation was square-wave type, and administered by the monopolar-monoaural method with 0.6mA for 5 seconds. An average of 5 records were computed.

A signal processor (NEC SAN-EI 7T18)

was used as an analyzer. The left and right directions of GEM and GBS, respectively, were averaged after addition. The repetition period of galvanic stimulation was 20 seconds.

Results

Control study

Fig. 2 shows the finding of the CGT in the case of a healthy adult, by cathodal stimulation on the right retroauricular electrode. The eyes and body responded by moving in predictable directions after the onset of stimulation. The eyes moved to the opposite side from the stimulated ear, and the body moved to the same side as the stimulated ear. These initial responses consisted of short and small movements. These are so-called "initial eye movement in galvanic eye movement test (GEMT)" and "initial wave in GBST"[9]. After the initial response, the body deviated to the opposite side, away from the stimulated ear (so-called "maximum deviation point")[10].

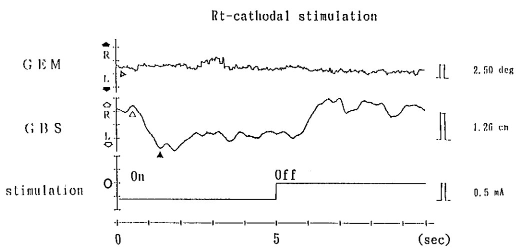

Fig. 2 CGT finding and parameters (nomal subjeots).
(Δ)initial eye movements, (△)initial wave and (▲)maximum deviation point.

In the results of CGT obtained by the monopolar-monoaural method. the directions of initial eye movement in GEM and initial wave and maximum deviation point in GBS reversed in each case when the polarity of stimulation was changed. The evaluation of CGT was made on the basis of the criteria laid out in the report by Ogata[10] (Table 2). The initial eye movement, the initial wave and the maximum deviation point were evaluated as parameters. The normal value of each parameter was obtained from 20 healthy subjects. When they were not within normal latency limits, it was considered to be abnormal.

Table 3 shows the follow-up results of the caloric test and the CGT for eleven cases with vestibular neuronitis. At the initial examination, abnormal findings were detected in 10 cases (90.9%) out of eleven by GBST and in 11 cases (100%) by GEMT. The cessation of the abnormal findings in both the caloric test and the GEMT were observed at the same time. The abnormal findings of the GBST abated earlier than those of the caloric test and GEMT. In other words, the findings of the caloric test corresponded to those of the GEMT, but did not always correspond to those of GBST.

All cases which did not produce normal results in GBST within one month continued to produce abnormal results in the caloric test and GEMT at the final examination. Therefore, it seems that cases with vestibular neuronitis whose GBS did not become normal within one month show poor prognosis of both the caloric response and GEM.

Case 1

A 49-year-old woman bad had a slight cold

Table 2 Normal value of the CGT. (mean±SD)
[by Ogata (1990)]

latency / stimulation	GEM	GBS	
	initial eye movement	initial wave	maximum deviation point
Rt-anodal	0.16±0.082	0.55±0.085	1.69±0.372
Lt-anodal	0.18±0.118	0.50±0.062	1.62±0.485
Rt-cathodal	0.15±0.078	0.52±0.079	1.90±0.434
Lt-cathodal	0.21±0.173	0.52±0.068	1.66±0.382

(sec.)

Table 3 Follow-up results the caloric test and the CGT.
In the caloric test, ● indicates no response to the ice water test and canal paresis, which are considered to be abnormal findings.In GEMT and the GBST, ▲ and ■ indicate respectively that GEM and GBS were not ioduced ,and that both responses were noted, but weak. △ and □ indicate respectively that GEM and GBS were induced normally.

case \ period	I (~0.5month)	II (0.5~1month)	III (1~7months)	IV (6months~)
1. 49 F	● ▲ □	○ △ □	○ △ □	○ △ □
2. 36M		● ▲ ■	● ▲ ■	● ▲ □
3. 26 F		● ▲ ■	● ▲ ■	● ▲ ■
4. 53M	● ▲ ■	● ▲ ■	● ▲ ■	● ▲ □
5. 24M	● ▲ ■	● ▲ □	○ △ □	○ △ □
6. 54 F	● ▲ ■		● ▲ □	● ▲ □
7. 30 F	● ▲ ■	● ▲ □	○ △ □	○ △ □
8. 29 F	● ▲ ■		● ▼ ■	● ▲ ■
9. 53M		● ▲ ■	● ▲ ■	● ▲ ■
10. 22M	● ▲ ■	○ △ □		○ △ □
11. 38M		● ▲ ■	● ▲ ■	● ▲ □

with nasal discharge for 4 days before the rotatory vertigo attack. One day before the vertigo, she experienced a floating sensation while walking in the night. On January 23, 1991., she had a sudden attack of rotatory vertigo on waking up in the morning. She had no cochlear symptoms, but experienced severe nausea. She was referred to our outpatient clinic after a short period of treatment by a nearby internist and a nearby otolaryngologist. At the age of 42 years, she had had a myomectomy. She showed no abnormalities in otorhinolaryngological findings.

The findings of the initial otoneurological examination are shown in Figure 3. In Mann's test, she fell to the lett when her eyes closed. In square drawing test (SDT). she showed deviation to the left with micrographism. Nystagmus beat horizontally to the left side in gaze. positional and positioning test. A caloric test revealed canal paresis on the right side. Her audiogram showed normal shortly after onset and two months later. No other neurological signs suggestive of central lesion were noted.

Serologically, significant changes in serum viral antibody titer were not observed. The CGT was initialy performed on the 5th day after onset. In GEMT. the initial eye movement of affected side was not evoked. In GBST, both initial wave and maximum deviation point were evoked, but these parameters were not within normal latency limits.

Figure 4 shows the chronological change in the CGT during the follow-up period. About 3 weeks after the onset, the floating sensation had already disappeared, and right canal paresis was not noted in the caloric test. In CGT. the initial eye movement, initial wave and maximum deviation point were evoked, and these parameters were within normal latency limits. About 11 months after onset, the findings of the CGT were normal in all

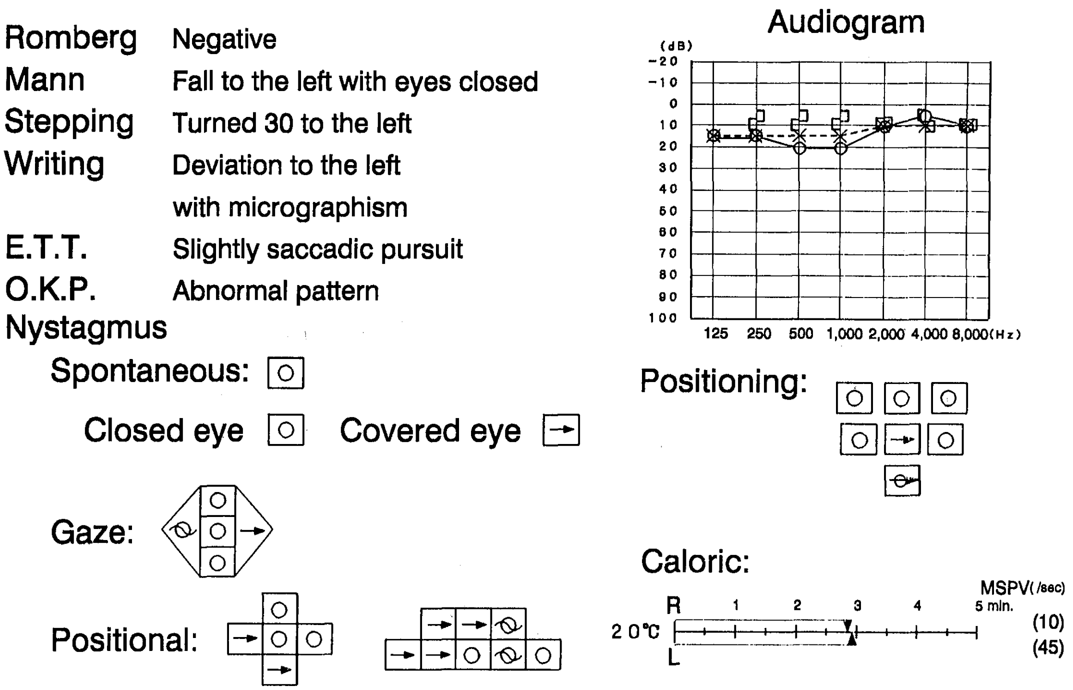

Fig. 3 Otoneurological findigs (Case 1).
A caloric test revealed canal paresis on the right side. Abbreviation; MSPV= maximal slow phase velocity, E.T.T.= eye tracking test, O.K.P.= optokinetic pattern test.

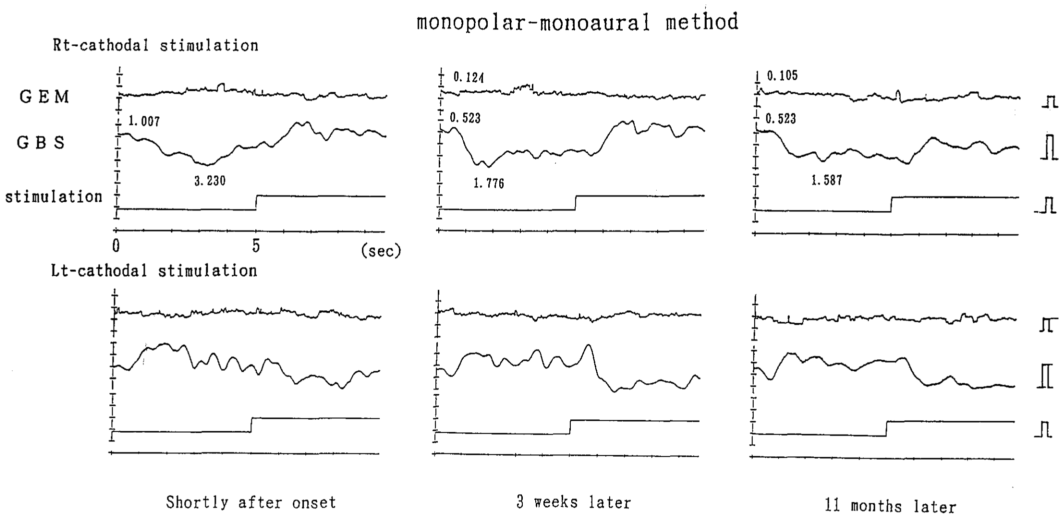

Fig. 4 Chronological change in the CGT (Case 1).
3 weeks after the onset. the findings of the CGI were normal in all parameters.

parameters.

Case 2

A 36-year-old man caught a slight cold, including nasal discharge and nasal obstruction, one week before the rotatory vertigo attack. One day before the vertigo, he experienced a floating sensation, while working. On April 22. 1990, the rotatory vertigo attack suddenly appeared when he rolled over in bed. He had no cochlear symptoms, but experienced severe nausea with vomiting. He was treated by a nearby internist. He was referred to our outpatient clinic with a 26 day history of floating sensation. At the age of 10 years, he had had acute nephritis, He had no abnormalities in otorhinolaryngological findings.

The findings of the initial otoneurological examination are shown in Figure 5.. In SDT, he showed deviation to the left side with micrographism. Nystagmus, recorded by electronystagmograph (ENG), was horizontal to the left in gaze, positional and positioning test. A caloric test revealed canal paresis on the right side. No other neurological signs suggestive of a central lesion were noted. Audiometry performed shortly after onset. and two months later, showed no abnormalities.

The magnetic resonance imaging (MRI) on July 21 showed no central lesion. Serologically, the serum viral antibody titer of cytomegalovirus showed significant change. However, the initial examination was performed at one month after the onset, so the change can not necessarily be ascribed to the vertigo. The CGT was initialy performed on the 30th day after the onset. In GEMT, the initial eye movement of the affected side was not evoked. In GBST, both initial wave and maximum deviation point were evoked as abnormally delayed response.

Figure 6 shows the chronological change in the CGT during the follow up period. About 3 months after the onset, the floating sensation in rapid head movement disappeared, but the caloric test continued to reveal right

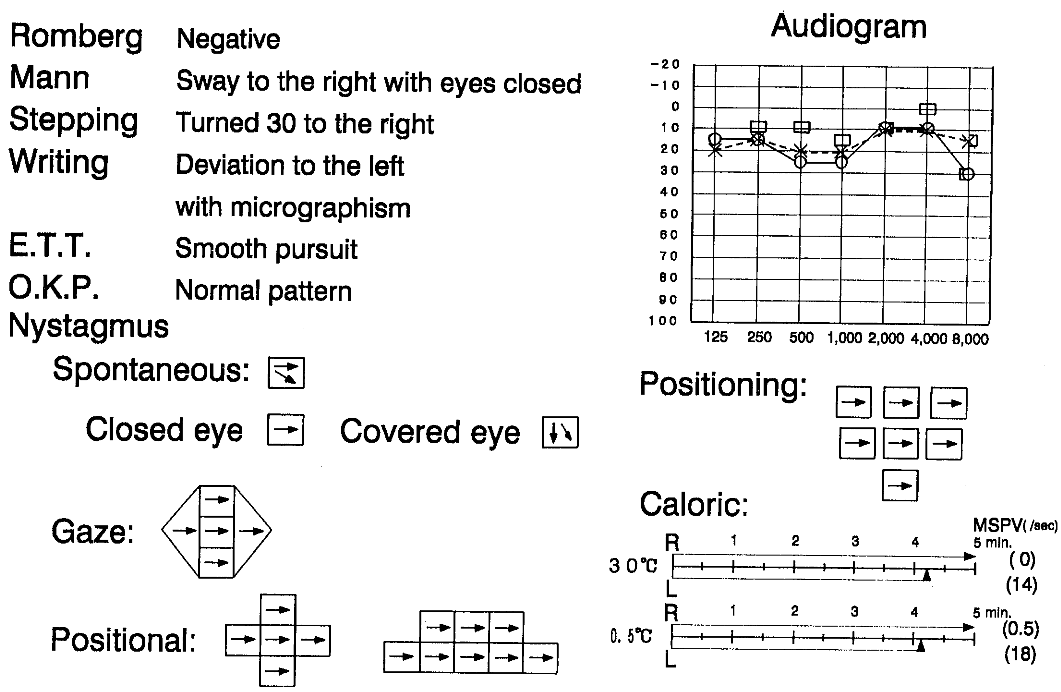

Fig. 5 Otoneurological findings (Case 2).
A caloric test revealed canal paresis on the right side.

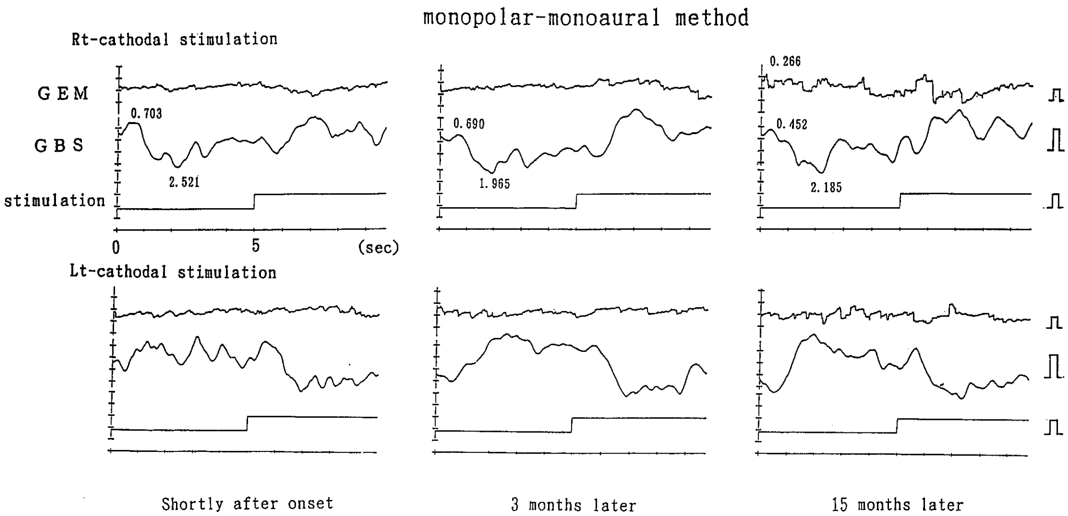

Fig. 6 Chronological change in the CGI (Case 2).
15 monthe after the onset, initial eye movement was evoked. but the latency was ewcessive.

canal paresis. In CGT, initial eye movement of the affected side continued to be absent. The latency of the initial wave and maximum deviation point became shorter, but were still not within normal limits. About 1 year 3 months after the onset, the bead-heavy sensation had disappeared, but right canal paresis was still noted in the caloric test. In CGT, initial eye movement was evoked, but the latency was excessive. In addition, the latency of the initial wave and maximum deviation point showed normalization.

Discussion

Ito, et al.[11] and Tokita, et al.[12] reported that the galvanic nystagmus test and galvanic body sway test showed different results in patients with bilateral labyrinthine disturbance. They suggested that galvanic nystagmus indicated mainly the reaction of the semicircular canal system, whereas galvanic body sway was mainly the reaction of the otolithic system. Serizawa, et al.[13] reported that there were some cases, in acoustic tumor and neurovascular compression syndrome, in which the results of the caloric test and GBST were not consistent, and Watanabe, et al.[14] reported the same result in cerebellopontine angle tumor and vascular disorder of the brain. However, these reports did not include follow-up examination.

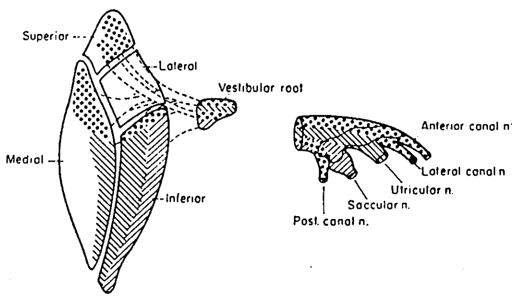

Fig. 7 Diagrammatic representation of relationship between portion of the vestibular ganglion and central projecting fibers within the vestibular nuclear complex.
[Redrawn from Stein and Carpenter (1967) by Brodal (1972)]

From the results in the cases with vestibular neuronitis in the long-term, successive study, it was determined that the findings of the caloric test corresponded to those of the GEMT, but did not always correspond to those of the GBST. Therefore. we suggest that the GBST reflects abnormality in e system different from the system in which the caloric test and the GEMT reflect abnormality.

Figure 7 is a diagrammatic representation of the relationship between a portion of the vestibular ganglion and the central projecting fibers within the vestibular nuclear complex. The semicircular canal system has been neuro-anatomically and neurophysiologically described in detail[15)-17)] but the otolithic system 6as not been clarified yet[18),19)].

Gacak[20)] reported that the primary vestibular neuron from the otolithic sense organs projeots mainly to parts of the medial, lateral and inferior vestibular nucleus. It is believed that the fibers from all parts of the lateral vestibular nucleus enter the spinal cord as a part of lateral vestibular-spinal tract, which plays a important role in body balance, and that all parts of the lateral vestibular nucleus are closely connected with the otolothic system. Okami and Sekitani[21)], using immunohistochemical evaluation of the neurotransmitter (GABA), reported that the galvanic body sway related to the lateral vestibular-spinal tract. Therefore, the point of action of retroauricular galvanic stimulation is the whole of the vestibular nerve, but the afferent fibers not from the semicircular canal system but mainly from the otolithic system produce the body sway under galvanic stimulation.

On the other hand, the pathway of caloric stimulation is the lateral semicircular canal ampullar nerve system. In this study, the findings of the caloric test corresponded to those of the GEMT. Therefore, it is suggested that the GEM reflects mainly the reaction of the semicircular canal system to galvanic stimulation.

The galvanic nystagmus test and the GBST, as generally accepted, have been used for detecting retrolabyrinthine disorder. It has been very important to detect retrolabyrinthine disorder in cases with vestibular neuronitis, since the Dix and Hallpike report[22)]. On the other hand, when the pathology of vestibular neuronitis is considered, it is also important to differentiate whether the disorder exists in the semicircular canal system or in the otolithic system. In this study, the CGT was successively performed for cases with vestibular neuronitis. The different follow-up results of GEM and GBS showed that the CGT can effectively differentiate between disorders of the two systems. Therefore, it is concluded that the CGT could be useful for differentiating the disorders of the vestibular system.

Conclusions

1. Eleven cases with vestibular neuronitis were successively studied with the CGT, based on simultaneous recording of both GEM and GBS.
2. The CGT could be useful not only for detecting of retrolahyrinthine disorders of the vestibular system, but also for differentiating between disorders of the semicircular canal system and of the otolithic system.

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