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An adequate parameter evaluating the galvanic body sway test: comparison with the caloric test in patients with vestibular schwannomas

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Abstract
It has been reported that the galvanic body sway test does not correlate with the caloric test. We evaluated the galvanic body sway test in patients with vestibular schwannomas using three parameters: the angle of deviation response onset, the maximum value of the deviation response, and the area of deviation. These parameters reflect velocity, position, and locus of the centre of pressure, respectively. Among these parameters, only the angle of deviation response onset showed unilateral weakness of the response correlating with the canal paresis value, which indicates that velocity is responsible for conduction in the vestibular nerve. However, the galvanic body sway test is apt to be preferred to the caloric test. This might be attributed to the decreased sensitivity of this test.

Key words: Neuroma, acoustic; Vestibular function tests

Introduction

Galvanic stimulation has been thought to excite both the superior and inferior vestibular nerves. It has been suggested that the galvanic body sway test indicates mainly the reaction of the otolithic system that stimulates a vestibular nerve (Serizawa *et al.*, 1987; Tokita, 1988). On the other hand, caloric stimulation affects mainly the lateral semicircular canal, and, thus, stimulates a superior vestibular nerve. Previous comparisons between the caloric test and the galvanic body sway test have shown no correlation (Watanabe *et al.*, 1983; Serizawa *et al.*, 1987; Fujita *et al.*, 1993), using the presence or absence of responses as a parameter. These results were attributed to the course of different conducting processes in each (Tokita, 1988). However, the lack of correlation of body sway with canal paresis may be due to the parameters used for analysis.

In this paper, we evaluated the galvanic body sway test in patients with vestibular schwannomas using three parameters, and compared them with the canal paresis value to determine which parameter was appropriate for the analysis of the galvanic body sway test.

Materials and methods

We studied 42 patients with unilateral vestibular schwannomas who were operated on in our clinic from January 1996 to December 1997 (14 males and 28 females, ranging in age from nine to 61 years, 12 on the right side and 30 on the left). A caloric test was performed in each patient, with their eyes open in a dark room, using 50 ml water for 20 seconds, under an electronic nystagmograph. They were frequently mentally alerted. Water, at temperatures of 30 °C or 44 °C, was used alternately for stimulation. The canal paresis value was calculated with the parameter of maximum slow phase velocity of the eyeballs.

The galvanic body sway tests were carried out in a dark room, with patients awake and alert and standing on the stabilometer (G5500, software:ver. 2.03B–1, ANIMA Co., Ltd. Japan) in Romberg's posture, with their eyes fixed on a mark in front of them. The anodal electrodes were placed on the retroauricle of both ears and a cathodal electrode was placed on the forehead. The electronic stimuli were delivered eight times with 0.6 mA direct current for 5 seconds (GS6700, software:ver. 1.0, ANIMA Co., Ltd. Japan). Bilateral stabilometer reactions were averaged with a microcomputer.

The body sway response consists of an initial response (IR) and a deviation response (DR) (Noda *et al.*, 1993) (Figure 1a). The data were processed, using a software NIH image ver. 1.59, as mentioned below:

Perturbations of patients were plotted around the time axis, which was placed to be consistent with the centre of pressure on the stabilometer. The point of deviation at 0 seconds and the point on the time axis

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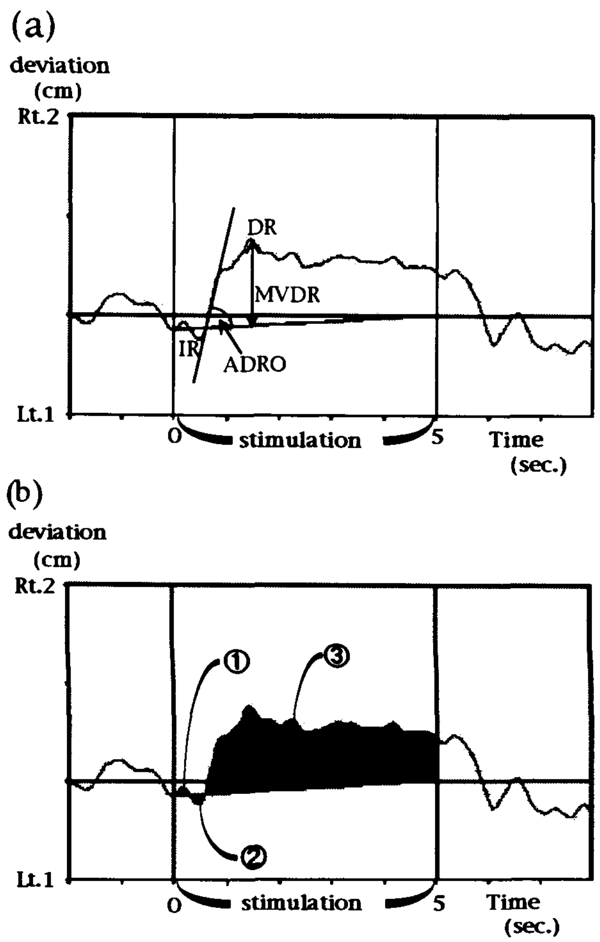

FIG. 1

(a). The point of deviation at 0 sec. and the point on the time axis at 5 sec. were connected with a straight line as baseline. Angle of deviation response onset (ADRO): Maximum angle between a line from IR to DR and baseline. Maximum value of the deviation response (MVDR): Maximum perpendicular distance between the response curve and the baseline. (b). Calculate the summation of areas between a response curve and baseline on each side of a baseline (upper side: ① + ③ lower side: ②). Area of deviation (AOD): Remainder between each summation of the stimulated side and the contrary side (① + ③ − ②).

at 5 seconds were connected with a straight line as a base line. The following three parameters were measured in each case:

(1) Angle of DR onset (ADRO): Maximum angle of slope between the overall IR and the overall DR from baseline (Figure 1a).

(2) Maximum value of DR (MVDR): Maximum perpendicular distance between the response curve and the baseline (Figure 1a).

(3) Area of deviation (AOD): Calculate the summation of areas between a response curve and a base line on each side of the baseline, and find the remainder between each summation of the stimulated side and the contrary side (① + ③ − ② in Figure 1b).

The unilateral weakness (UW) was measured for each of the three parameters as the ratio of the difference between bilateral ears to the summation of them (Coats and Stoltz, 1969; Coats, 1972, modified), computed as follows, (Contra−Ipsi)/(Contra+Ipsi).

Results

Forty-two patients with unilateral vestibular schwannomas were investigated. Reactions were performed using the middle cranial fossa approach in 22 patients, and the translabyrinthine approach in 20 patients. Tumours had originated from the inferior vestibular nerve in 37 cases. In the other five cases, the original nerves could not be confirmed, although the cochlear and facial nerves were ruled out.

UW measurements, with each of the above mentioned three parameters, were analysed. Frequency distributions of these and the canal paresis value are shown in Figures 2a–d. None of these seemed to fit the normal distribution pattern. Therefore it seemed the non-parametric test should be applied. Each of the three parameters was statistically compared to canal paresis values using Spearman's rank correlation coefficients. It revealed UW with ADRO correlates to the canal paresis value ($p<0.05$) (Figure 3a). Neither MVDR nor AOD was in proportion to the canal paresis value (with MVDR: $p<0.2$, with AOD: $p<0.05$) (Figures 3b, 3c).

Discussion

The caloric test was thought to reflect mainly the superior vestibular nerve function. On the other hand, both of the vestibular nerves (superior and inferior) might be the conducting course of galvanic stimulation. During almost all of the operations to resect vestibular schwannomas, we found the tumour squeezing and thinning the other vestibular nerve, leading us to suspect dysfunction of both vestibular nerves, regardless of the origin of the tumour. Therefore, our comparison between results of the galvanic body sway test and the caloric test seems to be significant. Furthermore, fixation on the reference point might make the galvanic body sway test less sensitive.

Stimulation of the vestibular system triggered various streams of information. The vestibular end-organs sense accelerations. This information is first integrated to velocities by the end-organ itself and then integrated again to positions by neural circuits (Fuchs, 1989). Therefore, in vestibular nerves, information about a velocity occupies a greater weight. Among the three parameters mentioned previously, ADRO represents the outcome of the reflex motor response to velocity, and MVDR relates that to position of the centre of gravity, and as well, AOD relates that to locus. Among UW measurements, only UW with ADRO correlates statistically with the canal paresis value. It is reasonable because of the fact, mentioned above, that information about velocity is the main stream in a vestibular nerve. Accordingly, using UW with ADRO, as a parameter, is thought to be adequate for the evaluation of the galvanic body sway test of patients with vestibular schwannomas. Besides, canal paresis values are calculated using velocities as

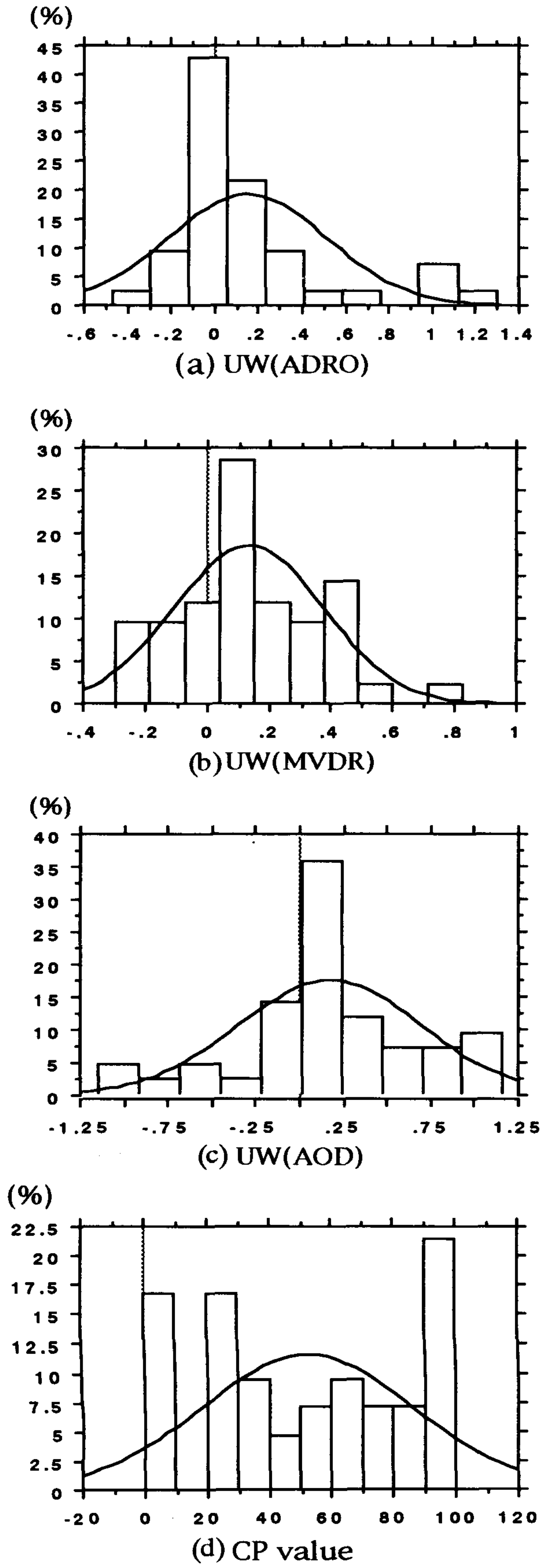

FIG. 2

Frequency distributions of UW measurements with each of the three parameters and canal paresis (CP) value. None of these seemed to fit the normal distribution pattern. a). UW with ADRO; b). UW with MVDR; c). UW with AOD; d). CP value.

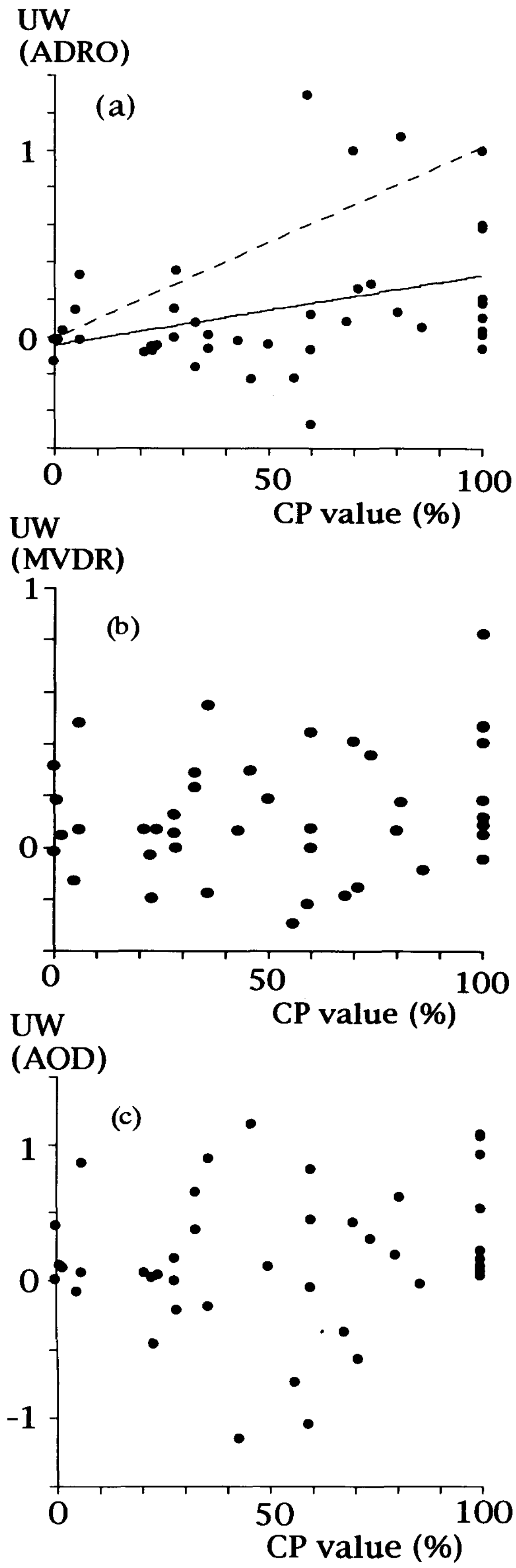

FIG. 3

Scattergrams of each of the three prepared UW-parameters statistically compared to canal paresis (CP) values. Only ADRO correlates to CP value ($p<0.05$). a). with ADRO; b). with MVDR; c). with AOD.

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parameters. This might also support the correlation between UW with ADRO and the canal paresis value.

In a scattergram of UW with ADRO compared to the canal paresis value (Figure 3a), if each parameter is directly in proportion, the regression line should be as dashed. But, UW is apt to be lower as lined, which means galvanic responses tend to be preserved rather than canal paresis values in cases of vestibular schwannomas. Frequency distributions (Figure 2a–d) also support this fact. Each of the three parameters of the galvanic body sway test (ADRO, MVDR, and AOD) tend to be distributed below the canal paresis value. Furthermore, these three parameters should be zero and over. If under zero, it would mean the relationship of the ipsilateral side to tumour exceeds that of the contralateral side. However, in many cases, these parameters distribute under zero. These might reflect the decreased sensitivity of the galvanic test. In some cases, the stability control system might be underdamped so that the initial displacing velocity might be greater than is the case when compensation to unilateral weakness is complete and the antigravity reflexes fully functional. This can be the cause of the decreased sensitivity.

Conclusion

We evaluated the galvanic body sway test of the patients with vestibular schwannomas using three parameters reflecting the velocity of the body sway, position of the swayed body, and locus of the centre of pressure, respectively. Among these parameters, only one representing velocity could provide UW of the response correlating with the canal paresis value. It might be attributed to the fact that information about a velocity is a main stream in a vestibular nerve. However, the galvanic body sway test is apt to be preferred to the caloric test. This might reflect the decreased sensitivity of the galvanic test.

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