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Functional Exploration of Vestibulo-Ocular Reflex by a Caloric Stimulation

*Nam-Gyun Kim, *Bu-Gil Kim, **Hyun-Soo Im

= **Abstract** =

In this paper, we proposed the bidirectional mono-thermic test for the functional exploration of the vestibules by considering a temeprature variation in the semicirular canals constant for a short time and an inclination of the semicircular canal plan relative to the vertical. Through the proposed test we showed the evidence of an eventual asymmetry between the responses of right and left vestibules. In view of clinical practice, the proposed test has the advantages of saving the test time, of using only one temperature for the ear irrigation and of making only head movements to the given angle for the stimulation.

1. INTRODUCTION

In general, the caloric stimulation consists in irrigation of one ear with either cold or warm water. In the inner ear a temperature gradient is so created which in turn produces a pressure gradient in the endolymph of the semicircular canal with consequent stimulation of its receptors. This method is simple and but it does not allow a rigorous quantitative approach to vestibulo-ocular reflex (V.O.R) analysis for two main reasons. First of all the stimulus hardly can be quantified, second the artifacts due to the use of an unphysiological stimulation condition can not be evaluated. This means that only one ear is stimulated. Whereas in physiological conditions both ears always are together stimulated. Nevertheless, the caloric test is considered an important diagnostic tool in clinical practice[1~4].

When the rotatory stimulations concern both right and left vestibules, the caloric stimulation permits to excite only one vestibule. With this propriety, the aims of this paper are to propose a bidirectional mono-thermic thest for the exploration of vestibules and to show the evidence of an eventual asymmetry between the responses of right and left vestibules through this test.

2. LOGICAL MODEL

It seems that a response to the thermic stimulation depends on two influential elements of the semicicular canal the one is the temperature, the other is the gravity.

1) The irrigation of ear with cold water creats a temperature gradient which propagates upto the semicircular canal in the petrosal bone. This temperature gradient produces a mass volumic gradient of the endolymph.

2) If the semicircular canal is not in the horizontal

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*Dept. of Biomedical Eng. College of Medicine, Chonbuk National University.
**Dept. of Biomedical Eng. Chungnam National University Hospital.

plan, the gravity acceleration transforms this mass volumic gradient to the pressure difference of cupule. It results in a defermation of cupule.

As the other physiological stimulations, the thermic stimulation creats a pressure difference in the cupule by a different mechanism. So one of two vestibules is stimulated[5~6]. This fundamental simple model leads us to propose a bidirectional monothermic test for the exploration of vestibules. The classical thermic test consists in making the head immobile and in leaving the temperature difference to traverse the semicircular canal changeble with time.

3. BIDIRECTIONAL MONO-THERMIC TEST

The bidirectional mono-thermic test that we propose is to use a profit of slow temperature variation which can be considered constant during a short time and impose an angle variation of the head between the normal direction relative to the plan of semicircular canal and the vertical by only the head movement (Fig. 1).

As the head position corresponds to a cold stimulation the cupule is deformed to the given direction, the

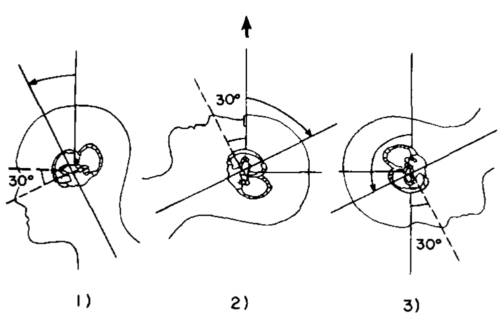

Fig. 1 Head movements in the bidirectional mono-thermic test
1) A neutral position at the time of irrigation
2) A position having the same effect like the cold test
3) A position having the same effect like the warm test

inverse head position corresponds to a warm stimulation. It results that the cupule is deformed to the inverse direction. Thus we use only one temperature.

In this test we examined the horizontal nystagmus which was commaned by the signal issued from the lateral semicircular canal (S.C.C). This lateral S.C.C is in the horizontal plan, so will not respond to the thermic stimulation when the head is inclined forward with the angle of 30 degrees. The head movements in the reference plan permit to place the lateral canal in vertical plan succesively following to two opposit directions. Thus it realizeds an inverse stimulus. The position of the head relative to vertical direction is 60 degrees forward and 120 degress backward.

The test procedures are the following.

1) The ears of subject was irrigated with cold water (volume=50 cm^3, temperature=25℃, injection time=20 seconds). The head position was inclined forward with the angle of 30 degrees. So the lateral semicircular canal was in the horizontal (Fig. 1.1).

2) As soon as the irrigation was over, the head was rotated backward with the angle of 90 degrees in the reference plan. This head position was maintained for 50 seconds (Fig. 1.2).

3) The inverse stimulation was obtained by rotating the head forward with the angle of 180 degrees. This position was maintained for 50 seconds (Fig. 1.3).

4) The new inverse stimulation was realized by rotating the head backward with the angle of 180 degrees (Fig. 1.2).

For the recording of the horizontal response we used the classical electronystagmography (E.N.G) method of recording eye movements using skin electrodes for the signal pick-up. The data acquisition, the signal treatement and analysis such as the detection of a fast phases, the separation of two phases, the removal of fast phase and construction of a cumulated slow phase were realized by a real time processor (Intertechnique 110) with the help of the

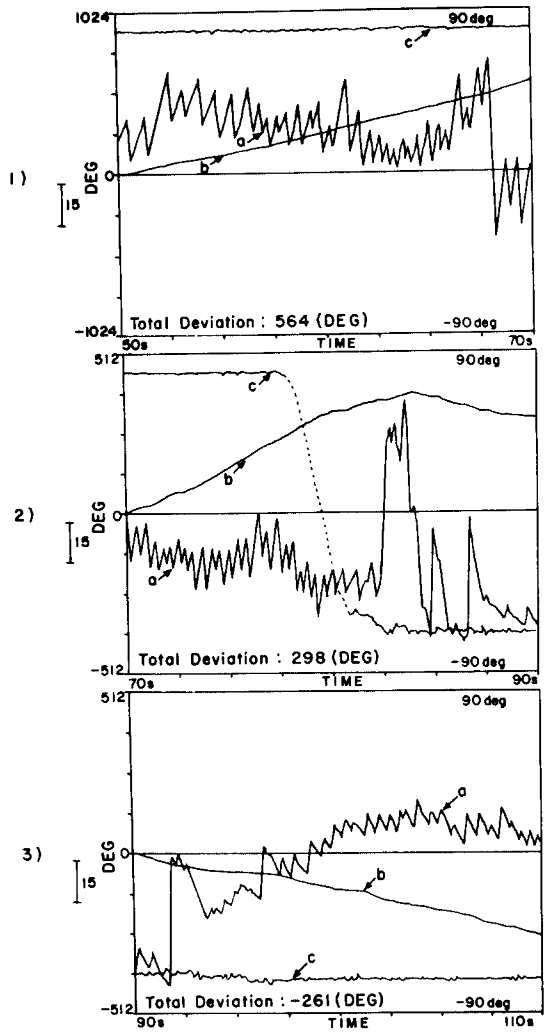

Fig. 2 Responses to the first inversion of stimulation (a : Eye movement, b : Cumulated Eye movement, c : Head movement)
1) Before the stimulus inversion
2) During the stimulus inversion
3) After the stimulus inversion

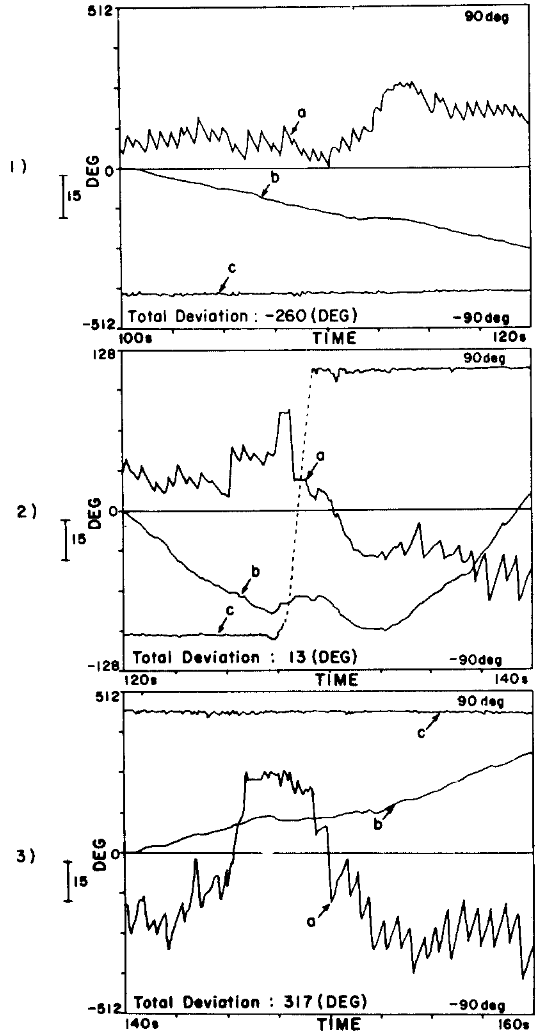

Fig. 3 Responses to the second inversion of stimulation
(a : Eye movement, b : Cumulated Eye movement, c : Head movement)
1) Before the stimulus inversion
2) During the stimulus inversion
3) After the stimulus inversion

software which was developed in our laboratory for the nystagmus related data[7].

4. RESULTS

The typical responses to the first inversion of stimulation is shown in Fig. 2. For about twenty examination cases we observed a slow phase velocity of eye movements sensibly constant during 20 seconds considered before the first inverse stimulus (Fig. 2.1). During 20 seconds considered after the first inverse stimulation an inverse eye movements with the constant velocity was observed (Fig. 2.3).

The typical responses to the second inversion of stimulation is shown in Fig. 3. At the time of the second inverse stimulation, we obtained a new inverse eye movement (Fig. 3.1), but with a high velocity absolute value after the inverse stimulation (Fig. 3. 3).

Thus we could observed an asymmetry as shown in Fig. 4. It was that the head position (Fig. 1.2) was more efficient than the position Fig. 1.3). This asymmetry was similar to the one well known in the classical thermic test. This means that a warm stimulus is less efficient than a cold stimulation.

5. DISCUSSION AND CONCLUSION

In this study, a bidirectional mono-thermic test was proposed. For this test we took into account that the responses to the thermic stimulus depends on 2 influential elements of the semicicular canal. These are the temperature gradient and the inclination of the semicircular canal plan relative to the vertical. The stimulation was obtained by the head rotation movement to the given angle. These permited us to use only one temperature for the fluid irrigation and made us free from the mesuring of a thermic function transfer.

In view of the clinical practice this test lead us to the saving of test time. In the classical caloric test we need 4 manipulations combining right and left ears, warm and cold water and 3 time intervals necessary to the rest of the system. But the bidirectional mono-thermic test needs only two manipulations and one interval time for the rest of the system. So the test duration is reduced to the half.

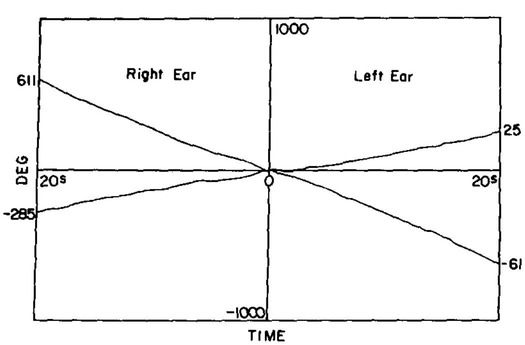

Fig. 4 Responses to the first inversion of stimulus for right and left ears

The examination of this test was done on the cumulated slow movement which was the pure origine of the vestibules. For the calculation of a cumulated slow movement the detection of fast phase, the seperation of a slow phase from the nystagmic movement and the removal of the fast phase can hardly are considered without the informatic methods. But the chosen study, the symmetry test in the two periods of 20 seconds before and after the stimulus inversion permits to realize the bidirectional mono-thermic test with a personal computer in condition that it is composed of a data acquisition device and of a memory enough to record for 2-3 minutes.

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■ 국 문 초 록 ■

열자극에 의한 전정안구반사의 기능분석

김남균* · 김부길* · 임현수**

본 연구에서는 세반고리관(半規管)에서의 온도변화가 잠시동안 일정하고 수직면에 대해 세반고리관면의 경사를 고려하여 전정(前庭)의 기능분석을 위한 양방향의 단열(單熱)검사방법을 제안하였다. 또한 이 제안된 검사를 통해 좌우 전정(前庭)의 응답에 있어서 비대칭성이 일어날 수 있음을 보여 주었다. 실재 임상적인 측면에서 이 제안된 방법은 검사시간을 감소시키고 자극을 위해 오직 하나의 온도사용과 주어진 각에 따라 단순히 머리운동만 시키면 되는 장점들을 가지고 있다.

*전북대학교 의과대학 의용공학과
**충남대학교병원 의용공학과