

Simultaneous Bilateral Calorization to the Labyrinths

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FORWARD

It is oftenly reported that the change in the temperature of the external auditory meatus and the semicircular canal wall will stimulate the vestibular endorgans since 1866 by Brown-Séguard¹⁾, Hitzig²⁾, and Breuer³⁾.

The fact was first confirmed experimentally by Bornhardt (1876)⁴⁾, and then, Barany (1906)⁵⁾ applied those experimental fact and phenomenon to clinical test for evaluate the vestibular function. Thenafter it is generally accepted that caloric test would be one of the most valuable test to stimulate each labyrinth. E. Ruttin (1909)⁶⁾ used bilateral calorization test to detect a difference of excitability of each labyrinth and obtained the finding that no nystagmus was induced in normal persons by this calorization, i. e. the simultaneous-equivalent stimulation to both inner ears.

Consequently, many outstanding physicions and researchers investigated these problems and discussed enthusiastically. Though most of the investigators believed that no nystagmus was induced by equivalent bilateral calorization, Ruttin, Allers and Leidler⁷⁾ reported that a few vertical nystagmus was observed, but not definitely elicited. M. H. Fischer⁸⁾ who made similar and comprehensive investigation clarified that equivalent bilateral calorization induced constantly body reflex and nystagmus, and also, there was close relationship between these stimulation and head position against gravity.

In spite of these various and many investigations, most of the investigators evaluated on only a few restricted kind of test condition; and few of them investigated and reported this test quantitatively. As consequence, clinical availability of this test was seemed in low.

The purpose of our investigation are to clarify the following problems; on conditions that the simultaneous-equivalent bilateral calorization technique are administered to the human subjects, 1) whether horizontal

nystagmus is elicited or not at any test condition; and 2) at what condition, vertical nystagmus will be induced constantly.

In this paper, the results and findings obtained from the healthy subjects are reported and discussed.

MATERIALS AND METHODS

One hundred seventy one clinically healthy subjects, those who were not suffered from ear disease, cerebro-spinal disease, high fever disease; and all who have normal eardrums, normal hearing acuity and normal vestibular function, especially, no marked difference of the vestibular response between the left and the right against unilateral caloric test (27°C, 5cc for 2 seconds) and Barany's rotation test (10/20 sec), were selected to this series.

Age of the examinee ranged from 16 to 35 years old. Equipments was designed to be able to keep constant temperature of the irrigating water and to measure a temperature near the external acoustic canals. Equipments consisted of 1) Thermo-regulating water tank which set at 1 m. high from the ears, 2) Rubber hose inserted through vinyl hose with air space between them, 3) a Y-shaped glass tube, 4) Lower two rubbervinyl hoses, 5) water tube and thermometer, 6) Instilling hose with stop-cock, and 7) Measure pots for measuring the volume of the flow-out water at every irrigation. And, volume of the irrigated water in each ear was confirmed to be equivalent. Structure of regular thermobox wooden made, of which inner wall was covered and imbedded with cork plate 5 cm. in thickness. Motor-driven stir at the center, and two thermostats were equipped. Tap water pooled in this tank and overflow down through the hose.

Head and body position of the examinee was settled as shown in Figure 1. Examinee laid on bed, supine position with head raised 30 degrees (i. e. Brüning's optimal position), gazing straight forward at a mark on the ceiling.

Amount of the water was 1500 ml in each ear with the flow speed of 250 ml per min. for 6 minutes. Observation of nystagmus was made under 20 Dioptrie glasses till 5 minutes after the water irrigation was stopped in the "not elicited" case, and however, till 3 minutes after the elicited nystagmus stopped in the elicited case. Some case who showed only one to two nystagmus like eye movement through 6 minutes irrigation was excluded as indefinite eye blink.

Interval of each calorization took 30 minutes or above.

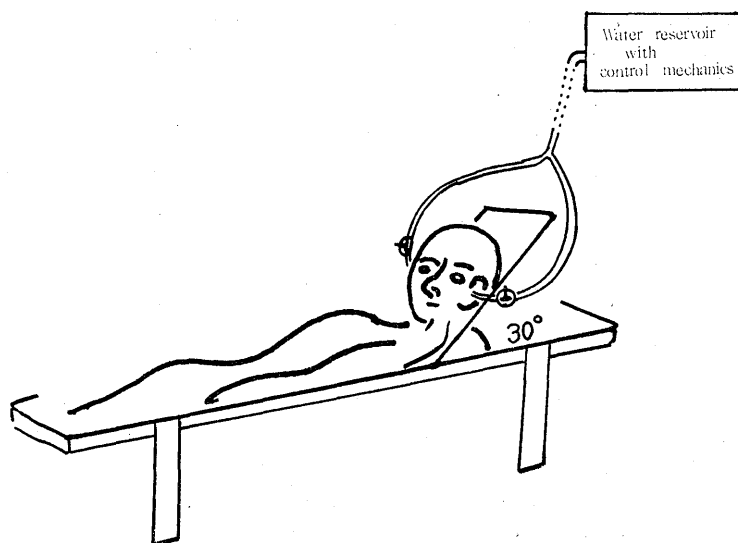


Fig. 1. Schema of Test Arrangement —Head position and bilateral irrigation—

RESULTS

I. Changing of the Temperature of the irrigated water

- a. Bilateral Calorization 10°C 1500 ml in each ear for 6 minutes from 1 m. in height (Table 1).

All 55 clinically healthy subjects in this test induced vertical nystagmus upward direction (100 percent). Two of all, the elicited vertical nystagmus ceased during water irrigation. In those cases, no more nystagmus was observed though observation continued till 3 minutes after water irrigation stopped. In more detail, on the beginning of this vertical nystagmus, vertical-rotatory nystagmus was observed in 6 of 55 examinee, however, remainder 49 of 55 showed purely vertical upward direction. Latency period, duration and frequency of nystagmus were expressed by their mean standard deviation, mean error; and maximum and minimum value in Table 1.

Mean of latency was 58.1 seconds; Duration, 370.3 seconds. Frequency of nystagmus, 263.4. Two cases whose nystagmus ceased during water irrigation showed the following results; latency, 67 sec. Duration, 135 sec. Frequency, 50.5. No horizontal nystagmus was observed even though the keen observation continued during irrigation and 4 minutes after the stoppage of irrigation. The following subjective complaints were explained in some subjects; rotating and floating sensation with the head down and the feet upward, otalgia, heavy head sensation, headache, and nausea.

Table 1. Value of Latent time, Duration and Frequency of Vertical Nystagmus in Clinically Healthy Subjects (55 Examinees) elicited by 10°C Bilateral Calorization

	Latent time	Duration	Frequency
M ± m	58.1 ± 2.40	370.3 ± 19.97	263.4 ± 9.04
σ	17.84	148.52	67.04
Max	108	473	927
Min	29	92	48

b. Calorization with 20°C of water.

Vertical nystagmus was observed in 49 of 55 subjects (89.1 percent). Three of them showed vertical nystagmus which ceased during irrigation. Six of 49 showed vertical-rotatory nystagmus. Former three of 49 showed purely vertical nystagmus upward directed. As shown in Table 2, the following results were expressed. Mean of latency was 74.9 sec. duration, 335.8 sec. Frequency of nystagmus 204.4.

In three of the examinee in this test, who showed nystagmus cease during irrigation, mean of latency was 83.6 sec.

Duration, 199.6 sec. and frequency of nystagmus 119.6. No horizontal nystagmus was observed at all through whole observations. Side effects were noted as follows; otalgia in case who not elicited; In some of the elicited, rotatory sensation, otalgia, headache, heavy head sensation or nausea, were explained.

Table 2. Values of Latent time, Duration and Frequency of vertical Nystagmus in Clinically Healthy Subjects (49 Examinees) elicited by 20°C Bilateral Calorization

	Latent time	Duration	Frequency
M ± m	74.9 ± 1.69	335.8 ± 7.36	204.4 ± 16.50
σ	11.52	51.57	115.50
Max	123	460	580
Min	35	120	47

c. 30°C of the water.

Vertical nystagmus upward direction was observed in 10 of 55 subjects (18.2 percent). Mean of latent time was 115.4 sec. Duration, 295.0 sec. Frequency 104.3. (Table 3).

No horizontal nystagmus was elicited in all cases during irrigation and till 5 minutes after irrigation was stopped. No side effect such as headache, heavy head sensation, nausea or otolgia was noted in all cases. However, in only 4 cases who elicited vertical nystagmus, the rotating sensation with abnormal posture sense such as the feet raised upward.

Table 3. Values of Vertical nystagmus elicited by 30°C Bilateral Calorization in 10 of 55 examinees

	Latent time	Duration	Frequency
M ± m	115.4 ± 12.25	295.0 ± 152.35	101.3 ± 20.56
σ	38.72	39.05	65.00
Max	195	373	255
Min	61	208	38

d. 40°C of the water.

Any kind of nystagmus was not observed in all 55 subjects who were bilaterally irrigated with 40°C water. No side effect was noticed.

e. Comparison of the results among these various degree of temperature

Elicitation rate of vertical nystagmus with various kinds of temperatures of the irrigated water were as follows (Fig. 2 and 3); 100 percent with 10°C irrigated water; 89.1% with 20°C; 18.2% with 30°C; but, no one elicited with 40°C water. No horizontal nystagmus was observed in these series.

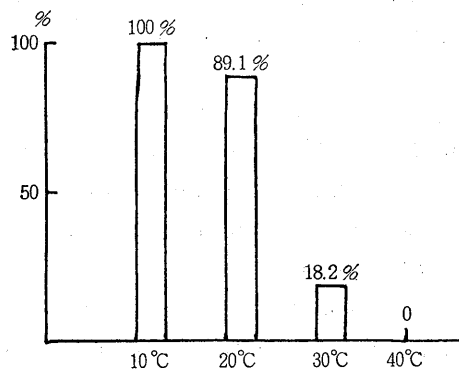


Fig. 2 Occurrence rate of nystagmus induced by each different caloric stimulations

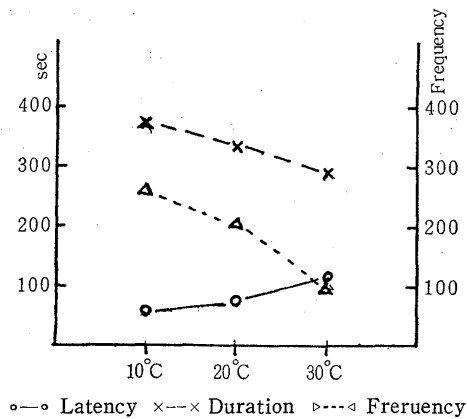


Fig. 3. Changes in the Parameters of Nystagmus by different temperature of irrigation

Average latent time (Means of latent time on condition of 10°C, 20°C and 30°C were as shown in Fig. 3, showing a tendency that the time became short in connection with low temperature. i. e. shorter average latent time at 10°C than at 30°C. Meanwhile, there was some tendency to prolong the duration of nystagmus in low temperature, i. e. longer duration at 10°C than at 30°C. On frequency of nystagmus (Fig. 3), there was some tendency to increase frequency as low temperature, i. e. highest frequency of nystagmus at 10°C than others.

f. Brief summary.

Results in 55 clinically healthy subjects examined by simultaneous-equivalent bilateral calorization on conditions that 1) various kinds of temperature (10°C, 20°C, 30°C and 40°C), 2) 1500 ml in each ear, 3) 6 minutes of irrigation and 4) from one meter in height were summarized as follows:

- 1) Vertical nystagmus upward direction was elicited and observed in 100% at 10°C water irrigation; 89.1% at 20°C, and 18.2% at 30°C.
- 2) At 40°C water irrigation, no nystagmus was induced.
- 3) No horizontal nystagmus was observed in the examinees totally 220 subjects and at these temperatures.

II. Effect of Head Positions

a. With head bending backward 60° at supine position (i. e. pessimum position 10°C bilateral calorization: All of the 13 clinically healthy subjects did not elicit any kind of nystagmus neither horizontal nor vertical during 6 minutes of irrigation and in 5 minutes after stoppage of irrigation.

A few of them noted earache, heavy head sensation, headache and nausea.

b. With head bending more 30° degree from the ordinary position (i. e. pessimum position), 10°C bilateral Calorization: None of all eleven clinically healthy subjects in this test elicited any kind of nystagmus horizontal or vertical during 6 minutes of irrigation and in 5 minutes after stoppage of irrigation. Similar side effects as mentioned before were noted.

c. Comparison of the results between of the optimum head position and of the pessimum position: Seven clinically healthy subjects were selected to test for solving the heading problem in this series.

All of them with head in the optimum position showed vertical nystagmus by 10°C bilateral calorization, but none of all with pessimum head positions showed any kind of nystagmus (horizontal or vertical).

d. Brief summary

1. Notwithstanding the vertical nystagmus was elicited in all examinees (100 percent) as the optimum head position, none of all examinees induced nystagmus in the pessimum head position.

2. No horizontal nystagmus was observed at all.

COMMENTS

Ruttin (1909)⁶⁾ clinically used the bilateral calorization first to evaluate a difference in excitability of the labyrinths,

Then after, many available reports and articles on the bilateral calorization were issued, but most of them studied it with a few restricted test conditions, only reporting that no horizontal nystagmus was elicited in normal person, and also vertical nystagmus was elicited when the head position was changed after the calorization.

The following factors are important to have to consider when any kinds of calorization will be performed, i. e., 1. head position 2. temperature 3. irrigation period and 4. amount of water.

On the amount of water, DeKleyn and Versteegh⁹⁾ described 75 ml; Fischer and Wodak¹⁰⁾, 15 ml.; J. Fischer¹¹⁾ recommended 200 ml, and Brunner¹²⁾ used 20 ml of water. There is no available articles on massive douching (irrigation).

We used massive irrigation with 1500 ml of water in each ear canal.

The following points on test conditions were specially investigated and discussed in this paper: i. e. A) on the temperature of irrigating water and B) head position changing.

A. On the temperature of irrigating water

Bilateral calorization in the ear canals with Brunnings optimum head position induced vertical nystagmus; 100 percent in 10°C water irrigation, but no vertical nystagmus was observed in 40°C irrigation.

On the fact of vertical nystagmus elicited when bilateral calorization test, the following available literatures were issued by Barany, Ruttin, Allers, Leidler, Brunner and M.H. Fischer.

According to Barany's explanation⁵⁾, when both labyrinths are stimulated in the same degree by bilateral calorization, the two components (horizontal and rotatory) become neutralized, while the third component (vertical) remains intact.

Meanwhile, Ruttin⁶⁾ explained that it might be due to a hyperirritability of the sagittal semicircular canals.

According to M.H. Fischer⁸⁾, an upward nystagmus is elicited when the head of the patient is bent backward, while a downward nystagmus is produced when the head is bent forward. Bilateral calorization with the head in the indifferent position does not reveal any nystagmus at all.

However, those noteworthy explanations are still not sufficient to explain the mechanism of the vertical nystagmus which was produced and observed in our present study.

There is no available literature or consideration on the manifestation of vertical nystagmus.

In this study, the fact that the vertical nystagmus is elicited with 10°C irrigation, the lowest degree in present study, in 100 percent of the examinees, meanwhile the fact that none of vertical nystagmus with 40°C (warmer) irrigation is observed suggests that difference in temperature of the water is very important factor.

On unilateral calorization with the optimum head position, the change of the temperature will occur in the horizontal semicircular canal wall and anterior vertical semicircular canal wall producing the horizontal-rotatory nystagmus. The 10°C calorization, this cold stimulation, will easily affect not only the anterior vertical semicircular canal but also the posterior vertical semicircular canal, making sufficient endolymphatic flow in the canals. This endolymphatic flow will probably produce the impulse to elicit the vertical nystagmus, from the vertical canals which situated in or nearly in the sagittal plane, directing upward.

However, it is suggested that caloric stimulation with 40°C of water did not affect the posterior vertical canal to elicit any nystagmus.

As far as the present study on test conditions such as the optimum

head position and bilateral calorization to the clinically healthy subjects is concerned, there is no horizontal nystagmus observed even when a different temperature of the water were administered. Ruttin, Quix¹³⁾, Barany, Allers & Leidler, Brunner, M.H. Fischer, DeKleyn & Versteegh, Veits and Wodak explained that no horizontal nystagmus was observed in normal person. According to Barany's explanation, when bilateral calorization is performed in the normal person who has normal labyrinthine function, the stimuli from both sides become neutralized in the central vestibular nuclei and no impulse at all are sent to the eye muscle.

B. Effect of the Head position

On test condition of the indifferent head position, i. e. the head was set at 60° bent back from the supine position or the head was set at 30° degree bent forward from the normal position, bilateral calorization does not reveal any nystagmus, neither vertical nor horizontal, at all.

On this fact, M. H. Fischer also explained that calorization with the head in the indifferent head position does not elicit any nystagmus.

SUMMARY

Bilateral calorization were investigated precisely on various conditions, i. e., temperatures and head positions. On hundred seventy one clinically healthy subjects were tested in these series; and the following results were obtained.

1. Vertical nystagmus was always elicited by 10°C water bilateral calorization with the optimum head position (in 55 of all 55 examinees, 100 percent).
2. Vertical nystagmus were not induced by 40°C water bilateral calorization at all (in 55 of all 55 examinees).
3. Elicitation rate of vertical nystagmus with the optimum head position became lesser in a warm temperature than accompanied with the cold temperature.
4. Horizontal nystagmus was not observed in all subjects.
5. None of any kinds of nystagmus was elicited by those bilateral calorization in the pessimum head positions.

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