Medical Journal of the
Islamic Republic of Iran

Volume 16
Number 4
Winter 1381
February 2003

THE EFFECT OF ELECTROSTIMULATION ON CALORIC-INDUCED NYSTAGMUS: A PRELIMINARY STUDY

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ABSTRACT

The objective of this study was to describe the role of electrical stimulation in controlling peripheral vertigo.

In a prospective study on 13 healthy volunteers, nystagmus was induced with caloric stimulation and the interval of nystagmus disappearance was recorded. This time indicates the basal response of vestibular end-organ. After caloric irrigation, pulsed signal was applied for each person through retroauricular transcutaneous electrodes and the interval of nystagmus disappearance was measured, secondarily. In second examination on three new volunteers, simultaneous caloric warm water irrigation in one ear and electrical induction in the other ear were done for a long period.

There was a significant decrease in the duration of nystagmus with electrical stimulation in the first stage ($p<0.05$), and in the second not only was there no rotational feeling, but also at the end of irrigation no strong nystagmus was seen.

Regarding the results of this study we conclude that electrical stimulation has a beneficial effect on vestibulosuppression.

MJIRI, Vol. 16, No. 4, 193-197, 2003.

Keywords: caloric irrigation, galvanic stimulation, transcutaneous electrode, peripheral vertigo.

INTRODUCTION

The effect of transmastoid galvanic stimulation on eliciting body sway and eye movement has been well recognized previously.[1] However, recently new studies have indicated that electrical stimulation can accelerate the compensatory process after peripheral vestibular difficulties, i.e. following labyrinthectomy.[1,2]

For symptomatic management of a patient with peripheral vertigo, oral vestibulosuppressive medication are useful in acute attack, but they can reduce the effect of compensation and should be reduced or discontinued as soon as possible.[3,4]

For these reasons, it is attractive to accelerate the compensatory process in combination with reduction in disabling symptoms by other means like electrical stimulation. In the present study, the effect of electrical stimulation on the compensatory process after caloric-induced nystagmus was studied in healthy volunteers.

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MATERIAL AND METHODS

Electrical equipment

Stimulator

A bipolar pulse stimulator was used to produce electrical square wave with variable frequency.

Energy source of the stimulator was provided by four batteries that can produce variable voltage between 0-36 volts. The basic components responsible for producing square wave were two IC 555 timers. The output of the second IC timer which was amplified with an amplifier (LM 741), was entered to the active electrode that was placed over mastoid bones. The volunteer kept the other electrode (cathodic electrode) in his or her hand to complete the circuit (Fig. 1).

Bipolar surface electrode

The active electrodes were transcutaneous electrodes which were maintained in place with a small headphone apparatus that was placed over the head in a way the electrodes have had complete contact with the mastoid bone.

To improve electrical conductivity, the electrodes were covered with a wet sponge. The cathodic electrode was a metal plate which was covered with a wet sponge again, to improve conductivity.

Recording unit

The produced nystagmus during different steps of the examination, was recorded with a mechanical electronystagmograph.

Date recording

The impulse parameters (voltage and frequency) were regulated with a multichannel high-pass filter oscilloscope.

Test performance

Binaural bipolar electrode stimulation

The test were done on sixteen healthy volunteers. Every volunteer laid down supine on a nonmetal table and the head was elevated 30 degrees in relation to the horizontal plate.

In the first step the ear was irrigated with warm water (44 degrees on centigrade scale) for about 45-50 seconds and the nystagmus was recorded until the nystagmus disappeared. The duration of nystagmus beats was determined.

After a time interval of about 20 minutes to diminish the effect of irrigation on the labyrinth, the active electrodes were placed over both mastoids and based on the frequency of the caloric-induced nystagmus, the electrical signal frequency was chosen.

The maximum voltage that could be applied, was based on the volunteer tolerance that was determined prior to test performance.

In this step caloric irrigation was performed with the exact previous condition (temperature and irrigation duration).

At the end of irrigation the electrical pulse wave was applied and signal duration was recorded. Nystagmus beats were recorded until they disappeared. Decrease in nystagmus beat duration between these two steps was calculated. Because the electrical wave can produce electrical interferance in nystagmus recording, at the end of caloric irrigation and just before applying electrical impulse, a brief recording was done to be sure that another vestibular response like the first step was produced. This brief time was determined as wasting time.

Monoaural bipolar electrode stimulation

In this examination (cases 14-16) the left ear was irrigated with warm water (44 degrees on centigrade scale) for a prolonged period and at the same time the electrical impulse was applied to the right ear.

Signal voltage and signal frequency was chosen like the previous examination. The frequency of nystagmus was determined at the end of irrigation and electrical induction.

In two cases (14, 15) a brief second signal was applied.

RESULTS

Out of thirteen examinees with binaural bipolar electri-

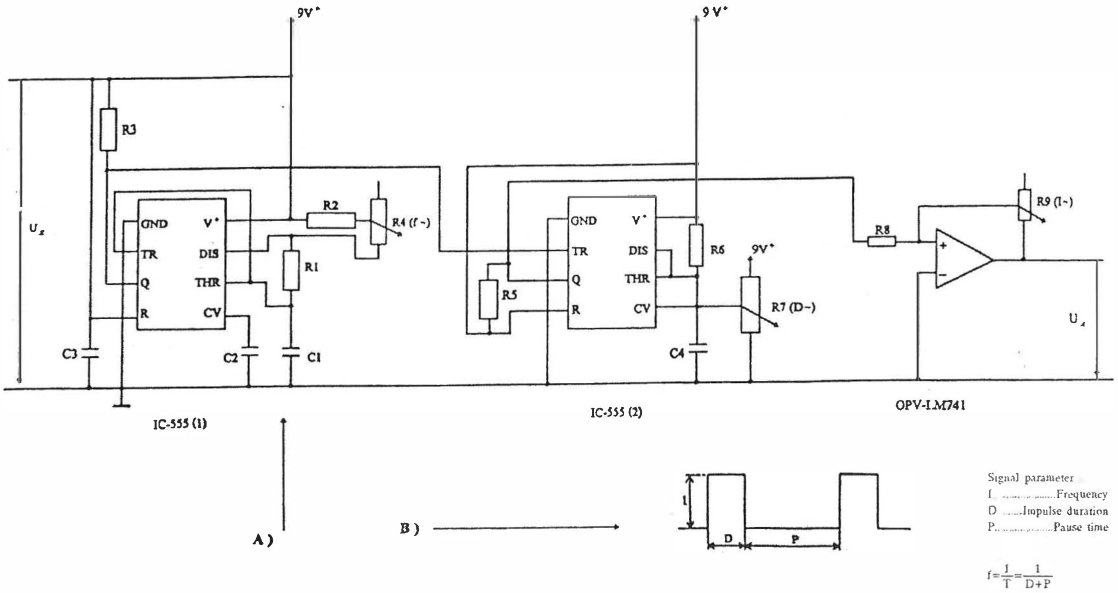

Fig . 1. Schematic plan of the stimulator.

cal stimulation, nine had a decrease in nystagmus duration. The volunteers also recorded rapid disappearance of rotational feeling during test performance (Table I).

None of them had any complications but only one person (case 7) who had had a past history of motion sickness had severe nausea in the second step of caloric irrigation. In this case, however, electrical impulse improved nystagmus disappearance.

In each case the first step is done as a control state. In four examinations no decrease in nystagmus duration was seen. (case 1,2,9,10) In three of these four tests electrical impulse was applied 20-30 seconds after the irrigation and this time wasting may be responsible for the negative result.

Statistical analasis with paired t test showed a significant difference and the P value was less than 0.05 (Table III).

In those tests that caloric irrigation and electrical stimulation was done simultanaously, no rotational feeling was recorded and the frequency of nystagmus was remarkably less at the end of electrical stimulation. This nystagmus rapidly disappeared with a brief second electrical stimulation (Table II).

In the 16th case that electrical impulse was 40 seconds longer than caloric irrigation, no nystagmus was seen at the end of impulse.

DISCUSSION

The response of vestibular nerve afferent fibers to external galvanic stimulation has been studied previously.

Goldberg et al. in 1982 found that cathodal current can increase the afferent discharge of vestibular nerve.[5]

Masumitsu and Sekitani in 1991 found that pulse stimulation has an influence on both vestibulo-ocular and vestibulo-spinal reflex. They also found that the effect of electrical stimulation on vestibular compensation was dependent on the intensity of the applied current.[1]

Park et al. in 1995 investigated the effect of sensory deprivation or electrical stimulation on acute vestibular symptoms following unilateral labyrinthectomy in rabbit and found that the electrical stimulation of the lesion-side seemed to have a favorable effect on suppression of acute vestibular

Table I. The parameters and results of binaural bipolar electrode stimulation.

Case number	Water temp.	Irrigation duration	Nyst. freq.	Signal voltage	Signal freq.	Wasting time*	Signal location	Signal duration	Duration of nyst.**		Time of improvement	Nyst. at the end of signal
1	44 (L)	45”	4	17	5	33”	both ears	50”	107	108	-1	+
2	44 (L)	45”	4	17	5	15”	both ears	30”	105	120	-15	+
3	44 (L)	45”	4	17	5	15”	both ears	90”	159	128	31	+
4	44 (L)	50”	3	18	5	15”	both ears	100”	180	140	40	-
5	44 (L)	45”	3	11	5	27”	both ears	40”	130	87	43	+
6	44 (L)	45”	2	16	5	15”	both ears	40”	120	108	12	+
7	44 (L)	45”	4	17	5	12”	both ears	60”	84	69	15	-
8	44 (R)	45”	3.3	16	5	0”	both ears	33”	120	84	36	+
9	44 (L)	45”	4	18	5	0”	both ears	50”	100	135	-35	+
10	44 (L)	50”	4	12	5	30”	both ears	50”	108	120	-12	+
11	44 (R)	50”	3	17	5	24”	both ears	50”	129	90	39	-
12	44 (L)	45”	2	16	5	6”	both ears	30”	120	93	27	+
13	44 (L)	45”	3	17	5	12”	both ears	45”	99	78	21	+

*Duration between the end of irrigation and the beginning of electrical signal; **the time of nystagmus disappearance: without electrical impulse (left column) and with electrical impulse (right column).

Table II. The parameters and results of monoaural bipolar electrode stimulation.

Case Number	Water temp.	Irrigation duration	Signal voltage	Signal freq.	Signal duration	Signal location	Nyst. freq. after signal	Signal duration second stage	Nyst. frequency after second stage
14	44 (1)	150”	23	5	150”	right ear	2HZ	30”	——
15	44 (1)	150”	17	5	150”	right ear	1HZ after 12”	30”	+(0.03 HZ)
16	44 (1)	150”	17	5	190”	right ear	——	——	——

Table III. The statistical analysis with paired t test in binaural bipolar electrode stimulation.

Case number	End time without impulse (sec)	End time with impulse (sec)	Difference (d)	Square of difference (d^2)
1	107	108	-1	1
2	105	120	-15	225
3	159	128	31	961
4	180	140	40	1600
5	130	87	43	1849
6	120	108	12	144
7	84	69	15	225
8	120	84	36	1296
9	108	135	-35	1225
10	108	120	-12	144
11	129	90	39	1521
12	120	93	27	729
13	99	78	21	441
Total	1561	1360	201	10361

symptoms which had been induced by unilateral vestibular lesion.[3]

Mosca in 1994 examined the effect of electrostimulation on vestibular nuclei by direct spino-vestibular pathway. In that study electrodes were placed lateral to the cervical column on the opposite side of the vestibular deficit. The results pointed out a good effect of electrostimulation on vestibulo-ocular reflex compensation.[6]

The vestibular symptoms after unilateral peripheral lesion are due to an imbalance between resting discharge of both sides and a decrease in signs and symptoms may be achieved by CNS compensation.

During CNS compensation a decrease in nuclear activity in both medial vestibular nuclei occurs.[1,7] This decrease in electrical activity is greater on the contralateral side than on the ipsilateral side. The ipsilateral nucleus undergoes a regeneration of its resting activity near the end of critical stage or the beginning of the acute stage.[1]

Thus, if by any means one can be able to accelerate this process, compensation occurs rapidly.

In the first examination we consider that some impulses can reach more rapidly to the vestibular nucleus than the vestibular impulse, and if these impulses are tuned carefully they can block the impulses from a diseased and healthy labyrinth, so a new artificial resting state is obtained. In other words, if after irrigation of one ear with warm water and induced nystagmus a binaural bipolar pulsed electrical stimulation with suitable voltage and greater signal frequency than the nystagmic frequency was applied, both vestibular nuclei would receive this new impulse and respond equally to that, so the volunteer would experience rapid resolution of nystagmus.

In the second examination we studied the equalization of resting discharge at the level of the vestibular nerve.

Simultaneously with caloric warm water irrigation that can produce an increase in resting discharge, electrical stimulation was applied to the opposite ear with nearly the same frequency of the caloric-induced nystagmus.

After that, not only did the volunteer not have any rotational feeling, but also at the end of prolonged irrigation no strong nystagmus was seen.

Although it must be remembered that irrigation effect on the vestibular end-organ lasts for a few seconds before complete disappearance and in the 16th examination, electrical impulse was applied 40 seconds longer than irrigation, and at the end of electrical signal no nystagmus was present at all. Therefore the result of the second examination was better than that of the first.

Although more prospective studies are needed, our series suggests that electrical stimulation has a positive effect on peripheral vertigo and can accelerate CNS compensation.

ACKNOWLEDGEMENT

While comemorating Morteza Mirsalehi, M.D., who taught us patience and humanity, the authors wish to thank Frank Rattay, Ph.D., and Majid Ahmadipour, Ph.D. (Technical University of Vienna, Austria) for designing the stimulator.

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