Effect of Galvanic Vestibular Stimulation on Recovery from Gaze Palsy

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ABSTRACT

The purpose of this study was to evaluate the effect of galvanic vestibular stimulation (GVS) on recovery from gaze palsy. Twenty patients with gaze palsy, (14 males and 6 females) their age ranged from 20–63 years with mean age 47.9±12.5 years. Duration of gaze palsy ranged from 4–24 months with mean of 10.6±5.23. Twelve patients were post stroke and eight patients with definite multiple sclerosis. They received galvanic vestibular stimulation three times/week for four weeks. They were assessed by using three point scale for gaze deviation, line bisection test and line crossing test. These measures were recorded before the vestibular stimulation (pre treatment) and after four weeks (post treatment). Results of this study showed that, there was significant decrease in the grades of gaze deviation, significant improvement in line bisection and line crossing. It was concluded that, galvanic vestibular stimulation is a beneficial central non invasive modality to improve recovery from gaze palsy. (Egypt J. Neurol. Psychiat. Neurosurg., 2005, 42(2): 359-364).

INTRODUCTION

Conjugate eye deviation (CED) occurs in approximately 20% of patients with cerebrovascular disease¹ and in 18%-39% of patients with multiple sclerosis². The underlying mechanism of CED is thought to be a disturbance of the cortical or subcortical pathways involved in the control of voluntary eye movements. A sudden imbalance between the left and right tonic frontal inputs on the superior colliculus and/or premotor reticular formations of the brain stem is the possible mechanism of the initial eye deviation observed after an acute frontal lesion³.

Disorders of ocular motility may occur after injury at several levels of the neuraxis. Unilateral supranuclear disorders of gaze tend to be transient; bilateral disorders more enduring. Nuclear disorders of gaze also tend to be enduring and are frequently present in association with long tract signs and cranial nerve palsies on opposite sides of the body³. Eye-movement disorders commonly occur in vertebrobasilar stroke, although they are often unappreciated. Vertebrobasilar strokes can yield varied disturbances of eye movements, by affecting specific centers and pathways contained in the brain stem and cerebellum. Unique disorders combining supranuclear, nuclear, and infranuclear syndromes may occur⁴,⁵.

Vestibular system plays an important role in maintenance of human balance, posture, coordination of eye movement with head movement and spatial representation⁶,⁷. Vestibular stimulation is used to treat abnormalities of muscle tone, gravitational insecurity, movement intolerance, vertigo, and different forms of spatial neglect⁷,⁸,⁹.

The semi-circular canals and the otolith organs both contribute to gaze stabilization during head movement. The six semicircular canals form three functional pairs that lie in planes roughly orthogonal to each other. In addition, each canal works in a reciprocal arrangement with its paired partner in a push-pull fashion. The brain stem
supplies the necessary neural connections to deliver the signals from the canals to the eye muscles to move the eyes appropriately for the vestibulo-ocular reflex (VOR)\(^1\).

Two kinds of pathways ascend from the vestibular nuclei; some are concerned with oculomotor control and some are concerned with spatial orientation. Signals concerned with control of the eye movements ascend the medial longitudinal fasciculus to the nuclei of cranial nerves III, IV, and VI. Both sets of vestibular nuclei send bilateral projections to the cranial nerves some of which are excitatory and some of which are inhibitory\(^1\).

The vestibular system can be stimulated by galvanic vestibular stimulation (GVS). Galvanic vestibular stimulation has been used for almost 200 years for exploration of vestibular system. The eye movement pattern induced by application of electric currents to labyrinth is known as the galvanically induced vestibulo-ocular reflex\(^1\).\(^1\)

**SUBJECTS AND METHODS**

**Subjects:**

Twenty patients with gaze palsy where included in this study, twelve patients with post stroke and eight patients with definite multiple sclerosis (MS). Patients with definite multiple sclerosis (MS) were diagnosed as having clinically definite MS according to poser criteria\(^1\)\(^3\), or having MRI supported definite MS according to Paty and Li\(^1\)\(^4\). All patients chosen from neurology department at El-Kasr El-Aini Hospital, Cairo University. their age ranged from 20 – 63 years with mean age of 47.9±12.5 years. Duration of gaze palsy was ranged from four to twenty four months with mean of 10.6±5.23 months, they were 14 males (70%), 6 females (30%).

**Exclusion Criteria:**

Patients with vestibular disorders, other ophthalmological problems, perceptual deficits, auditory, speech, and mental disturbances were excluded.

**Methods:**

Subjects with definite MS patients were subjected to the following.

1- Full clinical assessment including through history taking to detect the disease duration, the number of relapses, the type of symptoms and the proper stage of the disease. The clinical evaluation included also through clinical examination and assessment of the disability by the expanded disability statues scale (EDSS).

2- Neurophysiological assessment by the different evoked potential.

3- Examination by MRI brain and cervical cord if indicated.

4- Laboratory tests including:

- Assay of Oligoclomal IgG.
- Assay of IgG/Albumin Ratio in Serum and CSF.
- Assay of CSF Myelin Basic Protein.

Subjects with stroke were subjected to examination by MRI brain.

**Measurement procedures:**

1- **Three point scale of gaze evaluation**\(^1\)\(^5\).

Gaze will be evaluated by asking the patient to look to the left then to the right, to look at specific objects within the left and right fields and to follow slowly the moving objects leftward and rightward and the patient's behavior is scored on a three-point scale.

2- **Line bisection test**\(^1\)\(^6\).

The subject marks the midpoint of 18 staggered lines of 20-mm, 40-mm, and 60-mm lengths. In left neglect the patients typically displace their mark to the right of the objective midpoint, neglecting part of the left of the line. The distance between the left edge of each line and the patient's mark showing the subjective midpoint was measured to the closest millimeter.

3- **Line crossing test**\(^1\)\(^7\).

The patient was asked to cross out lines (36 black lines, 25X2 mm) slanted in various directions and spaced randomly on a 9 x 12-inch card. All patients received GVS from
sitting position on a chair with a back supported, feet rested on the ground with flexed hips and knees, transmastoid GVS was used through two applied plate electrodes covered with sponges after cleaning of the skin with alcohol. The anode was placed on the mastoid process of the affected side, while the cathode was placed on the contralateral mastoid process.

The measurements were conducted pretreatment and repeated after 4 weeks (post treatment).

**Therapeutic procedures:**
All patients received GVS from sitting position on a chair with a back supported, feet rested on the ground with flexed hips and knees, transmastoid GVS was used through two applied plate electrodes covered with sponges after cleaning of the skin with alcohol. The anode was placed on the mastoid process of the affected side, while the cathode was placed on the contralateral mastoid process. The stimulation period lasted 5 minutes in every sitting with current intensity of about 4 MA and frequency of about 0.5-1 Hz. Expressions and reactions of patients were watched carefully during stimulation period which was preceded by precise explanation of what he would feel during stimulation.

**Statistical Method:**
Statistical package for the social sciences (SPSS) (version 9) was for data analysis. Mean and standard deviation were estimates of quantitative data. Paired t-test were used to test the significance of difference between two means within the same group. P value is significant at 0.05.

**RESULTS**

1- **Assessment of the grades of gaze deviation:**
The mean values of the grades of gaze deviation before vestibular stimulation (pre) and after four weeks (post) are presented in Table (1) and Fig (1).

![Fig. (1): Changes of mean values of gaze deviation.](image)

### Table 1. Changes in the mean values of the grades of gaze deviation.

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.4</td>
<td>1.6</td>
</tr>
<tr>
<td>SD</td>
<td>0.502</td>
<td>0.753</td>
</tr>
<tr>
<td>t</td>
<td>-2.85</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.007*</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at P<0.05 
Pre: before treatment. Post: after the application of galvanic vestibular stimulation.

The paired t test shows a statistical significant decrease of post gaze deviation mean value compared to its pre mean value (P < 0.01).

2- **Assessment of the line bisection test:**
The mean values of the score of the line bisection before vestibular stimulation (pre) and after four weeks (post) are presented in Table (2) and Fig (2).

### Table 2. Changes in the mean values of the line bisection test.

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.456</td>
<td>0.291</td>
</tr>
<tr>
<td>SD</td>
<td>0.150</td>
<td>0.164</td>
</tr>
<tr>
<td>T</td>
<td>11.68</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.001*</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at P<0.05 
Pre: before treatment. Post: after the application of galvanic vestibular stimulation.

The paired t test shows a statistical significant improvement of post mean value of line bisection, compared to its pre mean value (P < 0.01).
Fig. (2): Changes of mean values line bisection test.

3- Assessment of the line crossing:
The mean values of the grades before vestibular stimulation (pre) and after four weeks (post) are presented in Table (3) and Fig (3).

Table 3. Changes in the mean values of line crossing test.

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>26.8</td>
<td>30.3</td>
</tr>
<tr>
<td>SD</td>
<td>4.942</td>
<td>5.292</td>
</tr>
<tr>
<td>t</td>
<td>-8.809</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.001*</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at P<0.05

Pre: before treatment.
Post: after the application of galvanic vestibular stimulation.

The paired t test shows a statistical significant improvement of post mean value of line crossing , compared to its pre mean value (P<0.01).

Fig. (3): Changes of mean values of line crossing test.

DISCUSSION

Clinical results after four weeks of treatment indicated that patients who received GVS, showed significant improvement of the ability to gaze into the affected field.

The improvement in gaze deviation could be attributed to inhibition of the tonic phase of contraction of antagonistic muscles which causes the horizontal gaze deviation, or facilitation of the agonistic yoked pairs of muscles, thus increasing their voluntary strength. Vestibular stimulation have a direct effect on enhancing alpha motor neurons which resulted in facilitation of extraocular eye movements. This explanation agree with Marshall & Mynard[18].

The improvement of conjugate eye movements could be also attributed to brain activation induced by GVS. A significant activation due to vestibular stimulation was demonstrated in regions behind the primary auditory cortex, the insular and retroinsular regions, the inferior parietal lobe, certain temporal areas, and other regions also take part in the processing of vestibular signals received from the periphery. These areas are situated in both hemispheres, with a contralateral predominance over the stimulated side. Additionally, increased activity has been registered in the postcentral gyrus, claustrum, putamen, precentral gyrus, and gyrus cinguli. This explanation agree with Lobel et al.19, and Emri et al.20.

GVS provides a direct repetitive stimulus to the ascending tracts of the brain. Thus GVS could improve the reorganization process in which it strengthens the synaptic activity. GVS provides more activation of brain areas resulting in improvement of cerebral blood flow. The increase of blood flow in a particular area of the brain is thought to reflect a greater metabolic activity resulting in increased synaptic activity within that region21.

Trans- mastoidal stimulation with the anode over the right and the cathode over the left mastoid induces an inhibition of the right and an excitation of the left vestibular nerve.
Behaviorally, this provokes the following effects: The tonic vestibular tone imbalance results in deviations of eye position (ipsilateral to the anode) and the feeling of being tilted ipsiversively.

Concerning the patients of stroke, studies showed that most recovery after stroke occurred within the first three months following stroke. Recovery takes place very early as a result of post lesion reparative mechanisms in the brain as resolution of oedema and functional recovery. The duration of illness is an important factor that shouldn’t be neglected in this study. The duration of illness of stroke patients ranged from six to twenty months, so the improvement attributed to GVS rather than spontaneous recovery. It was also the main cause that may be attributed to it than the non-significant improvement in certain patients.

In the present study, a simple method of vestibular stimulation was used to be more applicable, available and tolerable than previous method as caloric method. In contrast with caloric vestibular stimulation which mediates its effect mainly via semicircular canals, galvanic vestibular stimulation has been shown to act equally on semicircular canal and otolith afferents, also galvanic stimuli can be controlled precisely.

Conclusion:
It was concluded that, galvanic vestibular stimulation is a beneficial central non invasive modality to improve recovery from gaze palsy.

REFERENCES

الملخص العربي
تأثير التنبيه الكهربائي لدهليز الأذن على الشفاء من الشلل التحذقي

يعتبر الشلل التحذقي الذي ينتج عن بعض الأمراض من الأسباب التي تؤثر على الوظائف البدنية، وقد أظهرت بعض الدراسات أن استخدام التنبيه الكهربائي لدهليز الأذن يمكن أن يحسن شفاء المرضى من الشلل التحذقي.

التوصيات:
1. تقييم حركة العين باستخدام مقياس ثلاثي القاطع.
2. تقييم التجاهل البصري باستخدام اختبار تنصيص الخط.
3. تقييم التجاهل البصري باستخدام اختبار سطح الخطوط.

هججو تحسن ملحوظ في قدرة الحركات التحكمية للعين، وقد لوحظ ارتفاع في نسبة الأفراد الذين تحسنت أوضاعهم.

أما سبق يتضح أن استخدام التنبيه الكهربائي لدهليز الأذن يقد كثيراً في علاج مرضى الشلل التحذقي.