VESTIBULOSPINAL REFLEX IN COCHLEAR IMPLANT RECIPIENTS

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Abstract

This is a cross-sectional study that comprised 20 adults who underwent unilateral cochlear implantation, compared to 20 well-matched controls. The aim was to assess balance function in CI recipients using sensory organization test (SOT) of computerized dynamic posturography (CDP) and to compare the findings with vestibular evoked myogenic potential (VEMP) and to correlate findings of these 2 tests with the patients' imbalance symptoms. Vertigo was present in 5/20 cases. Eleven had post-operative dizziness. Thirteen out of 20 cases had SOT abnormalities, 10 of which had vestibular ratio abnormality. The cases had statistically significant lower scores than their controls in SOT conditions 4, 5, 6, composite score, vestibular, visual & visual preference ratios. VEMP response was preserved bilaterally in 11/20, out of which 5 had abnormal inter-aural amplitude difference, which was statistically significantly lower than the controls. The remaining 9 had lost VEMP irrespective of the tested side. Statistically significant differences in p13 latency were found comparing implanted and nonimplanted ears, as well as comparing implanted ears with the controls. There was no statistically significant correlation between patients' age, duration of sensory deprivation or implant duration with any of the posturographic or VEMP parameters. Both tests were not correlated. Balance dysfunction is not uncommon in CI recipients post-operatively, requiring vestibular rehabilitation. We recommend adding CDP and VEMP to the routine pre-and post surgical testing.

Keywords: balance • cochlear implant • posturography • vestibular evoked myogenic potential • vestibulo-spinal reflex

Background

Computerized Dynamic Posturography (CDP) which assesses the vestibulo-spinal reflex (VSR) is well documented in the clinical and scientific literature as an objective method of differentiating sensory, motor, and central adaptive functional impairments of balance [1]. Cervical vestibular evoked myogenic potential (VEMP) are used to assess the vestibulo-colic reflex and vestibulospinal reflex (VSR); they can be recorded from the averaged electromyogram of actively contracting sternocleidomastoid muscle [2]. There is a wide range of balance alterations post-cochlear implantation (CI) and a variety of their causes, as well as controversies regarding their occurrence. Some of the CI patients may have combined disabilities and/or be prone to falls, so the aim of this study was to assess balance functions in CI recipients using sensory organization test (SOT) of CDP, to compare these findings with the cervical VEMP and to correlate findings of these 2 tests with the patients' imbalance symptoms.

Material and methods

The study included 20 patients who underwent unilateral cochlear implantation (mean age =36.9±12.69) 10 females and 10 males, tested at least 8 weeks after surgery, from June 2009 to January 2011, in Kasr Al-Aini Hospital, Cairo University. The mean duration of hearing loss was 10.44±9.34 years; implant duration was 7.38±4.49 years. Cases were compared with 20 healthy controls well-matched in terms of age (mean =31.15±10.67 years) and gender. All were submitted to: 1) History taking, 2) E.N.T. examination. 3) Bed side examination of dizzy patient. 4) Basic audiologic evaluation: using Audiometer: Model Orbiter 922 in a sound treated room: Amplisilence & GSI 33 (Garson Stadler) middle ear analyzer. 5) SOT of CDP using Equitest (Neurocom International, Clackamas, Oregon, USA) equipment. It was performed with the CI device-on so the patients could hear the instructions. Parameters measured were: equilibrium scores in the 6 SOT conditions, composite score, and sensory analysis ratios (somato-sensory (SOM), visual (VIS), vestibular (VEST) and visual preference (PREF). 6) VEMP, using Auris one channel instrument, while the CI device was off to avoid high current intensities causing pain or facial nerve stimulation. P13-N23 biphasic responses were judged as either present or absent. Parameters measured are: p13 and n23 wave latencies and p13-n23 peak to peak amplitude, and inter-aural amplitude difference (IAD) ratio. An IAD >0.36 is abnormal. Statistical analysis was done by statistical software package SPSS version 11.5. A difference was considered to be statistically significant when the probability (p) value was ≤0.05.

Results

Vertigo was present in 10/20 cases pre-operatively and in 5/20 cases post-operatively, two fifth of those recovered from vertigo later on. Eleven cases had post-operative dizziness that disappeared later on in 1 case. SOT revealed that 7/20 cases were normal and 13 had abnormalities of some kind (Figure 1). There was a statistically significant

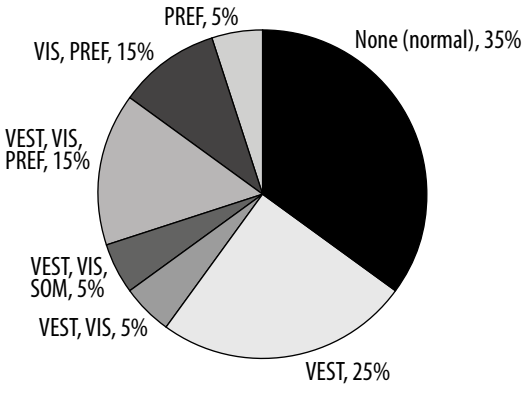

Figure 1. Distribution of posturographic findings of the CI recipients.

and non-implanted ears with regard to p13 latency only and between cases' implanted ears and controls with regard to p13 latency and p13-n23 amplitude and between cases' non-implanted ears and controls with regard to n23 latency (Table 1). Six of the 11 bilaterally preserved VEMP were normal and 5 had abnormal IAD that differed significantly from controls with the implanted ear showing lower VEMP amplitude (Table 2).

All patients with post-operative vertigo and the majority (82%) of patients with post-operative dizziness had abnormal VEST ratio, and these showed statistically significantly worse VEST ratio, but not VEMP results, than those without symptoms. Although 50% of cases with normal VEMP showed abnormal SOT (other cause of imbalance than saccule), and 71.4% with abnormal VEMP showed normal SOT (compensated saccular dysfunction), this was not statistically significant (Fisher's Exact χ^2=0.829;

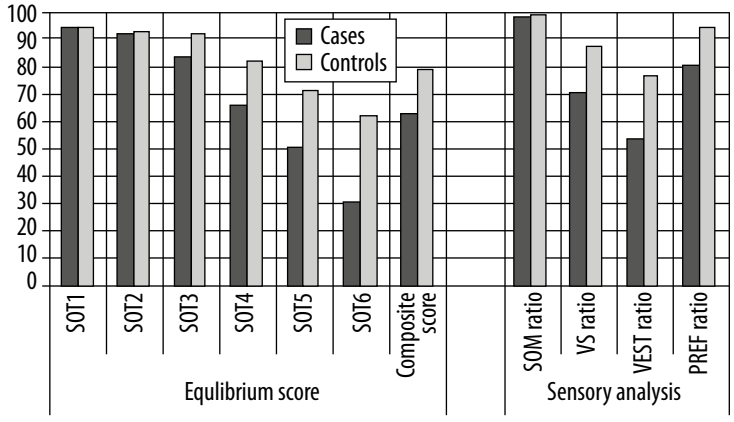

Figure 2. Mean values of equilibrium scores in the cases and controls.

Table 1. VEMP results of cases' implanted, non-implanted ears & controls.

	Cases' Implanted (N=20)		Cases' Non-Implanted (N=20)		Controls (N=40)	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
p13 latency (msec)	15.07	1.89	13.75	1.69	13.61	1.51
n23 latency (msec)	21.00	1.70	19.86	1.15	20.88	1.56
p13-n23 amplitude(uv)	13.25	6.08	22.25	16.17	30.50	8.50

N – number of ears; N.B. A statistically significant difference is found between: cases' implanted ears & non-implanted ears, with regard to p13 latency (p=0.016). Cases' implanted ears & controls, with regard to p13 latency (p=0.008) and p13-n23 amplitude (p=0.000). Cases' non-implanted ears & controls, with regard to p13-n23 amplitude (p=0.001).

difference between cases and controls with regard to SOT conditions 4, 5, 6 and composite score as well as VIS, VEST and PREF ratios (p=0.026, 0.006, 0.000, 0.000, 0.014, 0.005 & 0.017 respectively) (Figure 2).

VEMP was bilaterally preserved in 11/20, unilaterally lost in 6/20 and bilaterally lost in 3/20. VEMP was preserved in 13/20 implanted ears and 15/20 non-implanted ears with no statistically significant difference between them (χ^2=0.476; p=0.366); nor between the loss of VEMP in right (6/12) or left (6/8) ears (χ^2=0.343; p=1.000). There was a statistically significant difference between implanted p=0.613). Pearson's correlation coefficient between the two tests: p>0.05). There was no statistically significant correlation between patients' age, or duration of sensory deprivation, or duration of implant use and neither of the different posturographic nor VEMP parameters.

Discussion

Balance symptoms in our CI recipients are consistent with authors reporting symptoms varying from mild to severe, mostly transient, that improve or pass over time through the processes of compensation, substitution and

Table 2. Inter-aural difference of VEMP parameters in cases and controls.

		Cases (N=20)	Controls (N=20)	z	p-value
Inter-aural amplitude difference (IAD) (uV)	Mean	12.85	0.80	–2.878	0.004
	S. D.	15.41	8.04		
	Min.	2.00	–17.00		
	Max.	60.00	13.00		
IAD RATIO	Mean	0.29	0.03	–3.202	0.001
	S. D.	0.20	0.15		
	Min.	0.09	–0.20		
	Max.	0.64	0.30		

N – number of subjects.

habituation [1,3–6]. The type of functional alteration is marked by anatomic factors, by individual predisposition to the stimulus pattern produced by the CI and also by the plastic capacity of the neural system of each individual [7]. Different etiologies are postulated, most commonly related to surgical trauma and/or electrical stimulation of the vestibular system by the CI, or to a disorder that existed preoperatively [8], or to an advanced age [9]. Delayed episodic dizziness could result from chronic changes in the inner ear; endolymphatic hydrops was suggested [10]. Chronic, persisting dizziness is largely based on a dysfunction of the saccular macula which is an integral component of the otolith system. Histo-pathologic studies revealed that the saccule is the most frequently damaged organ, followed by the utricle, then the semicircular canals [3]. Our CDP results agree with these of many authors [1,11,12]. However, Buchman et al., [6] concluded that unilateral CI rarely results in significant adverse effects on the vestibular system; on the contrary, recipients experienced significant improvements in postural stability, with an additional positive effect on device activation in music. The presence of VEMP in some of our implanted ears or its absence in some non-implanted ears eliminates any direct traumatic effect of CI surgery on the saccule. The bilateral loss might be due to the etiology of the hearing loss itself. But the difference in p13 latency between them and between cases' implanted ears and controls may indicate minor saccular affection. Our results agree with those of other authors [9,12,13]. We found no correlation between patients' symptoms and VEMP, in agreement with Zhou et al. [14] opinion stating that possible explanations for why many hearing-impaired patients with abnormal VEMP do not have complaints of vestibular symptoms include: (1) saccular impairment alone is not enough to cause clinically significant vestibular disturbance, (2) chronic peripheral vestibular deficit may generate central compensation, and (3) less attention is paid to subtle manifestations of vestibular dysfunction in the patient. We recommend including CDP and VEMP in the pre-implantation and post-implantation test battery, to detect and monitor any balance or saccular dysfunction, if any, to initiate an early vestibular rehabilitation program when necessary, for a better quality of life.

Conclusions

Balance dysfunction is not uncommon in CI recipients. But vestibular nerve does not seem to be necessarily stimulated by the CI, which does not necessarily damage the saccule whose dysfunction can be compensated.

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