How Can the Cochlear Implant Interfere with the Vestibular Function?

Patricia Arena Abramides*, Ricardo Ferreira Bento**, Roseli Saraiva Moreira Bittar, Rubens Vuono de Brito Neto****, Robinson Koji Tsuji*****.***

* Specialist Physician in Otolaryngology.
** Professor of the Otolaryngology Department, FMUSP.
*** PhD in Medicine from the University of Sao Paulo. Assistant Physician, Department of Otolaryngology HCFMUSP
**** Associate Professor, FMUSP. Assistant, Division of Clinical Otorhinolaryngology HCFMUSP
***** PhD in Otorhinolaryngology by FMUSP. Attending Physician, Division of Clinical Otorhinolaryngology HCFMUSP Coordinator of the Cochlear Implant Team HCFMUSP

Institution: Departamento de Otorrinolaringologia da FMUSP ICHC.
São Paulo / SP - Brazil
Mail address: Patricia Arena Abramides – Departamento de Otorrinolaringologia da FMUSP ICHC – Avenida Enéas de Carvalho Aguiar 255, 6º andar – Sala 6021 – São Paulo / SP – Brazil - CEP: 05403-000 - Telephone: (+55 11) 8271-0138 – E-mail: parena@terra.com.br
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SUMMARY

Introduction: The cochlear implant is a therapeutic option for patients with deep neurosensorial deafness. Some implanted patients evolved with dizziness in the postoperative, which started the interest for the vestibular function. Since then, many studies have reported the association between the cochlear implant and the vestibular dysfunctions.

Keywords: cochlear implant, dizziness, Ménière's disease.

Introduction

Hearing is the function that helps us understand the world around us. The presence of the hearing capacity was fundamental for the survival of our species: getting around from predators, the crying of the suckling, the calling of the group. However, what differs the general living beings from humans is the tireless search for a means that allows us not only living more, but living with quality. And hearing has a basic importance in the so dreamed quality of life. It was aiming at rescuing this function that several researchers dedicated to the development of some interface that could recover the sound perception to those who lost it or never had it.

The cochlear implant (IC) is a prosthesis aiming at replacing the affected organ of Corti, by directly stimulating the nervous fibers and the ganglionar cells of the auditory nerve. This option enables the auditory sensation and the speech and sound recognition.

Differently from the hearing aid, that requires the existence of hair cells to transfer the signal to the auditory nevus, the cochlear implant takes over the function of such cells and activates the auditory nerve directly. Then, by using the CI, the individual with severe and deep hearing loss is able to perceive auditory sensations.

The interest for the vestibular function in implanted patients started with the observation that some of them evolved with dizziness in the postoperative. Since then, several authors dedicated to the research and documentation of the vestibular system function in these patients.

The objective of this study is to review the current knowledge concerning the vestibular function in patients with CI.

Method

The first article that addresses the subject was written by Black in 1977 (1). From then, a survey in the literature has found 40 articles regarding the vestibular function in patients with CI. The bibliographic research was made between 1970 and May 2008, in the following databases: PUBMED, MEDLINE, LILACS, OVID.

The keywords used for the search were: cochlear implant, vertigo, dizziness, Ménière's disease The articles were selected according to inclusion criteria: articles published in English; articles that related CI with the vestibular system and the body balance study; articles that addressed dizziness relating to the CI surgery. We excluded articles written in other languages rather than English and those from magazines not published in Brazil.

Our research focus comprised: the presence and the type of involvement of the vestibular function and the anatomic description of the vestibular-cochlear interaction.

Results

Out of 40 articles found, 31 met the inclusion criteria. Nine articles were excluded for meeting the exclusion criteria. 5 for having been published in papers that are not published in Brazil and 4 for having been published in other language (1 article in Japanese, 1 in German, 1 in Russian and 1 in Polish).

In Table 1 you find 30 reported articles that med the inclusion criteria and were selected for analysis.

Discussion

Since Black (1977) (1, 2) described a reduction or absence of the answers in the caloric proofs of patients submitted to CI, many other studies reported the potential risk of the cochlear implant to interfere with the vestibular function (3, 4, 5, 6).

The articles studied presented a variable general quality. In 4 articles we didn't even set up the number or group of the patients studied (see articles with ?). Most authors carried out a prospective study from the observation of patients submitted to CI who presented some complaint regarding body balance during its evolution. Even though, in many studies the variable "time" was not well defined. The number of patients studied ranged from 5 to 469, which makes it difficult and, to a certain extent, not much reliable to set up a pattern of comparison between the various results found. Other difficulty was to group the studies around a common point, since they presented different objectives. The authors used different evaluation criteria of the vestibular function, since questionnaire, such as the dizziness handicap inventory (DHI), activities-specific balance confidences (ABC); electronistagmography (ENG), video-oculography (VOG), use of force platforms, computer dynamic posturography (CDP), descending pendular rotatory test (DPRT), Dix-Hallpike maneuver and even criteria for Ménière's disease. The evaluation criteria were the same before and after surgical interventions, except for Bonucci, who used the caloric proofs from water in the preoperative and air in the postoperative; which makes the adequate and reliable results analysis difficult.

Table 1. Relation of article selected for analysis.

	Author	Year of publication	Type of Study	n	CI X vestibular function interference
1	Black et al	1977	prospective	11	yes
2	Black et al	1977	prospective	13	yes
3	Black et al	1978	prospective	?	yes
4	Einsenberg et al	1982	prospective	22	no
5	Black et al	1987	prospective	5	yes
6	Boek et al	1983	prospective	25	yes
7	Huygen et al	1994	prospective	25	yes
8	Huygen et al	1995	prospective	50	yes
9	Brey et al	1995	prospective	52	yes
10	Ito	1998	prospective	55	yes
11	Bance et al	1998	prospective	17	yes
12	Ribari et al	1999	prospective	?	yes
13	Vibert et al	2001	prospective	15	yes
14	Kubo et al	2001	prospective	94	yes
15	Szirmai et al	2001	prospective	60	yes
16	Steenerson et al	2001	retrospective	?	yes
17	Ribari et al	2002	prospective	?	yes
18	Lustig et al	2003	retrospective	9	yes
19	Fina et al	2003	control case	75	yes
20	Özdogmus et al	2004	prospective	9	yes
21	Buchman et al	2004	prospective	86	yes
22	Klenzner et al	2004	prospective	120	yes
23	Bouccara et al	2005	multicentric	469	yes
24	Migliaccio et al	2005	Prospective	16	yes
25	Limb et al	2005	retrospective	12	yes
26	Filipo et al	2006	prospective and retrospective	93	yes
27	Enticott et al	2006	prospective	146	yes
28	Zanetti et al	2007	prospective	32	yes
29	Suarez et al	2007	coorte	13	no
30	Viccaro et al	2007	control case	70	yes
31	Bonucci et al	2008	prospective	38	yes

Out of 31 authors, 16 chose ENG isolated or combined with other exams for evaluation of the vestibular function. Buchman et al (2004) were the only authors to use ENG, Computer Dynamic Posturography DPRT, and DHI jointly, and presented a complete and reliable study regarding preoperative and postoperative vestibular function (14).

From our research focus we may infer that as for the vestibular function, the opinions of the authors are controversial. Some believe that CI interferes with the vestibular function and has a risk of loss ((Brey, Vibert, Enticott, Huygen and Steenerson) (3, 6, 25, 28, 31) and others believe CI has no effect on vestibular function (Einsenberg, Migliaccio AND Suarez) (19, 23, 24). In the other hand, there are authors who believe the CI may improve body balance (Buchman, Szirmai, Bance and Ribari) (14, 15, 16, 38).

The risk of vestibular function loss was variable for Huygen et al (6, 39). While such risk was estimated in 31% in the first study (6), in a second sample the same author reports the risk between 50-60% of post cochlear implant vestibular function loss (39). His last study is according to the results of Van Den Broek et al (40), who found 60% of risk of post-CI vestibular function loss. However, Bouccara et al (4) found 16% of the adults and 3% of the children who presented dizziness at the CI postoperative. For Vibert (28) et al the canalicular function was temporarily damaged in 20% of the cases while the otolithic function was preserved in all the 6 patients tested.

According to Suarez (24) et AL, the alterations on the balance didn't remain and, in spite of this vestibular function loss, the children could keep an adequate balance control, and CI doesn't affect the sensorial organization strategy.

Another group of authors believes the CI doesn't cause balance risk, such as Einsenberg et al and Migliaccio et al. Bance et al (19,23,38), believed it's possible that the multichannel CI activates the vestibule-ocular system in some cases, but in a clinically non-significant manner.

Opinion shared by Buchman et al (14), who believe the patients submitted to CI may have a significant improvement of the posture evaluated by the Computer Dynamic Posturography. If we analyze the period of follow-up carried out by each author, we verify that Buchman (14) performed serial evaluation in 30 days, 4 months, 1 year and two years after CI, while Migliaccio followed the patients for 4 to 6 weeks after the CI. Einsenberg (19) and Bance (38) did not set up the follow-up period. That is, the "time" factor was determining to define the CI influence to the vestibular function. The work by Buchman (14), who studied the major period of follow-up, described the improvement of the vestibular function. Therefore, the studies with a short or undefined follow-up period may not be taken into account upon determination of the real influence of the entire work of stimulation and fitting of the CI for body balance.

Out of the 60 patients studied by Szirmai et al (16), 16 had a vestibular response improvement at the postoperative, whose explanation is not clear for the author. For Ribari et al (1999) both the auditory and the vestibular improvement of the ear contralateral to CI may be ascribed to 2 factors: Efferent innervation and brain plasticity. In 2002, the same author (15) reported a hearing and response improvement to the caloric test of the non-implanted ear in 30% of the cases. The author concludes that such observations may be explained by the neuronal plasticity and the auditory stimulus may affect the labyrinth.

As for the complications occurred in the CI postoperative, we also find controversy in the literature. For Filipo et al (20), the CI may induce to vestibular damage right after its placing or activation, which could be a possible complication of the intraoperative trauma or, at a lower degree, the electric stimulation. According to Enticott (3), one third of the patients may present some disorder of the vestibular system after CI and apparently the oldest patients are more prone to permanent vestibular damages.

Fina et al (21) reported that in 39% of the implanted patients who presented with dizziness, it occurred lately and could be a result from changes in the inner ear such as endolymphatic hydrops. For Kubo (22), the inner ear lesions secondary to CI develop gradually and are clinically comparable to the Ménière's Syndrome, which indicates the presence of labyrinthic hydrops. According to Lustig et al (27), patients with Méniére's Disease, previously submitted to the vertigo control surgery (neurectomy, endolymphatic sac decompression) don't present contraindication for IC, which could benefit them from the audiologic point of view.

For Brey et al (25), most symptoms in the postoperative are transient, but when persistent, the treatment indicated is vestibular rehabilitation. For Klenzner et al (29), the risk of vestibular disorder after the CI surgery is reduced by the atraumatic insertion of electrodes.

Amongst the vestibular disorders described, the benign paroxist postural vertigo is a problem remarked in the literature as a post-CI complication. The relationship between this vertigo (VPPB) and CI was studied by Limb et al (26), Viccaro et al (32) and Zanetti et al (36). According to the first two authors the vertigo (VPPB) does not usually occurs after CI, but has a major incidence than in the general population. The treatment consists of repositioning maneuvers as it's usually done, and according to Zanetti (36), the VPPB does not interfere with the patients' speech perception.

According to studies carried out by Black et al, between 1977 and 1978 (1, 2, 18), the CI stimulates the vestibular nucleus through electric current and, therefore, the stimulus generated is not only limited to the auditory system. We observed instability when the patients were evaluated with the CI on, which suggests the action on the vestibular system. According to the author (1987) (34), the auditory, vestibulocolic and vestibulospinal reflexes confirmed their dependence upon the stimulus duration, frequency and amplitude. According to Ito (5), there was dizziness in 18% of the cases when the CI was activated; which indicates the electric current generated by the CI reaches the vestibular nerve.

Recently, Özdogmus et al (13), showed connections between the lower and cochlear vestibular nerves fibers and between the upper and facial vestibular nerves by means of electronic microscopy. The descriptions of connections between the vestibular and auditory systems may justify some clinical findings observed in implanted patients.

Conclusion

There are clinical evidences that CI is able to interfere with the vestibular function. The type of functional alteration is marked by anatomic factors, for individual predisposition to the stimulus pattern produced by the CI and also by the plastic capacity of the neural system of each individual.

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