Auditory Brainstem Implant in Children

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Introduction

The cochlear implant (CI) for rehabilitation of patients with profound or total bilateral sensorineural hypoacusis represents the initial use of electrical fields to provide audibility in cases where the use of sound amplifiers did not have satisfactory results. The basic condition for a cochlear implant to function is that the cochlear structure and also the cochlear nerve are anatomically intact.

Patients with a lesion of the auditory nerve between the spiral ganglion and the cochlear nuclei of the brainstem will not benefit from cochlear prosthesis, and remain isolated in a silent world. In such cases, where the nerve undergoes a lesion, whatever its cause, it is not possible to perform a cochlear implant. The use of an auditory brainstem implant (ABI) that promotes a direct stimulation of the cochlear nuclei (CN) is beneficial. Until now, these devices have been designed to provide superficial and deep stimulation of the CN, with the possibility of providing auditory sensations in subjects with lesions on the auditory nerve.

Presently, more than 500 patients with neurofibromatosis type II (NF-2) with tumors in both ears have received ABI implants. Most of these cases (85%) receive auditory information, thus improving their communication skills; they hear environmental noises, have speech auditory information (mainly suprasegmental: accent, duration, rhythm), which help them with lipreading (LR). A limited percentage can recognize speech in open format without the help of LR. In general, this achievement is considered similar to what is obtained in patients with mono-channel CI. It is possible that patients with post-lingual deafness can understand telephone speech with a multi-channel CI.

ABI is presently being used in a series of patients, both children and adults, non-tumor cases: *with aplasia or hypoplasia of the cochlear nerve, with large cochlear malformations or cochlear agenesis, with skull base fracture, with avulsion of the 8th pair and severe cochlear ossification.*

Prof. Colletti from Italy has the largest experience with such cases and his results are encouraging.

The cause of the large difference observed between CI and ABI is still being evaluated, as these devices are generally similar, the difference being the site of the stimulation.

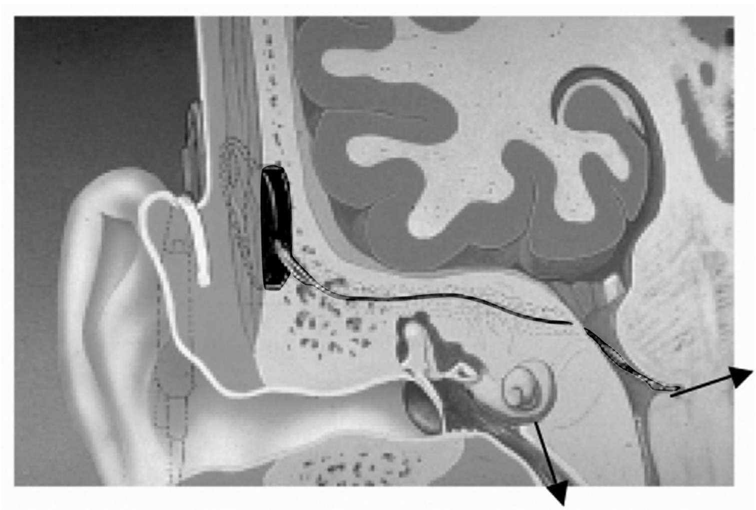
Prof. Colletti found that in post-lingual deafened adult patients, carefully studied

beforehand, ABI provided results similar to those obtained with a CI, including the use of a telephone. Results were also positive in children with congenital hearing impairment, in which CI could not be performed.
In Buenos Aires, in March 5, 2007, the author (VD) performed the first surgery for placement of an ABI together with Prof. Colletti, in a two-year old girl, with cochlea and auditive nerve agenesis. This is the first South American case in a pediatric patient.
History
The first ABI was developed in the House Ear Institute and manufactured by William House and William Hitselberger (Los Angeles) in 1979. At that time, the device was used as mono-channel prosthesis with a ball electrode and a percutaneous transmission system, based on the 3M-House cochlear implant system. The patient had bilateral deafness, secondary to the removal of bilateral auditory nerve tumors due to NF-2. After this first experience, the House Ear Institute researchers developed a more appropriate device, to be placed in the lateral recess, with two platinum electrodes mounted on a rectangular piece of Dacron®, designed to promote fibrous integration. Afterwards, this two-electrode system was implanted in 25 patients and then a similar three-electrode device was used. These internal parts were connected to the 3M-House processor.
The design of the electrodes project has been modified since the first attempts to electrically stimulate the CN. As a consequence, results have improved and a higher stabilization of the device has been achieved.
The development of a new generation of ABI was started in 1989, the multi-channel implants, based on the Nucleus 22 cochlear implant system, and was the result of a cooperative work between the House Ear Institute, the Cochlear Corporation and the Huntington Medical Research Institute.
In 1992, this device with 8 surface electrodes was first implanted in a patient. This multi-channel prosthesis was developed based on the Nucleus 22 cochlear implant. The electrode plate is placed on the CN surface, in the lateral recess of the fourth ventricle at the time of the tumor removal by translabyrinth approach. A transcutaneous system provides the stimulation, and a variety of communication strategies and stimulation modes can be used depending on the individual responses to the electrical stimulus. In most cases it was possible to use multiple electrodes in the calibration maps, with higher success possibilities in handling the nonauditory sensations, frequent in this type of patients.
In 1998, the “Prof. Diamante Cochlear Implant Center” in Buenos Aires was the first South American group to receive authorization to perform ABI. Later on, the ABI Nucleus 24 with 21 electrodes on a plate was launched, and more recently, as a result of intensive research trials, a deep insertion electrode is being used, with limited experience in humans. It is called PABI – penetrating ABI.
There are other companies with prototypes similar to ABI, as Medel, Advanced Bionics and Digisonic.
We have presently three patients with ABI placed to electrically stimulate the inferior colliculus (**Figure 1**). The results are promising, although the CN is still the site of choice for the placement of an ABI.

In children, ABI is indicated when:

- it is impossible to place a CI or CI has failed;
- absence of neurological deficits that prevent auditory habilitation;
- the family is motivated and the social environment is adequate;
- the surgical team has experience with posterior fossa surgery;
- other members of the team have experience in auditory rehabilitation;
- it is possible to have a prolonged and intensive rehabilitation.

Figure 1. Position of the auditory brainstem implant (ABI)



Conclusions

Until a few years ago, ABI was considered only for patients with NF2, especially when the surgery is performed to remove a neuroma. Presently, the use of this type of prosthesis is also considered for children and adults, particularly for patients with the non-tumoral causes that were described above.

Studies have demonstrated that these patients have significantly better results than patients with NF2 that receive a transplant. With ABI in non-tumoral cases, Colletti and coworkers have achieved an average of auditory phrases recognition, without LR, around 63%. In tumor cases, the average is 12.2%. According to these results, the non-tumoral cases are considered to be ideal for ABI placement, as the anatomy is intact. The ABI team involves professionals from many disciplines: otology, neuro-otology, audiology, electrophysiology, neurosurgery, neurology, and psychology. Very often, ophthalmologists and geneticists also participate. This type of implant has a very positive impact on the life of these patients. Results that were found are interesting and increase our knowledge about the potential of the central system auditory to respond to electrical stimulation and the possibilities of auditory realization with electrical stimulation on the surface of the cochlear nuclei in the brainstem, bypassing the cochlea and the nerve.

Recommended readings

1. Colletti V, Fiorino F, Carner M. Hearing restoration with Auditory Brainstem Implant in three children with cochlear nerve aplasia. Otol Neurotol 23: 682-693. 2002
2. Otto S, Brackman DE, Hitselberger, WE. Auditory Brainstem Implantation in 12 to 18 years old. Arch Otolaryngol Head and Neck Surg. 130: 656-659. 2004.
3. Colletti V, Carner M, Miorelli V, Guida M, Colletti, L, Fiorini, F. Auditory Brainstem Implant : new frontiers in adults and children. Otolaryngol Head and Neck Surg. 133: 126-138. 2005.