

EVOKED COMPOUND ACTION POTENTIAL (ECAP) OF THE AUDITIVE NERVE RECORDED FROM A GROUP OF CHILDREN USING PULSAR CI 100

**Dan V. Martu¹, Sebastian Cozma¹, Daniel Rusu², Aurel Curca²,
Laura Ungureanu², Cristian M. Martu¹**

REZUMAT

Introducere: La pacienții implantați cu implant cohlear MedEl se poate înregistra potențialul de acțiune compus al nervului auditiv (ECAP) pentru obținerea pragurilor care să fie utilizate în reglajul implantului. Scopul studiului a fost să determinăm în ce măsură înregistrarea intraoperatorie a ART (Auditory Response Telemetry) a avut rezultate, relația dintre ART și etiologia surdității, durata acesteia, resturile auditive și poziția electrodului intracohlear. **Material și metodă:** Am stabilit un protocol de evaluare a celor 10 copii implantați cu sistem MedEl tip Pulsar CI 100. Am înregistrat ECAP intraoperator, imediat după implantare, sub anestezie generală, apoi am verificat radiologic la fiecare caz poziția intracohleară a portelectrodului. **Rezultate și concluzii:** ART a putut fi înregistrat în condiții bune la majoritatea pacienților pe electrozii intracohleari. Calitatea răspunsului variază în funcție de poziția portelectrodului intracohlear. Am obținut răspunsuri ale nervului auditiv mai bune pentru electrozii situați în porțiunea medie cohleară și mai puțin ample pentru porțiunea bazală. Am determinat praguri auditive constant mai mari în grupul electrozilor bazali decât ale celor din regiunea medie și apicală cohleară. Nu a putut fi stabilită nici o dependență a ART față de durata privării auditive, dar am observat un răspuns ART mai deteriorat în hipoacuzia de cauză meningitică.

Cuvinte cheie: implant cohlear, ECAP

ABSTRACT

Introduction: The electrically evoked compound action potential (ECAP) of the auditory nerve can be recorded in cochlear implants and the obtained thresholds can be used to predict threshold levels for speech processor maps. The aim of the study was to determine how often the ECAP can be recorded using the auditory response telemetry (ART) system of MedEl cochlear implants and to find correlations with the deafness etiology, hearing loss duration, auditory rests and electrode array position. **Material and methods:** According with the established protocol, we have recorded the amplitude growth function of the ECAP on the Pulsar CI100 cochlear implants. This study included intraoperatively recordings in 10 children under general anesthesia immediately following the implantation. The X-ray control followed the surgery for each patient in order to localize the implant's electrodes. **Results and conclusions:** The amplitude growth function was obtained in the majority of measured intracochlear channels. The auditory response telemetry may vary depending of the position of the electrodes along the cochlea. The response was recorded better for the electrodes situated in the middle region of the cochlea and lesser in the basal part. We found thresholds values bigger in the basal group of electrodes than in the middle or apical group. No correlation can be established between the ART measurements and the hearing loss duration, but we observed a poor response in meningitis deafness.

Key Words: cochlear implant, ECAP, auditory response telemetry.

INTRODUCTION

The recording of the evoked compounded action potential (ECAP) of the cochlear nerve in the case of cochlear implants constitutes an instrument of orientation for establishing the auditory threshold of detection, essential elements in the adjustments of these prosthetic devices in children.^{1,2}

The results obtained depend on multiple factors, some connected with electro-physiological particularities of the auditory system of the patient, such as the quality of peripheral nervous fibers and their capacity of synchronization, refractory period etc., and others connected with the surgical performance (intracochlear insertion of the portelectrode and the correct choice of technological recording parameters.^{3,4}

The MedEl implant models Pulsar CI 100 and Sonata TI 100 feature the possibility of automatic recording of ECAP with the purpose of using the results for achieving an optimal implant tuning, in children, who do not collaborate for establishing the subjective detection thresholds. The method conceived by the producer of the implant and integrated in the Maestro program of assistance was named ART - auditory response telemetry.

¹ Gr. T. Popa University of Medicine and Pharmacy, Iasi, ² Department of ENT, Clinical Hospital of Recovery, Iasi, Romania

Correspondence to:
Dan V. Martu, 56 Lascar Catargiu Str., Iasi, Tel. +40-232-212185
Email: danmartu@personal.ro

Received for publication: May 22, 2008. Revised: Jul. 15, 2008.

The purpose of the study was to determine to what extent the intraoperative recording of ART (Auditory Response Telemetry) had results. Also, we studied in our patients the relationship between ART and the etiology of deafness, its duration, auditory remainders and the position of intracochlear electrode.

MATERIAL AND METHODS

The study included ten children with bilateral profound deafness who underwent bilateral cochlear implant, aged between two years and two months and eight years. The debut of deafness was congenital in eight cases, perilingual in one case and with ototoxic cause and postlingual in one case of meningial deafness.

The etiology of deafness in the other eight children with congenital debut was: hereditary in three cases, heredity and perinatal factors (prematurity, hypoxia at birth) in one case, and undetermined in the remainder. (Fig. 1)

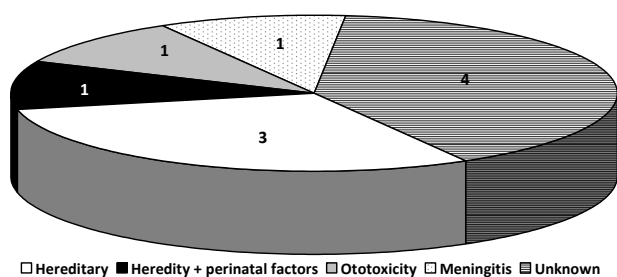


Figure 1. Etiology of deafness in children with cochlear implants.

We established a protocol of electro-physiological evaluation of the 10 children implanted with MedEl system, type Pulsar CI 100. After completion of the surgical intervention, under general anesthesia we performed the measuring of impedances.

We recorded the amplitude growth function through the Maestro Software version 2.0.1, the recorded electrode being close to the stimulated electrode. (Fig. 2)

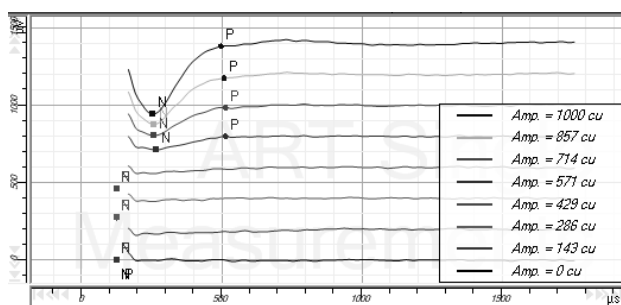


Figure 2. Measurement results.

The stimulation parameters of the electrodes were the following: the duration of phase $30\mu s$, minimum amplitude 0 with current unities, and the maximum amplitude was variable, depending on the response. In addition, the optimal measuring delay interval (recording delay) was searched individually. The interpretation of the results consisted in the visual identification of the reproducible positive and negative peaks of ECAP, the detection threshold being considered the lowest value of intensity in which these appear.

After the intraoperative recording of ECAP under general anesthesia, in every case we have verified radiologically the cochlear position of the portelectrode.

RESULTS AND DISCUSSIONS

In six patients a complete insertion of the 12-channel electrodes was realized, and were evident on the radiographs: in one patient - one extra-cochlear implant, in two patients - two extra-cochlear implants per patient, and three extra-cochlear electrodes in another case. (Fig. 3)

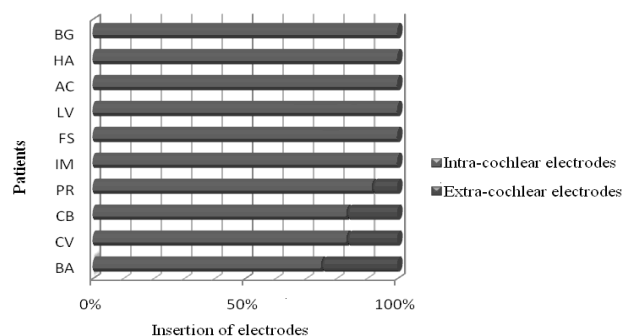


Figure 3. The situation of electrode insertion for the implant Pulsar CI 100 in the group of patients.

The impedances were normal for all patients in all the 12 channels of every implant.

We performed in every patient the maximum of admitted recordings by the particular situation of every intervention. All electrodes were tested in three patients, and in certain situations we tested at least four electrodes situated equidistantly on the port-electrode. (Fig. 4)

Figure 5 shows that 70% from the implanted electrodes were tested, and the testing ended with the collecting of ECAP in 85% from the measured electrodes. (Fig. 6) Their repartition in every patient is represented in Figure 4.

ART could be recorded in good conditions in the majority of the patients on intra-cochlear implants.

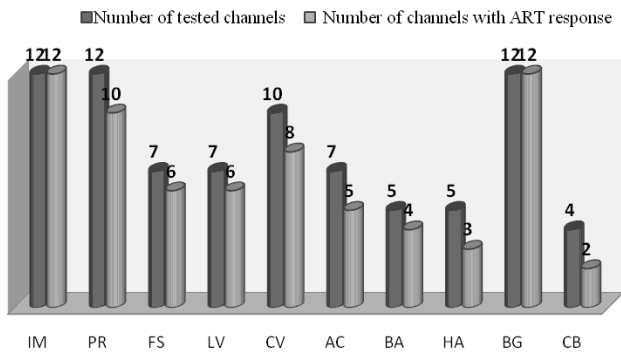


Figure 4. Individual recordings of ART on intra-cochlear channels.

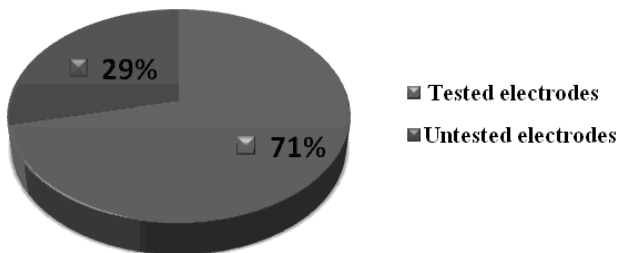


Figure 5. The percentage of the tested electrodes.

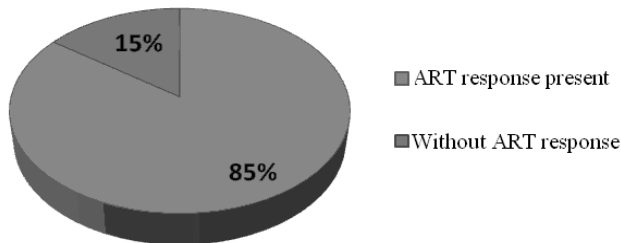


Figure 6. The percentage of the electrodes on which the ECAP responses were obtained.

The quality of the response varied, depending on the position of the portelectrode in cochlea.

We obtained better responses of the auditory nerve for the electrodes situated in the medial cochlear portion and less ample for the basal portion. (Fig. 7) Determined auditory thresholds were higher for the group of basal electrodes than those from the medial or apical cochlear region.

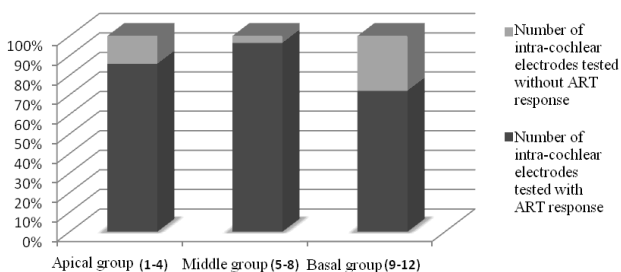


Figure 7. Representation of ART obtaining on groups of electrodes (basal, medial and apical).

We could not establish a dependence of ART on the duration of auditory privation, but a more deteriorated ART response was observed in the hypoacusia of meningeal cause.

We could not demonstrate, in our group of patients, the observations of other published studies according to which ECAP is better collected if there were auditory remainders on the implanted ear than in the case of complete auditory deprivation.⁵ The percentage of ART obtained is even better for the patients without auditory remainders (86% compared to 77%). (Fig. 8, 9)

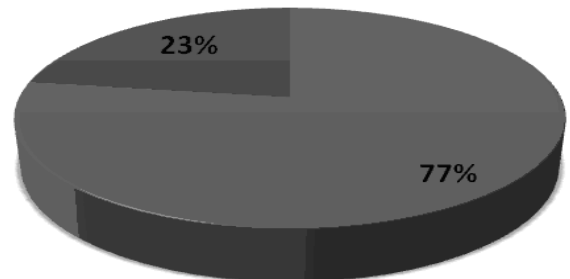


Figure 8. ART in patients with auditory remainders in the implanted ear.

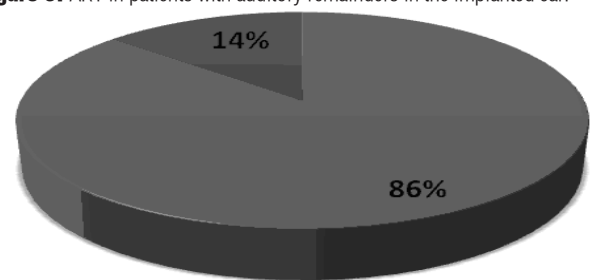


Figure 9. ART without auditory remainders in the implanted ear.

CONCLUSIONS

We obtained ART responses in an important proportion, on 85% from the tested intra-cochlear implants. In the case of profound insertion, the ART response is better in all the tested electrodes.

The most degraded ART response was recorded in the child with neural-sensorial hypoacusia, where we collected a response only from two of the four measured channels.

ART was better collected in the middle portion of the cochlea and worse in the basal portion.

We could not establish a relationship between the age of implantation and the quality of ART response, and ART responses in children with auditory remainders on the implanted ear were not better.

The ART proved to be an important instrument, which could be used with the aim to adjust the cochlear implants in child, except from those with deafness of

meningeal cause. ART is a good indicator of the intra- and extra-cochlear electrodes.

REFERENCES

1. Lai WK, Dillier N. Comparing neural response telemetry amplitude growth functions with loudness growth functions: preliminary results. *Ear Hear* 2007;28(2):42S-45S.
2. Abbas PJ, Hughes ML, Brown CJ, et al. Channel interaction in cochlear implant users evaluated using the electrically evoked compound action potential. *Audiol Neurootol* 2004;9(4):203-13.
3. Alvarez I, de la Torre A, Sainz M, et al. Generalized alternating stimulation: a novel method to reduce stimulus artefact in electrically-evoked compound action potentials, *J Neurosci Methods* 2007;165(1):95-103.
4. van Dijk B, Botros AM, Battmer RD, et al. Clinical results of AutoNRT, a completely automatic ECAP recording system for cochlear implants. *Ear Hear* 2007;28(4):558-70.
5. Basta D, Dahme A, Todt I, Ernst A. Relationship between intraoperative eCAP thresholds and postoperative psychoacoustic levels as a prognostic tool in evaluating the rehabilitation of cochlear implantees. *Audiol Neurootol* 2007;12(2):113-8.