

# Amplitude Changes of the Electrically Evoked Compound Action Potential of Children with Cochlear Implants: Preliminary Results

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## Abstract

**Objective:** Use of electrical instead of acoustical stimulation has made much objective electrophysiological evaluation possible. This is useful for management process of young children before and after the cochlear implant. These evaluations have been used for assessment of neuronal survival before cochlear implant and for monitoring of prosthesis function during and after the surgery. Electrically evoked compound action potential is one of these tests which makes a valid and reliable objective evaluation possible. The aim of this study was to evaluate the potential's amplitude changes three months after receiving the device in pediatric cochlear implant recipients.

**Methods:** In this longitudinal study, changes of the potential's amplitude in four given electrodes in four sessions after receiving the device are evaluated by approximately one month intervals in children implanted in Amir Alam and Hazrat-e-Rasoul hospitals, Tehran in July to December 2007.

**Findings:** The mean amplitude of the electrodes did not significantly change in different sessions, while there was significant difference between the first and the other electrodes' responses in every session ( $P < 0.05$ ).

**Conclusion:** Due to high reliability of the responses, the clinician can fit the speech processor for a long time. Better responses in apical electrodes may lead to develop an effective coding strategy.

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**Key Words:** Electrically Evoked Compound Action Potential; Amplitude; Neural Response Telemetry; Cochlear Implants; Children

## Introduction

In recent years, use of electrical stimulation instead of acoustical stimulation has made much

objective electrophysiological evaluation possible, that is useful for management process in young children before and after cochlear implant [1]. These evaluations have been used for assessment

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of neuronal survival before cochlear implant and for monitoring of patient and prosthesis function during and after the surgery [1,2].

One of these evaluations, nowadays in top of research projects, is called electrically evoked compound action potential (ECAP) which seems a valid and reliable objective evaluation [3,4]. Here, electrical stimulation of peripheral portion of auditory nerve via electrode array, evokes neuronal response in ascending auditory pathway, that can be recorded by using the same techniques in conventional acoustical evoked response audiometry (ERA) [1,5]. For this, the producers use similar method and technique with different names [3]. This technique in Nucleus CI24R (CS) and the related software – which has been used in this study – is called neural response telemetry (NRT) [1,3].

The ECAP amplitude is so large because of recorder electrode being in the vicinity of neural components is very flexible and efficient facing movement artifacts [3]. Therefore, there is no need to use sedatives in children and this is very suitable for the evaluation in young children [1,3]. The response consists of a negative peak ( $N_1$ ) with about 0.3ms and a positive peak ( $P_1$ ) with around 0.6ms latencies [3]. Fig. 1 shows a sample of mentioned response. Generation sites of the electrical evoked responses are the same as acoustical evoked responses. So, the sleep, unconsciousness and sedatives have similar effect on these responses.

During recent years many studies on ECAP have been conducted in adults after surgery [1]. Primary studies have focused on parameters needed to record an ECAP response amplitude [5-8]. Lai et al evaluated longitudinal behavior of the response and found the relative stability of NRT responses [9]. Cafarelli Dees et al evaluated the latency, amplitude and slope of amplitude growth function. They suggested normative data for amplitude and latency [10]. Later, other studies (for example Lai et al) were conducted to assess ECAP potential clinical functions [11]. Recently, such studies are accomplished in children before and after the surgery [1]. At present, due to importance of precise setting of speech processor and non accessibility of children's behavioral response, most of the studies evaluated the relation between ECAP threshold level, behavioral threshold and comfortable levels of the patients, and found Considerable results.

In this study, we evaluated ECAP amplitude changes three months after receiving the speech processor in pediatric cochlear implant.

## Subjects and Methods

In this longitudinal study the data are collected by observation and measurement. Statistical population consisted of all children less than four

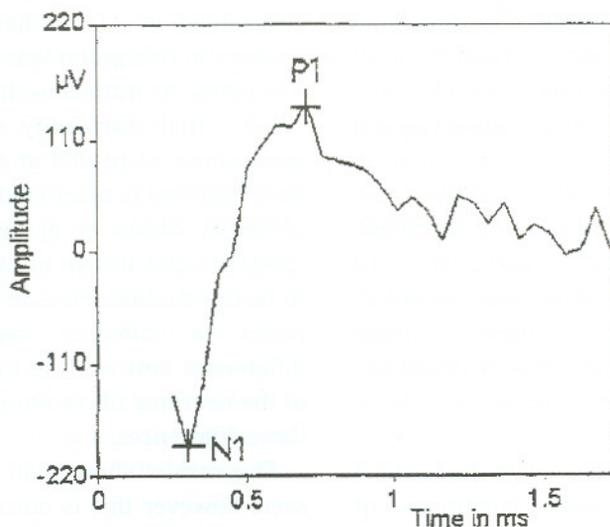


Fig 1: A normal evoked compound action potential waveform

years old which were operated for cochlear implant in two cochlear implant centers (Rasoul-e-Akram and Amir Alam hospitals) in Tehran during summer and autumn 2007. The study was complete on 36 (18 boys and 18 girls) operated cases. The remaining 6 were excluded from the study because of being absent in at least one session. The mean age was 41 months (SD 5.13).

## Evaluation process

The first session coincided with receipt of processor system (about 40-60 days after surgery). In this session, after voluntary completing of questionnaire by parent, external components (including speech processor, microphone, coil and related attachments) were delivered to the parents with the necessity guidance. The prosthesis in all patients was Nucleus 24 RCS (Cochlear Co. Australia). This test is noninvasive and a part of the evaluation. However, consent of the parents was achieved. In addition, because evaluation of all electrode arrays was time consuming (which included 22 active and two reference electrodes), only four electrodes in base, middle tended to base, the middle tended to apex and apex were evaluated. Therefore, according to electrode positions, we can evaluate thorough electrode arrays synoptically. In most of the patients, the 1<sup>st</sup>, 8<sup>th</sup>, 15<sup>th</sup> and 20<sup>th</sup> electrodes (from base to apex) were evaluated and only in five cases, the vicinity electrode responses were evaluated due to absence of response in one or some electrodes.

The first step in this evaluation was determination of ECAP threshold. The threshold was determined by ascending presentation of stimulus level in each of the four electrodes. The thresholds were determined by observational method. In this method, an expert clinician observes the waveforms and determines the smallest acceptable waveform as ECAP threshold. Then stimulation's intensity increased 5-10 current levels and this response was recorded, too. After that, the amplitude of these responses were determined and the difference between the amplitudes of these two responses were calculated as amplitude growth.

The evaluations were repeated in 1, 2 and 3 months later with the same conditions of stimulation parameters and response recording,

and all results were recorded again.

Finally, the amplitude changes in each case were compared in various sessions interelectrode and intraelectrode.

NRT software (v 3.1) was used to record the patients' responses. We used statistic parameters and applied Friedman test for analyzing. SPSS software (v 11.5) was used to analyze the data.

## Findings

Children's average age at the surgery was 41 months (range 26 to 48 months) (SD= 5.13). This was 41 months for boys (range 26 to 47 months) (SD= 5.27) and 40 months for girls (range 31 to 48 months) (SD= 5.11).

The amplitude changes in different sessions are shown in Table 1. The intraelectrode results showed little increase in amplitude average by time passing in all electrodes, and this was not significant in all electrodes ( $P>0.05$ ).

The interelectrode results showed that the average of amplitude changes in 1<sup>st</sup> electrode is less than in other electrodes. This was significant in most of sessions ( $P<0.05$ ) [Table 1].

## Discussion

Determination of normal limit for amplitude changes in this group was impossible due to high variability in intrasubjective and intersubjective results. High variability of intrasubjective and intersubjective results in different electrodes has been reported in other studies, such as Brown et al (1996)<sup>[6]</sup>, Abbas et al (1999)<sup>[7]</sup>, Cafarelli Dees (2005)<sup>[10]</sup> and Brown et al (1998)<sup>[15]</sup>. This seems to be due to differences in provocability of neural fibers in different cases. Inter subjective differences between the numbers and properties of the neuronal fibers are probably the reasons of these differences.

The results show that with the time, a little seen, however this is not significant. There is no increase in intraelectrode amplitude difference is

**Table 1:** Mean (standard deviation) amplitude changes in different electrodes in different sessions (n=36)

Session	Mean (standard deviation) amplitude changes in different electrodes				
	1 <sup>st</sup>	8 <sup>th</sup>	15 <sup>th</sup>	20 <sup>th</sup>	P value
1 <sup>st</sup>	14.30 (11.51)	24.87 (20.42)	22.97 (18.59)	23.60 (19.59)	0.08
2 <sup>nd</sup>	19.33 (21.17)	32.53 (23.48)	28.62 (31.29)	33.29 (22.56)	<0.001
3 <sup>rd</sup>	20.16 (17.63)	32.83 (23.54)	29.85 (28.36)	30.54 (22.46)	0.002
4 <sup>th</sup>	20.29 (17.58)	36.69 (27.45)	35.30 (33.91)	27.80 (21.86)	0.1
<b>P value</b>	Ns*	Ns	Ns	Ns	

Ns: Non significant

study in this field yet. Such results can be due to some peripheral physical changes in these patients. Formation of a fibrous tissue on electrode array which gradually happens after surgery, can move electrode array and affect the neural current, and so change the amplitude. In addition, neurophysiologic changes in this period should be considered too. Gradually changes in Na<sup>+</sup> and K<sup>+</sup> around the electrode can affect the current flow from electrodes to neural fibers, and change the ECAP amplitude. So, more changes are seen between intraoperative and responses achieved one month later. This is evident by changes in amplitude response, and consequent need to change the speech processor programming in patients with Menier's disease that received cochlear implant prosthesis. Also the same results are seen in patients with fistula. The general opinion is that the resulted changes in ECAP during the time indicate the stimulation path changing or variations related to neural response.

Probable effect of prosthesis type on amplitude of responses is presumed. Lai et al<sup>[9]</sup> and Hughes et al<sup>[16]</sup> already had shown this in ECAP threshold. Hughes et al have seen significant increase in ECAP threshold. This incompatibility in their study and present study's results may be due to different prosthesis, whereas the design of CI24R (CS) model is so that it causes closer electrode array to neural terminals (in comparison with CI2M model in Hughes et al studies). In addition, recent technological improvement which increased surgical accurateness can cause less damage in tissue, which in turn decreases the replacement of fibrous or bony tissues in place. Therefore, the interval between stimulator and the fibers does not increase.

Interelectrode results show that the 1<sup>st</sup> electrode's amplitude differences are lower than the other electrodes' results and this is significant. This is compatible with the results of the study of Cafarelli Dees et al (2005)<sup>[10]</sup>. It seems that this phenomenon is due to less neural cells in this region of spiral ganglion. Due to the more peripheral region for basal turn of the cochlea, it is more possible to damage this turn, so, less neural density of this region in comparison with apical turn. This significant difference between neural survival of these regions can explain the difference between our results.

It is not possible to determine the normal range in this group, which is due to high variability of intrasubjective and intersubjective results. This is the same as the results of other studies<sup>[6,7,10,15]</sup>. It seems that is due to the difference between the excitability of neural fibers in different patients. The difference between the density and properties of these fibers can cause this significant difference.

## Conclusion

This invariability of results during the time could ensure the clinician that these primary results can be used at least for three months for speech processor setting. The better results in more apical electrodes could have important role in prosthesis setting. In fact, we can use some electrodes for prosthesis adjustment that increase effectiveness of setting process, although a similar study in adults with postlingual deafness is recommended. Comparison of the results of these two studies would be valuable.

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**Conflict of Interest:** None

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