Int. Adv. Otol. 2009; 5:(1) 100-103

ORIGINAL ARTICLE

A Comparison of Electroaudiometry (EAM) and Electrically Evoked Brainstem Response (EABR) with the Cochlear Implantation Hearing Results

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Objective; Reliable preoperative assessment of the central auditory pathways is advisable in cochlear implant candidates. In order to decide the reliable technique, subjective and objective test techniques are correlated to each other.

Patients & Methods; Electroaudiometry (EAM) is a subjective, noninvasive investigation where the stimulating electrode lays in the external ear canal. It was performed in 86 deaf patients. In contrast, to detect the electrically evoked auditory brainstem responses (EABR), myringotomy is necessary and a stimulating electrode has to be inserted close to the round window. EABR is was performed in 52 deaf patients. The Results of both examination techniques were compared by using logistic regression. The data obtained were also compared with the hearing results obtained following cochlear implantation (CI) in 62 patients.

Results; Using EAM, the positive respondse was obtained in 154 of the 172 ears (90 %). In EABR, positive responses were obtained in 67 of 104 ears (64%). Among them unilateral cochlear implantation was performed in 62 patients. Logistic regression tests showed a significant correlation between EAM and EABR. The comparison of EAM and EABR prior to CI with the post CI hearing data revealed a strongly significant correlation.

Conclusion; Results of EAM and EABR were comparable. Results obtained with EAM or EABR were predictive for successful cochlear implant usage.

Submitted : 27 September 2008 *Revised : 02 January 2009* *Accepted : 03 January 2009*

Preoperative assessment of the central auditory pathway function and its integrity has to be performed reliably for all cochlear implant candidates [1,2]. For this purpose several noninvasive and invasive; subjective and objective electrophysiological tests, can be used [2-7].

Electroaudiometry (EAM) also known as extra tympanic electrical stimulation of the auditory nerve, is a subjective test method. The stimulating electrode is placed in the external ear canal pre-filed with saline solution and the electrical stimulating impulses are delivered. The patient subjectively determines the electric current that is stimulating a hearing sensation [5-9].

Electrically evoked auditory brainstem responses (EABR) is an objective and functional examination method, which allow us to assess the function of the remaining auditory nerve fibers as well as to determine the site of the auditory nerve lesion [10, 11]. The ⁄golf club® stimulating electrode is placed as close as possible to the round window, after a myringotomy incision and by using endoscopes. EABR are measured on opposite vertex and lobus under general anesthesia and muscle relaxation.

The post cochlear implant hearing is a final confirmation of the function of the auditory pathways and can be compared with preoperative electrophysiological evaluation of the auditory pathways [2, 5, 6, 12].

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Materials & Methods

Patients were recruited from the Ljubljana Cochlear implant program and the National newborn hearing Screening Program at University Medical Centre Ljubljana, Department of Otorhinolaryngology and Cervicofacial surgery, from February 1996 to March 2007. The protocol of this prospective study was approved by the National Medical Ethical Committee and informed consent was obtained from all subjects and/or parents of babies tested prior to the study.

In each patient, a complete medical history was obtained to determine the age at onset of deafness. The deaf subjects underwent a thorough otorhinolaryngological examination with a systematic search for signs of a syndromic deafness. Infants underwent ophthalmologic and pedoneurologic examination. Transient otoacoustic emission tests (TOAE), behavioral pure tone audiometry and auditory brainstem response tests (ABR) were applied to babies. Adults underwent pure tone audiometry with a diagnostic audiometer in a sound proof room. Air-conduction pure tone average thresholds in the conversational frequencies (0.5, 1, 2 kHz) were measured.

High resolution computed tomographies were obtained as well as magnetic resonance images in selected cases to exclude the morphologic etiology for deafness. Patients in whom the progressive hearing loss ended with deafness were referred to a neurologist and a rheumatologist to exclude other secondary causes of deafness such as Borrelia Burgdorferi.

EAM was applied to 86 deaf patients, (age range 3.5 - 76 years - mean age 21 years) by using MED-EL Medical Electronic electroaudiometer (Innsbruck, Austria). The electrical current threshold to evoke a hearing sensation was recorded. A bipolar electric impulse of 512 ms duration was used for stimulus. The measurements were performed at six different frequencies of electric current (63, 125, 250, 500, 1K, 2K Hz) and the current range of 500 -163 micro-amperes. Among 52 out of the 86 patients, EABRs were identified under general anesthesia. Reversed electrical stimuli with intensity from 200 micro-amperes to 1 mA and duration of 200 microseconds were used (Nicolet Viking IV system, and current stimulator up to 1 mA from Nottingham University, United Kingdom).

For detection of the EABR the ⁄far field® technique with electrode on the opposite vertex and lobus was used, as presented on Figure 1.

Sixty-two out of the initial 86 patients received a unilateral CI. After the unilateral cochlear

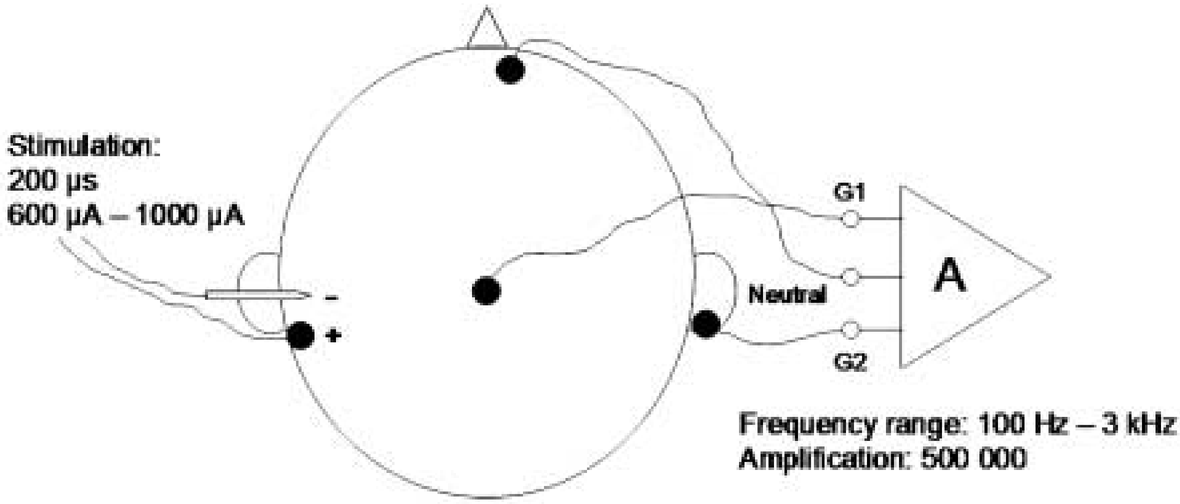

Figure 1. Method of presurgically electrically evoked auditory brainstem responses (EABR). On the left there is stimulation: rectangular electrical current stimuli of 100 ms duration and 200 _A - 1 mA intensity, with the stimulus repetition rate 10 Hz, at the promontory - near round window, were used. The ground electrode was on the ipsilateral mastoid. EABR were recorded between the contralateral earlobe and vertex. Earlobe negative polarity. The second ground electrode was on the forehead. The frequency range of the preamplifier was 100 Hz - 3 KHz, ampilfication was 500.000.

implantation, pure tone audiometry was performed to confirm hearing with the CI.

Results of preoperative EAM, EABR, and pure tone audiometry results after cochlear implantation were compared using logistic regression and t-test. ($p \leq 0.05$ was considered as significant). The SPSS 13.0 software (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis..

Results

Positive EAM responses was obtained among 154 of 172 ears (90 %), and positive EABR response were present in 67 out of 104 ears (64 %). Hearing was established in all patients with unilateral cochlear implantation, as presented in Table 1.

Comparison of the preoperative EAM and EABR results:

In 102 ears both EAM and EABR was performed. Results of the two methods correlated significantly (rEAM/EABR = 1.265, Wald = 4.246, pEAM/EABR = 0.039).

Comparison of EAM results and hearing with the CI:

In all 62 CI users, EAM was performed prior to the implantation. EAM results correlated significantly with the hearing using the CI (r EAM/CI = 2.210, Wald = 74.838, pEAM/CI = 0,000 pEAM/EABR = 0.039).

Comparison of EABR results and hearing with CI:

In 46 out of 62 CI users, EABR was performed prior to the implantation. EABR results correlated significantly with the hearing using the CI (r EABR/CI = 0.612, Wald = 9.036, pEABR/CI = 0,003). Table 2.

Discussion

Evaluation of the auditory pathways from cochlea to primary auditory cortex is still advisable before cochlear implantation during the candidate selection process [13-16]. In our study, EAM stimulated hearing sensation among 154 out of 172 ears (90 %). As reported in the literature, EAM is well tolerated [5-9, 17]. Results of both EAM and EABR were compared among 102 ears. Logistic regression tests confirmed that the results obtained by EAM correlate significantly with EABR. Our results are in accordance with reported studies where the results of EAM are compared with each other.

The method and the results of EAM are superior when compared with promontory tests [6,9,18]. Although EAM is a subjective investigation method, our results confirmed the significant correlation with functional hearing after CI implantation.

EABR responses were obtained among 67 out of 104 ears (64 %) in our study. When compared with hearing perception following cochlear implantation in 46 patients, significant correlation was observed. EABR remains the main preoperative and neurophysiologic investigation method for cochlear implant patients that should be performed during the preoperative period under general anesthesia [11, 12, 15, 19]. However, the prognostic value of preoperative EABR is limited (due to technical difficulties) and the absence of a positive EABR response is not, by itself, a contraindication for cochlear implantation. In some cases poor results of EABR can predict a poor speech perception in cochlear implant users [3, 10].

Table 1. Numbers of the ears with positive EAM, EABR and hearing results (CI) after cochlear implantation in deaf patients.

Positive EAM	Positive EABR	Hearing after cochlear implantation
154/172 (90%)	67/104 (64%)	62/62 (100%)

Table 2. Comparison of preoperative EAM and EABR with postoperative results and statistic significances.

Comparison of:	EAM/EABR	EAM/CI	EABR/CI
Numbers of the tested ears	102/102	62/62	46/62
Significance	pEAM/EABR = 0.039	pEAM/EABR = 0.039	pEABR/CI = 0,003

In conclusion, EAM and EABR results received before the CI insertion were significantly correlated. Post-implantation test results were also correlated significantly with both EAM and EABR results received before the CI. EAM is considered a less invasive pre-implantation investigation method, thus can be successfully used during the evaluation of CI candidates..

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