Original article

Stapedial reflection electrically evoked as an objective method in the programming of cochlear implant in pediatric population

Reflejo estapedial eléctricamente evocado como método objetivo en la programación de implante coclear en población pediatrica

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Abstract

Introduction: The electrically evoked stapedial reflex (ESRT) is a valuable clinical tool for determining hearing thresholds in users of cochlear implants (IC).
Objective: To determine the benefits of IC programming by obtaining the ESRT as an objective method to identify M levels in the pediatric population.
Material and method: A cross-sectional study evaluated 107 pediatric patients implanted with 6 months or more use. 55 patients were included in the inclusion criteria. They were performed clinical history, tympanometry, ESRT and by free field audiometry, before and after programming modifications according to M levels obtained by ESRT were performed.
Results: of the M threshold was performed by obtaining ESRT in 48 patients (87.27%). When comparing the previous audiometry with the increase in UC that triggered ESRT, a mean increase in UC was obtained: In patients with normal hearing of 12.98 UC, superficial hearing loss of 22.28 UC and with average hearing loss of 37.03 UC. In the audiometry performed after the modifications of UC based on the ESRT, normal hearing was found in 100% of the patients modified with this tool.
Conclusion: It has been shown that reliable thresholds are obtained through the ESRT at the M level, so its use in pediatric patients shortens the time to achieve normal hearing thresholds and language acquisition in an optimal time.

Key words: Electrically evoked stapedial reflex, cochlear implant.

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Resumen

Introducción: El reflejo estapedial eléctricamente evocado (ESRT), es una herramienta clínica objetiva valiosa para determinar los umbrales de la audición en usuarios de implante coclear (IC).
Objetivo: Determinar los beneficios de la programación del IC mediante la obtención del ESRT como método objetivo para identificar los niveles M en población pediátrica.
Material y método: Estudio transversal, se evaluaron a 107 pacientes pediátricos implantados con 6 meses o más de uso de IC. Cumplieron con criterios de inclusión 55 pacientes. Se les realizó historia clínica, timpanometría, ESRT y audiometría por campo libre, antes y después de las modificaciones de la programación de acuerdo a los niveles M obtenidos mediante ESRT.
Resultados: Se les realizó modificación de UC (unidades de corriente) del umbral M mediante la obtención del ESRT a 48 pacientes (87.27%). Al comparar la audiometría previa con el incremento de UC que desencadenaron el ESRT se obtuvo una media de incremento de UC: En pacientes con audición normal de 12.98 UC, hipoacusia superficial de 22.28 UC y con hipoacusia media de 37.03 UC. En la audiometría realizada posterior a las modificaciones de UC con base al ESRT, se encontró audición normal en el 100% de los pacientes modificados con ésta herramienta.
Conclusión: Se ha demostrado que a través del ESRT se obtienen umbrales confiables del nivel M, por lo que su uso en los pacientes pediátricos acorta el tiempo para lograr umbrales de audición normal y adquisición del lenguaje en un tiempo óptimo.

Palabras clave: Reflejo estapedial eléctricamente evocado, implante coclear

Introduction

The cochlear implant (CI) programing is an activity realized by an audiologist, with de objective of getting the patient to normal hearing levels, and in consequence obtain normal language acquisition. To create the CI programming map is necessary to determine the hearing detection threshold (T level) and the comfortable hearing threshold for each one of the electrodes (M level), previously choosing the speech codification strategy and the stimulation mode.

In a hearing map, the hearing threshold known as T level is defined as the minimum electricity that produces a hearing sensation. The comfort threshold or M threshold is the level at which the patient has a comfortable hearing stimulation. The difference between both levels limits the dynamic range of electrical stimulation.[1]

It is important to notice that each CI electrode directly stimulates the hearing nerve depending of the disposition on the cochlea. The amount of electric current necessary to cause a hearing sensation is known as current unit (CU) and is different in every person and each stimulation channel. For this reason, is why the CI programming has to be individualized.[2]

In adults this search of perception and comfort hearing thresholds are obtained with subjective measures that help the audiologist. On the other hand, this procedure is difficult in pediatric patients or with neurological disorders, that might lead to non-real responses, therefore the importance of the electrophysiological tests in this population.

The stapedial reflex is not just obtained with an acoustic stimulus in normal hearing individuals, but also with electric stimulation through the CI, known as the electrically evoked stapedial reflex (EESR). The existence of this reflex indicates an optimal function of the CI and the integrity of the auditory neural pathway and its connection with the ipsilateral and contralateral motor nucleus of the VIII cranial nerve at the brain stem.[3]

The EESR can be observed directly in the CI surgery through an impedanciometry.3 The stimulus for the test consists of train pulses in each one of the electrodes.4

The smallest level of stimulation required to obtain the stapedial reflex is known as threshold and can be altered by the relaxation produced with the anesthesia during the surgery .[5]

The correct adjust of the speech processor of the CI is very important to obtain a great quality of sound and voice perception, providing a maximum CI use. A poor estimation of these parameters degrades the quality of the presentation of the sound signal, leading to an important loss of information in the evoked hearing potential, and sometimes an annoying hearing perception.3

The EESR is an objective clinical tool for the investigation of hearing threshold in CI users.[6] Several studies report that this electrophysiologic measure can be included in the routine procedures, because its contribution is evident for the activation a mapping of the CI, and in consequence for the patient and audiologist .[2]

The objectives of this study where:

- Determine the benefits of the CI programming through the obtention of the EESR as a method to identify the M levels in pediatric population.
- Identify the levels at which the EESR is obtained, considering variables such as age, sex, etiology, neurologic antecedents, audiometry, time of CI use and modification of the current units to obtain it.
- Obtain a procedure guide of the EESR in pediatric patients CI users.

Methodology

Design. Transversal study.

Population. There are 107 CI users patients treated in the Audiology service of the National Rehabilitation Institute, in the period from November 2008 to November 2015. To obtain a more homogenic sample the EESR was realized to the children with an Advance Bionics CI, that were 55 total.

The patients were grouped according chronological age and time of CI use:

1. From 0 to 3 years old, 6 months to 3 years of CI use.
2. From 4 to 6 years old, 6 months to 3 years of CI use.
3. From 7 to 14 years old, 6 months to 3 years of CI use.
4. From 7 to 14 years old, 4 to 7 years of CI use.
5. The conformation of these 4 study groups was according the language development, and time using the CI.[7,8]

Inclusion criteria. Patients from 1 to 14 years old with 6 months or more of CI use, without middle ear pathology proved clinically and with an impedanciometry test. Patients with cranium X-ray obtained after the CI colocation surgery that corroborates the total insertion of the CI in the cochlea.

Exclusion criteria. Patients older than 15 years old, previous middle ear surgery such as stapedectomy, mastoidectomy or actual middle ear pathology like otitis, bilateral Eustachian tube dysfunction and tympanic perforation.

Elimination criteria. Patients that didn't complete the EESR test.

Tests included. All procedures were previously authorized by the parent or legal guardian through an informed consent, and with the confidential use of the information. The study was approved by the Ethic and Investigation Committee of the National Rehabilitation Institute. The CI functional gain was determined with the previous programming, obtained with free field audiometry using pure tones of modulated frequency on 250, 500, 1000, 2000 y 4000Hz frequencies with an Interacoustics At235 audiometer, calibrated according ANS S3.6 norm.

EESR evaluation. It was using an impedanciometer that tested ipsilateral and contralateral stapedial reflex, tone decay test, computer with the CI software, wires and an interface of the same Brand of the CI. The method used in this study was:

1. Otoscopy.
2. Tympanometry test. The normal values considered in children were: static compliance: 0.3-1.3cc, middle ear pressure +100 to -100 daPa. Normal Jerger curves (A and As) were included in the study, considering reflect normal middle ear function.
3. Connection to the CI software.
4. Programming of the impedanciometer to perform tone decay. Reflex option was selected, then manual button, contralateral button, tone decay button and start button.
5. According size of the external ear canal the olives used were chosen, to prevent artifact or sound interfering.
6. The impedanciometer probe is placed and supported in the patient's back or shoulder. It was prevented that during swallowing the olives were moved and obtain a false negative result. In two children the study was made with sleep deprivation.
7. The Advance Bionics Software, Sound Wave, was used simultaneously to obtain the reflex decay, using the speech burst stimulation that tests the 16 electrodes in groups of 4: 1-4, 5-8, 9-12 and 13-16.
8. To obtain the EESR response the current unit of the M level from the previous map were considered. In the cases where response was not obtained, the levels were increased 5 units to 5 units until triggering the reflex. The increment was realized with the CI turn on, proving its tolerance with Live Speech Mode.
9. In case of annoyance, the level was decreased 1 by 1, until obtaining the minimal threshold.
10. The stapedial reflex graphic was saved.

The M thresholds were modified in patients that needed it according the EESR response. Variables analyzed were genre, pre or post linguistic hearing loss, hearing loss etiology, average age of CI surgery, neurologic diseases or other disorders that could influence the current unit and the CI programming.

Statistical analysis. The 18 version of SPSS® software and Excel program were used. The response analysis was according the current unit used to obtain the EESR response.

Results

Of the 55 pediatric patients studied, 32 (58%) were feminine and 23 (42%) masculine, average age of 6 ± 3.14 years old, in boys 11 years (2 to 13 years old), girls 12 years (2 to 14 years old).

The most frequent etiology was the hereditary hearing loss in 21 (38%) patients, and the not determined etiology in 19 (35%) patients. Adverse factors at birth in 10 (18%) patients and infectious hearing loss in 5 (9%) patients.

51 (93%) patients had a prelinguistic hearing loss and 4 (7%) post locutive hearing loss. The timpanometric curve according Jerger classification was type A in 37 (67%) patients a type As in 18 (33%) patients.

From the 55 patients included, 11 (20%) had neurological disorders such as Attention deficit disorder in 1 (1.81%) patient, autistic disorder in 4 (7.27%) patients, lexic-syntactic disorder in 2 (3.63%), intellectual disability in 1 (1.81%) patient, microcephaly in 1 (1.81%) patient and epilepsy in 1 (1.81%) patient. In the other 44 (80%) no comorbidities were associated.

There were no statistical differences in the CU increment according the group of electrodes evaluated; there were no specific predominance in low or high frequencies.

All patients had an average CI use of 2.6 years.

It was identified a significant increment of CU in patients with neurological disorders in contrast of the children that didn't. Increments from zero CU to 125 CU, that was the highest increment in all studied patients. Nerveless when median value was obtained there were no statistical differences obtained between the two groups.

Previously determining the EESR response, 12 patients (22%) where in normal hearing thresholds, 27 (49%9 in superficial hearing loss and 16 (29%) in middle hearing loss. (Graphic 1).

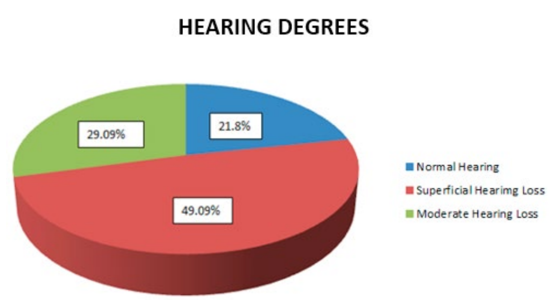
From the 55 CI patients studied, 48 (87%) required elevation of the CU to find the EESR (Graphic 2)

Comparing the audiometry made previously the increment of the CU required to detonate the EESR, there was an average increment of the CU obtained; in normal hearing threshold patients of 13 CU, superficial hearing loss 22 CU and middle hearing loss thresholds of 37 CU.

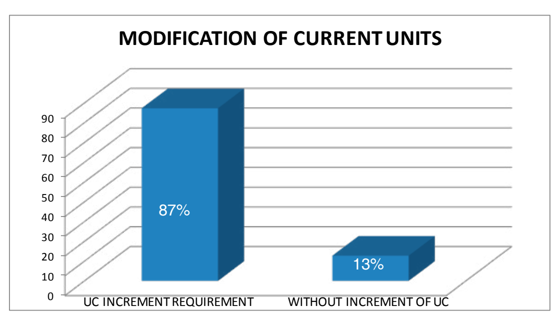
The group that required the less increment was the one comprehended between 7 and 14 years old, with 4 to 7 years of CI use. (Graphic 3)

In the audiometry realized posterior to the CU modifications according the EESR response, all patients (100%) were in normal hearing thresholds.

Graphic 1. Hearing levels, previous EESR response.

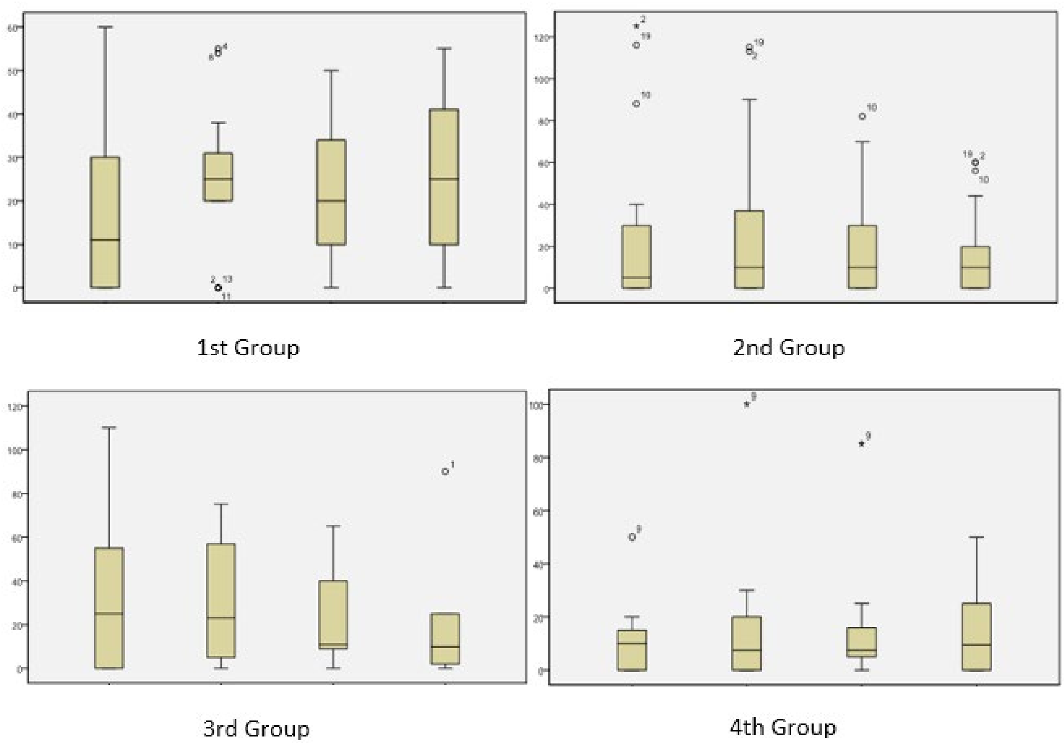


Graphic 2. Patients that required modification of CU to provoque EESR response and the ones that didn't need modification.



Graphic 3. Cage graphic according age, time of CI usage in electrode groups and increment of CU.

1. From 0 to 3 years old, 6 months to 3 years of CI use.
2. From 4 to 6 years old, 6 months to 3 years of CI use.
3. From 7 to 14 years old, 6 months to 3 years of CI use.
4. From 7 to 14 years old, 4 to 7 years of CI use**.**



Discussion

Since 1988 there have been different researches focused on the electrically evoked stapedial reflex as a method to obtain the CI effectiveness, some authors concluded that this test was a useful tool in programming difficult patients.[9]

Nevertheless, in our study we included difficult patients an all patients that covered the inclusion criteria previously described, according to previous reports that support its use in all CI patients, as an objective tool of the functional integrity of the CI and the optimal function of the auditory nerve.[10] Besides this test can be used during the CI surgery and afterwards.[11]

In this investigation was found that 87.27 % (48) of the CI patients required CU increments to trigger the EESR response and only in the 12.72% (7) of the patients wasn't required. The results obtained show that exists a variable increment in each patient, which can be consequence of the neural population of the auditory nerve, and the comorbidities presented that can influence the auditory processing in the neural pathways.

Some EESR studies propose that this test can be useful programming CI pediatric patients, but with careful approach regards the variability between patients.[12]

The group that required less increment was the one that encompass 7 to 14-year-old children, with 4 to 7 years of CI use. This demonstrates the objective of the study, which with more time of CI use and more programming, the increment is less. The time spent programming can be reduced by obtaining normal hearing thresholds with the EESR response. Caner's research exposes that with clinical experience comfort levels can be too high or small in children when behavioral conduct is observed. This can fluctuate in time with the cognitive development of the child.[12]

With this test made in time better results are obtained in language development, because its known of the auditory neural plasticity period, that goes from birth to 3 years old, helping obtain excellent results in children diagnosed and treated at smaller ages,[13] leading to normal hearing thresholds in an opportune time.

When comparing the audiometry and the EESR, it was required an increment in CU in 23 patients (41%) that had normal hearing thresholds obtained in a previous audiometry. In the behavioral tests such as the audiometry, children sometimes lack the attention, patience, and cognitive and linguistic abilities required obtaining reliable results.[10]

The audiometry is a subjective test, even with normal hearing thresholds CU increment was required to obtain the EESR response that is the objective test.

The audiometry is suggested as an evaluation method in CI users having in mind the error factors that can be present (patient's age, conduct, social status, languages spoken, comorbidities, clinical experience).[14]

In the literature is reported that if the EESR response replaces the behavioral test to establish the M levels, some criteria has to be fulfilled: (1) the maps of the EESR cannot be in discomfort levels, (2) the EESR maps have to give the same results or better than behavioral test, (3) the quality of the sound has to be similar or better than the produced from behavioral traditional techniques.[10] Previous studies sustain a higher correlation between the thresholds evaluated with the EESR response than with other tests like the electrically evoked compound action potential (ECAP).[15] This method is more reliable than the auditory brainstem responses and the ECAP even in patients with cochlear malformations.[8]

It is required to keep studying these tests in more cases to have better explanations tan the ones concluded.

Conclusion

It is important to include in the evaluation of the CI patients the EESR, because it is an objective tool that can lead to normal hearing thresholds in a short time, favoring normal language acquisition. On the other hand, these results suggest the need to use it with other objective and subjective tools to evaluate the CI patient. It is always necessary to observe the clinical evolution after any change made in the programming, to guarantee that any modification was optimal to the patient to help him obtain normal language development.

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