OBJECTIVE TESTS FOR THE EVALUATION OF COCHLEAR IMPLANT CANDIDATES
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ABSTRACT

Introduction: Cochlear implant indications have changed during the last decade. The objective tests are important in the cochlear implantation procedure. Purpose of the study: We proposed an evaluation for the objective tests in establishing a correct indication for cochlear implant in patients with bilateral sensorineural deafness. Materials and methods: We studied a group of 34 patients with bilateral sensorineural hearing loss tested by subjective and objective methods for an eventual cochlear implantation. Results: 74% of the patients presented a profound bilateral sensorineural hearing loss, 15% a severe type, 4% medium, 3% fluctuant and 4% cofosis. The examined patients fulfill the auditory criteria that justify the cochlear implant procedure. Discussions: The evaluation by subjective tests is followed by objective tests, offering provative evidence in clear cases and also in unclear ones. As a supplementary measure, all the patients evaluated by subjective tests in establishing the possibility for cochlear implantations received at least one objective form of testing. Conclusions: Currently, the objective tests represent an important step in the recommendation for cochlear implant. In all cases (excepting young children) the objective tests are compared/correlated with the subjective tests before the implantation procedure, specially with the subjective evaluation by a conventional prosthesis.

Key words: bilateral sensorineural hearing loss, cochlear implant, subjective tests, objective tests

INTRODUCTION

The cochlear implantation is the procedure by which the patients with profound deafness or with cofosis can benefit of the re-establishment of the auditory function. Cochlear implant indications have changed during the last decade by a greater area of indications due to the new knowledge regarding the hypoacusis and to the perfection of the implant itself and of the surgical procedures [1].

Besides subjective tests, the objective tests are important in the cochlear implantation procedure, essential for candidates with the age between 0 and 5 years old and also for the objectivity of the implant indication in borderline situations or special pathologies [2,3,4].

The objective test cad also provide indications for the auditory-verbal and behavioural future of the implanted patient, with the purpose of a proper social insertion [5].

PURPOSE OF THE STUDY

We proposed an evaluation of the objective tests in establishing a correct indication for cochlear implant in patients with bilateral sensorineural deafness in a group of 34 patients in the ent clinic, clinical recovery hospital iaşi, in the period 2012-2013.
MATERIAL AND METHODS

We studied 34 patients with bilateral sensorineural hypoacusis tested by subjective and objective measures with the purpose of an eventual cochlear implantation.

We used the following examination procedures:

- Subjective methods: pure-tone audiometry (PTA), vocal audiometry (VA), tone and vocal audiometry in free field with and without auditory prosthesis
- Objective methods: tympanometry, stapedial reflex (SR), brain-stem auditory evoked potentials (BAEPs), auditory steady state response (ASSR), evoked otoacoustic emissions (OAE), electrocochleography (ECochG).

All the patients included in this study received at least one objective test during the audiometry evaluation in establishing the indication for cochlear implant procedure.

RESULTS

In the study group 34 patients presented bilateral sensorineural hypoacusis tested by subjective and objective methods, 16 females (47%) and 18 males (53%).

We assessed 13 children with the age 0-5 years old (38%), 14 with the age between 5 and 18 years old (41%) and 7 adult patients (21%) (Fig.1).

The audiometry revealed the following data: 74% of the patients presented a profound bilateral sensorineural hearing loss, 15% a severe type, 4% medium, 3% fluctuant and 4% cofosis (Fig.2).

In the age group of 0-5 years old we diagnosticated 10 patients with profound sensorineural hypoacusis, 1 patient with severe bilateral sensorineural hypoacusis and 2 patients with bilateral sensorineural hypoacusis, with a severe form on one ear and profound on the other ear.

In the age group of 5-18 years old we diagnosticated 8 patients with profound sensorineural hypoacusis on both ears, 1 patient with moderate form, 1 patient with severe form, 1 patient with bilateral fluctuant form and 3 patients with different degrees of sensorineural hypoacusis on each ear (moderate/profound, severe/profound, severe/cofosis).

In the adult patients group (>18 years old), the majority (5 patients) presented bilateral profound sensorineural hypoacusis (71%), 1 patient – the severe form and 1 patient with cofosis.

After the conducted examinations we can...
observe that patients fulfil the auditory criteria that justify the cochlear implant procedure.

DISCUSSIONS

In the age groups after 5 years old (children, teenagers, adults), the implant indication can be supported only by subjective tests; in this category we can include bilateral sensorineural hypoacusis on 3 frequencies on PTA and VA and free field tone audiometry [6]. 21 patients were included in this group.

A lack of correlation was observed in the case of patient DO, 63 years old, between the PTA thresholds (severe bilateral sensorineural hypoacusis), free field tone audiometry with auditory prosthesis (medium threshold of 40dB) and free field vocal audiometry with auditory prosthesis which did not offer any answer (0%).

We must mention the fact that until now there is no objective method to assess the free field vocal auditory ability with prosthesis. In this case the objective tests with BAEPs were a necessity. We could not obtain a V-amp on BAEPs, therefore a retro-cochlear lesion could be possible, probably due to a neural dysynchrony.

In another case the objective methods were necessary to establish a proper indication for cochlear implant; it was the case of a 6 years old child (CF), with different thresholds on different times in PTA. The ASSR and BAEPs tests offered an objective diagnostic of fluctuant bilateral sensorineural hypoacusis and, according to these tests, we could include the patient in the cochlear implant candidates group.

The evaluation by subjective tests is followed by objective tests, offering probative evidence in clear cases and also in unclear ones.

As a supplementary measure, all the patients evaluated by subjective tests in establishing the possibility for cochlear implantations received at least one objective form of testing.

In the case of unrespondent patients to the subjective tests or in case of doubt we use the following objective methods: time, ASSR, BAEP, SR, ECochG, OAE [7].

In the case of child patients (less than 5 years old) the implant indication assessment is based on objective tests [8, 9]. The physiological methods include tests to obtain an answer to the auditory stimuli independently on the patient’s will [10, 11].

The objective methods address to the physiological mechanisms of the middle and inner ear (tymanometry, otoacoustic emissions), to neurophysiologic processes of the auditory pathways (electrophysiological methods) or to motor and neurovegetative reflexes provoked by auditory stimuli (reflex methods) [10, 12]. In this category we can include: standard tymanometry, SR test, measurement of the OAE, of the BAEP and the evaluation of motor and neurovegetative reflexes.

Tymanometry represents the measurement of the middle ear system compliance, in conditions of air pressure changes in the external auditory conduct [10]. It is useful for:

- Detecting any change of the tympano-bone transmission system
- Hypoacusis screening on newborns
- Examination of mentally or cognitive impaired persons and of the stimuli
- Evaluation of the Eustachian tube
- Diagnosis of the glomus jugulare or glomus caroticum.

In case of sensorineural hypoacusis the tymanometry is used for the exclusion of an associated pathology of the middle ear.

Stapedial reflex represents the reflex contraction of the stapedial muscle on acoustic stimuli higher than a certain threshold (on human: 75-80dB); this
contraction determines a tightening of the bone chain and a change of impedance of this system [12]. In clinical practice it is used for:

- Differential diagnosis between transmission and sensorineural hypoacusis
- Differential diagnosis of closed tympanic transmission hypoacusis
- Facial paralysis topographic diagnosis (supra or substapedial) [10]
- Hearing objective assessment on patients without the capacity of supporting behavioural tests (small children, psychically challenged persons, stimuli)
- Central lesions diagnosis with a cessed controlateral acoustic reflex arch on brain stem level.

The evoked auditory potentials are electrophysiological methods that allow the hearing testing by registering the nervous evoked auditory potentials of the auditory nerve, brain stem or cerebral cortex.

The quality and the form of the evoked auditory potentials depend on their latency (the time passing since the stimulation until their appearance). Based on the latency we can describe:

- Electrocochleography – the registration of cochlear and auditory nerve potentials, in a time of 1-10ms since the stimulation [13]; the transtympanic electrode is placed on the external wall of the cochlea (promontorium).
- Brain-stem auditory evoked potentials (BAEPs) – they register the electrical activity in the cochlear nerve and in various areas of the brain stem, in a window of 1-10ms post-stimulation [14].

The electrodes are placed on the skin surface, the electrical response is complex and reflect the activity from: cochlear nerve, bulbar cochlear nuclei, superior olivary complex and the lateral lemniscus [14]. They are presented as 5 amp, from I to IV, with different amplitudes and latencies (Fig.3).

Figure 3. The registration of brain-stem auditory evoked potentials on human subject. The I-IV amps and their latencies are presented

Brain-stem auditory evoked potentials present a series of clinical applications:

- retrocochlear pathology diagnosis – baeps do not require any suplementary supraliminary tests or ecochg;
- auditory screening on newborns – it is one of the main screening tests.
- objective estimation of the auditory threshold on difficult patients (small children, psychically challenged persons, stimuli);
- intraoperative monitoring of the auditory nerve; differential diagnosis between transmission and sensorineural hypoacusis (cochlear and retrocochlear).

Although they are capable of hypoacusis detection, they can not determine the cause of such hypoacusis; this method offers information regarding the existence and the localisation of a lesion in a certain segment of the auditory pathway [15].

Baeps are not capable of offering information regarding the superior auditory structures of the brain stem or the hypoacusis.
determined by lesions on these levels.

Medium or late latency auditory evoked potentials intervene in such cases.

Medium or late latency auditory evoked potentials are rarely used in the clinical practice, mainly for the assessment of the auditory acuity on low frequencies in children and uncooperative persons. Late latency auditory evoked potentials offer information on the primary and secondary auditory cortex areas, being extremely useful in determining of the tone threshold in non-organic hypoacusis evaluation in adults.

They are very sensitive in the vigil/sleep status and in anaesthesia, therefore they are very limited in testing the uncooperative patients (children, psychically impaired persons).

**Otoacoustic emissions (OAE)**

The otoacoustic emissions are acoustic signals produced by the cochlea, propagating backwards, through the middle ear, in the external auditory conduct where they can be registered with small microphones [16,17].

The contractile activity of the external ciliated cells represents the mechanical source for the energy of the cochlear amplifier [18]. The otoacoustic emissions are a secondary product of the amplified wave; they are retrogradelly transmitted in the cochlea to the stapes and then through the middle ear to the external auditory conduct, where they are registered.

OAE can appear spontaneously or after the auditory stimulation of the ear (evoked oae), implying an intact cochlea and normal outer and middle ear.

Spontaneous OAE appear in the absence of acoustic stimulations, in a limited number of normal hearing ears. They do not have a clinical significance. Evoked oae are currently used in clinical practice to diagnose the cochlea status.

In st patient, 3 years old, we observed the lack of correlation between the thresholds obtained on assr testing (severe bilateral sensorineural hypoacusis on one ear and profound on the other) and the absence of any response on baeps, situation in which the objective tests suggest an auditory neuropathy. In this case of lack of correlation between the two tests, it might be the case of an unfavourable prognosis for the auditory-verbal rehabilitation of the patient because the patients with auditory neuropathy do not obtain the same results on verbal evaluation after the cochlear implantation.

**CONCLUSIONS**

Currently, the objective tests represent an important step in the recommendation for cochlear implant. The obtained data can represent prognosis factors of the evolution after the implant procedure for auditory-verbal rehabilitation on children and for the vocal understanding on adult patients.

In all cases (excepting young children) the objective tests are compared/correlated with the subjective tests before the implantation procedure, especially with the subjective evaluation by a conventional prosthesis.

The objective tests used can be useful also after the implant procedure in the assessment of the electroneural system.

There are not any objective methods to assess the auditory performance with conventional prosthesis (verbal discriminatory tests); the testing can be conducted only by subjective methods.

The comparation between objective and subjective tests (where it is possible) offers information regarding the performance after the cochlear implant procedure (e.g. auditory neuropathy – a poor acquisition of the language).
REFERENCES


