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The Threshold Problem in Implanted Patients

By S. M. Petrov

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The Threshold Problem in Implanted Patients

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I. Introduction

The programming of the cochlear implant (CI) is essential for good performance [Vaerenberg B. et al, 2014]. Regardless of the type of the implant there are two main parameters of fitting: 1.-maximum comfortable levels (MCLs), i.e. the maximum amplitudes of the electrical stimuli (C-level) at which patient hears sounds near the threshold of discomfort and 2.- the electrical threshold levels (T-levels) at which patient hears sounds near the threshold of hearing (the quietest, hardly audible sound).

Accurate determination of T-levels of perception of the electrical stimuli in every channel of cochlear implant and recording these levels in the program of the processor is an important part of the fitting procedure of CI. For investigation of threshold perception pure tone audiometry (PTA) is used in some studies [Ramos-Macías Á. et al. 2014; Wang L. et al.2014; Ghiselli S. et al. 2016]. Our study is the consideration of the method of PTA in the implanted patients.

To facilitate understanding of this presentation, we assume that the trigger level of sound for the speech processor is 40 dB SPL. This value is close to real one. Trigger level is SPL when the processor produces an electrical stimulus with an amplitude equal to the value recorded in the program of the processor as the threshold current level. The patient hears (or doesn't hear) some sound. If the setting of electrical level THR is correct one patient perceives barely audible sounding - threshold sounding - at input sound 40 dB SPL.

Further we'll say a few words about the right performing of the PTA in CI patients and will look at how you can use results of this investigation in fitting of the implant.

Determination of threshold of audibility of a sound in the implanted children is far more complex procedure than in the hard-of-hearing patients.

Let's look at the method of estimated reaction. As a rule, hard-of-hearing children hear by the two(!) ears, have the auditory experience(!), know how to determine the sound source position in space(!). Unlike the hard-of-hearing patients the implanted patients perceive sounds through a single, omnidirectional microphone that nearly eliminates localization of the sound source. Therefore, the determination of threshold levels of perception by the estimated reaction is difficult (impossible?). Think about how little child, implanted, for example, on the right ear will be able to distinguish that the sound had become quieter because it is on the left side (owing to the shadow of the head), and not because of decreasing level of sound source on the right side.

In any case if you are going to perform PTA you first need to know in what channels of the implant (12) octave tone signals are processed. Depending on the frequency range of the implant these octave frequencies can be in 6-8 channels.

So let the tone threshold audiogram with the thresholds of 40 dB SPL is obtained. Looking at it, some people can say that the CI patient has a first degree of hearing loss. But this is a mistaken (false?) conclusion.

How can we talk about the first degree of hearing loss if CI-patients can distinguish only 12 painted(!) frequency bands in accordance with the location of the electrodes along the length of the basilar membrane. Patients with first degree of hearing loss can discriminate tens of tonal signals. Perception of suprathreshold SPL of hard of hearing and implanted patients has differences too. Obviously that to say about the first degree of hearing loss of CI patients in terms of audiology is absolutely wrong.

Further. This "first degree audiogram" can be obtained (even with great success) if THR levels are wrong. For example, when the levels of THR are 20% of most comfortable level (MCL). Such incorrect settings of the threshold current levels facilitates detecting of the sound of trigger level 40 dB SPL for the inexperienced patient. So the audiogram with "first degree of hearing loss" can be easily obtained. But this wrong setting decreases differentiation of current levels and negatively affects the intelligibility of speech [Petrov SM. 2002].

Therefore, it is necessary to understand that having audiogram after PTA at levels of "the first degree of hearing loss", you cannot say that the recorded threshold current levels in the processor program are wonderful ones. Moreover, if at the first examination you found that the threshold levels of sound perception in a young child are at the levels of 40 dB SPL, it obviously means that recorded T-levels of the electrical stimuli in

Author: e-mail: senn2001@mail.ru

the tested program is too high. Positive child's response to sound intensity of 40 dB SPL can be misinterpreted by parents as a result of the wondrous setting of T-levels with "the first degree of hearing loss". Not too competent audiologist will be able to dispel this misunderstanding. And even on the contrary, will strengthen the parents in it because the first degree of hearing loss is not very scary defect of hearing.

There is no rational reason to tell parents that after surgery their children will have the first degree of hearing loss and put it as a dignity and the achievement of the cochlear implantation. This statement, at least, means to introduce parents in the confusion.

As an argument in favor of correct setting of the threshold levels some of the "experts" claim the perception (and understanding!) whisper speech by CI-patient at a distance of 6 m. This is absolutely wrong statement. The real intensity of whisper is 20-25 dB SPL. And this intensity level is below a trigger threshold level of processor (40 dB SPL), i.e. the processor just can't "hear" whisper and, of course, that processor will not produce electrical stimuli at this SPL. N.B. High T-levels will not help to hear the real whisper.

In some systems of CIs there is the software's ability "WHISPER" which reduces the trigger level of the processor to 20 dB SPL ("Cochlear"). But in any case if the CI-patient repeats "whispered" words at a distance of 6 m it is either a loud whisper or soft speech. Therefore, the perception (not intelligibility!) of real whisper speech by CI-patient cannot be at a distance of 6 m.

If you are going to perform PTA in CI patient then this procedure should be done so. First, you need to know in which channels of the implant (12) octave tonal signals (6-8) are. Methods of PTA are well-known ones.

Let's you performed PTA and received the "audiogram".

What have you to do? You have to increase electrical T-levels in appropriate channels if patient has sound thresholds more than 40 dB SPL. You have to decrease electrical T-levels if patient has sound thresholds at level 40 dB SPL. After this correction of current T-levels in map you have to repeat PTA with subsequent regulation of the electrical T-levels. You have to perform PTA till you will achieve electric T-levels to the sound trigger level of 40 dB SPL. I.e. patient hardly hears 40 dB SPL and if you will decrease electrical T-level by 1 step down patient will not hear any sound. These electrical levels you can write as T-levels in program of processor. Naturally, the question is arised. Do you need to perform this bulky PTA examination? There is no need. It is absurd, because if CI-patient can give reliable results in this durable PTA "survey", there is no sense to waste time. Indeed, such intelligent CI-patient can simply estimate the threshold levels of electrical stimuli from the program "Maestro" and quickly to determine current T-levels in each of the 12(!) channels. And these levels are recorded in the map as T-levels. No problems.

If patient cannot participate in measuring of electrical threshold levels, then we should behave like that. We determine threshold discomfort SPLs using the program SHCHUP (audiometer, calibrated on B&K 4153 artificial ear) [Petrov SM. et al. 2009]. Further we correct electric MCLs till the sound discomfort levels will be 106 dB SPLs. The T-levels are set at 10% of this electric MCLs. T-levels can be less, because it was shown that even zero THR levels has almost no effect on intelligibility [Spahr AJ. et al. 2005; Boyd PJ. 2006].

This is understandable from the curve of implant's MAP-Law (output compression function). Curve MAP-Law shows the dependence of the current values on the SPL of the sound input. In the same studies [7,8] there are data that the overestimation of the T-levels degrades speech intelligibility, which also is clearly understanded from MAP-Law. So that the dynamic range of current (MCL-THR) 15% is not enough, and 20% (it is recommended by some "experts"), just harms to CI patient. Result of elevated T-levels is a narrowing of the optimal dynamic range of current. Result of this narrowing is compression of the dynamic range of the speech sound and consequently the deterioration of its perception [Petrov SM. 2002]. But for CI patient every microbit is necessary (expensive) one. Someone will be able to fully understand speech when high (wrong) T-levels are used (spectral redundancy of speech is great [Petrov SM. 2003], but for understanding of speech he will need to make greater "listening efforts". To live will be more difficult. Why to do so? And what about principle of medicine "Do no harm"?

Questions about electroaudiometry in candidates for a cochlear implantation were reviewed by us earlier [Petrov SM. 2003]. You can understand that electroaudiometry is the same not too useful procedure for CI as PTA. You had seen reaction of patient. But can small child say: "Now I don't hear sound. I feel electrical current"? Never. N.B. Sometimes I felt current and didn't hear sound during the electroaudiometry selftesting.

In more details some of the issues of threshold problem in CI-patients are concerned in our "Instruction" [Petrov SM. et al. 2015].

II. Conclusions

1. Pure tone audiometry in CI patients is time consuming and absurd procedure.
2. The threshold levels of current are set at levels of 10% (or less) of the electric MCLs defined by the program SHCHUP (audiometer calibrated on B&K 4153 artificial ear.

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