Changes in the auditory system accompanying unilateral hearing loss – first results

Veronika Svobodova*[1, 2], Oliver Profant[2, 3], Zbynek Bures[2], Diana Tothova[1, 2], Jan Plzak[1], Josef Syka[2]

[1]Department of Otorhinolaryngology and Head and Neck Surgery, 1st Faculty of Medicine, Charles University, University Hospital Motol, [2]Department of Auditory Neuroscience, Institute of Experimental Medicine CAS, [3]Department of Otorhinolaryngology, 3rd Faculty of Medicine, Charles University, University Hospital Kralovske Vinohrady, Prague, Czech Republic

EAONO21: Otology, Otology - Basic Science, EAONO21-197

Introduction

Unilateral hearing loss (UHL) is often considered to be an inferior topic compared to bilateral deafness. Nevertheless, the condition of UHL influences the processing of auditory input by several mechanisms. UHL causes the deterioration of orientation in space and increases the difficulty of speech understanding, especially in a noisy environment. Numerous potential etiology for UHL include: Ménière's disease, vestibular schwannoma (VS), congenital hearing loss, and sudden sensorineural hearing loss.

Methods

Twenty-eight patients with sensorineural UHL („VS“, 15 males, 13 females, age 28-79, mean age 49,44, median 46) and 37 controls with normacusis („YC“, 13 males, 24 females, age 21-77, mean age 41,95, median 31) underwent an auditory examination. Normal hearing in patients was confirmed in the unaffected ear and the interaural difference was at least 20 dB. Acoustic stimuli were delivered via Sennheiser HDA 200 high-frequency audiometric headphones. The battery of auditory tests comprised uni- and bilateral modification of routine tests (pure tone audiometry up to 16 kHz, speech audiometry, tympanometry), and experimental methods focused on both peripheral and central processing:

Speech audiometry in babble noise – 10 sentences were presented for each noise level (equaling speech intensity and +5 dB). **Periodically gated speech –** short sentences were gated (cycle duration 200 ms) with a given duty cycle (55 and 70 %). **Binaural time-intensity interchange ratio –** two clicks were presented separately to left and right ear, differing in intensity and time delay. Lower intensity or time delay in one ear simulated the sound source on the contralateral side, allowing the auditory system to compensate for this phenomenon. **Detection threshold of gap in noise –** 3 pauses in white noise (150 ms intervals between gaps). **Difference limen for intensity** (of tones in noise) and **for frequency** of the sound.

Results

The unpaired t-test was used for statistical comparison of means of two data samples. Originally, the pilot versions of all the experimental tests were carried out binaurally (except from binaural time-intensity interchange ratio). The average PTA of YC (both ears pooled together) was 7,19 dB, the average PTA of the healthy ear of the VS patients was 15,46 dB and the average PTA of the diseased ear was 47,76 dB (Fig. 1). Subsequently, we excluded 7 control subjects with above-average PTA result to create a group of YC with bilateral PTA precisely equaling the PTA of the healthy ear of the VS patients (10,88 dB and 11,90 dB, Fig. 2). We continued by comparing these two adjusted groups. The results in bilateral speech audiometry in babble noise, periodically gated speech and difference limen for frequency were not significantly different in the VS group compared to YC group (Fig. 3, 4, 6). This finding contributes to confirmation of previous theories, that one hearing ear is mostly sufficient for the perception of speech and the frequency modulation. The gap detection threshold was significantly prolonged (worsened) in the VS group and the parameter of difference limen of intensity was lower, meaning the VS patients were more likely to detect the change of intensity of sound, presumably according to some level of their hyperacusis, causing higher susceptibility to detection of the threshold shifts. The spatial hearing was deteriorated in 71 % and lost in 29 % of patients depending on the level of hearing loss.

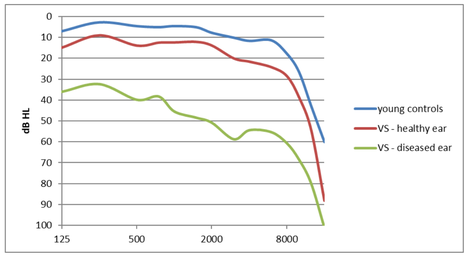

Fig. 1 – PTA of all participants

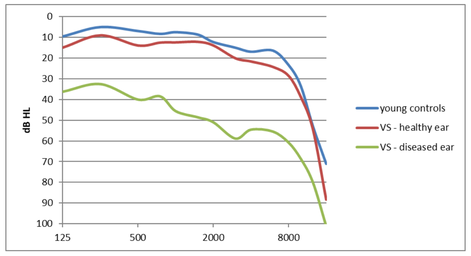

Fig. 2 – PTA of adjusted groups

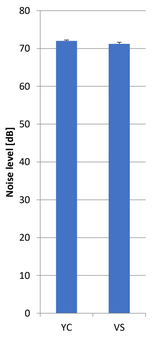

Fig. 3 – speech audiometry in babble noise

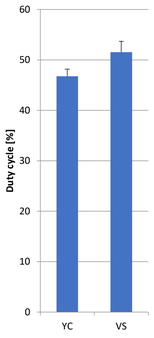

Fig. 4 – periodically gated speech

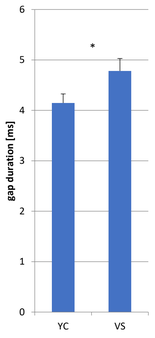

Fig. 5 – gap detection threshold

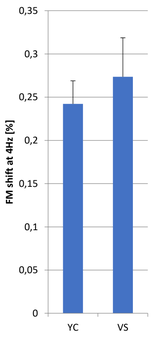

Fig. 6 – difference limen for frequency

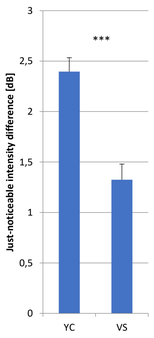

Fig. 7 – difference limen for intensity

Objective

In the current experiment, an extended auditory examination was conducted to characterize the hearing ability of patients with UHL more precisely.

Conclusion

The results in bilateral versions of several tests were not significantly different in the UHL group, compared to the controls. Therefore, we start to perform unilateral variants of the tests and variants with compensating components. The results in more sophisticated experimental tests indicate that the unilateral hearing loss is not merely a loss of sensitivity in one ear, but it may significantly influence central auditory processing and complex hearing abilities, including speech comprehension and temporal resolution. More attention should thus be paid to understanding the mechanisms of the UHL-induced plastic changes of the auditory system and their consequences for compensation and treatment.

.

This project was supported by grant 392119 funding from GA UK (Grant Agency of Charles University) and grant 19-08241S funding from GA ČR (Czech Science Foundation).