Poster 137

ELECTRICAL STIMULATION OF THE AUDITORY NERVE USING MONOPOLAR STIMULATION USING VERY HIGH STIMULUS RATES

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Speech processing strategies based on high rate electrical stimulation have been associated with recent improvements of speech perception among cochlear implant users. In the present study we investigated the effects of chronic monopolar stimulation using very high rates (14493 pulses/s). Under general anaesthesia (ketamine (20 mg/kg) and xylazine (3.8 mg/kg) i.p.) six normal hearing cats were implanted bilaterally with a three channel platinum (Pt) scala tympani electrode array, while a return Pt-electrode was placed outside the bulla. Chronic electrical stimulation using charge-balanced biphasic current pulses was delivered unilaterally via a transcutaneous leadwire connected to a backpack-stimulator for up to 2000 h. The animal's hearing status was periodically monitored using acoustically evoked compound action potentials (CAP's) and brainstem responses (ABR's). In addition the electrically evoked ABR (EABR) was also recorded to ensure that the chronic stimulus was above threshold. Stimulus current and electrode voltage waveforms were monitored twice daily and access resistance (R_a) and electrode impedance (Z_e) calculated. ABR and CAP thresholds were elevated immediately following implantation, but generally showed evidence of partial recovery (0-40 dB). Further deterioration of thresholds on the stimulated side (10-30 dB) was subsequently observed, while control-thresholds remained more stable. R_a (1.3-1.8 kΩ) and Z_e (2.2-3.8 kΩ) typically increased in the first few weeks of electrical stimulation up to R_a: 5.6 kΩ and Z_e: 8.1 kΩ, before decreasing slightly to a constant plateau. These initial results indicate changes in the electrode-tissue interface and tissue growth within the cochlea. They also indicate that chronic stimulation at these high rates may decrease residual hearing.

Poster 138

CHRONIC ELECTRICAL STIMULATION OF THE AUDITORY NERVE USING NON-CHARGE BALANCED STIMULI

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Cochlear implants use charge balanced biphasic current pulses and electrode shorting between current pulses to minimise potentially damaging direct current (DC). In the present study we evaluated the effectiveness of the electrode shorting technique using a non-charge balanced stimulus regime. Under general anaesthesia (ketamine (20 mg/kg, i.m.) and xylazine (3.8 mg/kg, i.m.)), eight normal hearing cats were bilaterally implanted with two channel platinum scala tympani electrodes. Each animal was stimulated unilaterally for 500 to 2200 h using 50 μs monophasic current pulses. The stimuli were delivered at rates of 500 or 2000 pulses per channel continuously at mid-dynamic range intensities. Electrically-evoked auditory brainstem responses (EABR) were periodically recorded to monitor the status of the auditory nerve and to ensure stimulus intensity remained above threshold. At a stimulus rate of 500 pulses/s, electrode shorting effectively reduced DC levels to ≤ 0.3μA. Longitudinal EABR's recorded from these animals remained relatively stable over the stimulus duration. These cochleae showed minimal tissue response and there was no statistically significant difference in spiral ganglion cell density when compared with controls (p=0.21, Mann-Whitney U-test). Chronic stimulation at 2000 pulses/s resulted in increased DC levels (0.6-2.8μA). These cochleae exhibited a highly significant reduction in spiral ganglion cell density when compared with controls (p<0.0001), and their EABR's typically displayed an elevation in threshold as a function of stimulus duration. The present findings indicate that continuous non-charge balanced stimuli at rates of 2000 pulses/s can result in significant loss of spiral ganglion cells, presumably as a result of increased DC levels.
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