CHRONIC ELECTRICAL STIMULATION OF THE AUDITORY NERVE IN NORMAL HEARING KITTENS


Multichannel cochlear prostheses selectively stimulate discrete populations of residual auditory nerve fibres in order to provide profoundly deaf patients with pitch and temporal cues for speech discrimination. An important requirement for the success of these devices is that long-term intracochlear electrical stimulation must not have adverse effects on the spiral ganglion cell population or the cochlea in general. We have previously shown that chronic stimulation using charge balanced biphasic current pulses is safe in normal hearing adult animals (Shepherd et al., 1983). The present study was designed to examine the effects of chronic stimulation in the cochleas of young animals.

Five normal hearing kittens were used in the present study. Using sterile conditions, bipolar scala tympani electrode arrays were implanted when the animals were two months old. Both cochleas of each animal were implanted, one side being stimulated while the other served as a control. Anaesthesia was induced with saffan (9 mg kg⁻¹ i.m.) and maintained with halothane and methoxyflurane. Chronic electrical stimulation commenced ten days following surgery and consisted of a charge balanced biphasic current pulse of 200 μs per phase, presented at a rate of 100 pulses per second. Charge densities at the electrode surface were in the range 21 to 52 μC cm⁻² geom. per phase. Periodically during the stimulation program click- and electrically-evoked auditory brainstem responses (ABRs) were recorded under saffan sedation (12 mg kg⁻¹ i.m.). Following total stimulation periods of 1000 - 1500 hours each animal was killed with an overdose of pentobarbitone sodium (i.m.) and the cochleas removed for histology. Spiral ganglion cell densities were determined for a region adjacent to the stimulating electrodes and were compared statistically with similar populations from control cochleas using multiple linear regression analysis and the Mann-Whitney U test.

Histopathological examination of the cochleas showed minimal cochlear pathology, and no evidence of stimulus induced damage when compared with implanted control cochleas. There was no statistically significant difference in spiral ganglion cell density adjacent to the stimulating electrodes when compared with similar populations from control cochleas. In addition, hair cell loss, which was restricted to regions adjacent to the electrode array, was not influenced by the degree of electrical stimulation. The evoked potential recordings were consistent with these histopathological findings. In cochleas with only slight hair cell loss adjacent to the electrode, click-evoked ABR thresholds remained similar to preoperative levels for the duration of the stimulation program. Chronically recorded electrically-evoked ABR's showed stable thresholds and increases in the response amplitude with duration of implantation and electrical stimulation.

The present findings indicate that the young mammalian cochlea is no more susceptible to cochlear pathology following chronic implantation and electrical stimulation than is the adult. These findings have encouraging implications for the use of cochlear prostheses in young children.


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