Morphofunctional Characteristics of the Spiral Ganglion of Cats with Neurosensory Amblyacousia

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The histo- and cytoarchitectonics of the spiral ganglion in health and in neurosensory amblyacousia have been studied by just a few authorities [1-5], and there are virtually no data on the morphophysiological features of ototoxic involvement of the initial component of the acoustic analyzer in animals of various age groups.

MATERIALS AND METHODS

The spiral ganglion of normally developing cats was studied: that of newborns, of kittens aged 10 days, 1.5 months, and 3 months, and of adult cats in which neurosensory amblyacousia was simulated by a previously developed method (Pat. № 1677713, 1989). In young kittens simulation was started after they were 1 month old. Ten animals were used in each experimental series. Acoustic function was assessed by the method of short-latent brain stem evoked potentials (SBEP). A wide-band click 0.1 msec long in the 100 to 20 dB range with a 10 dB step was used as the acoustic stimulant. Registration was carried out with a Biomedic device for evoked potentials. In animals injected antibiotics SBEP were recorded before and 2 months after the injections were started. After the experiments the animals were killed under nembutal anesthesia. For light microscopy the cochleas were formalin-fixed. Every tenth section of serial paraffin sections of the cochlea 10 μ thick made in the plane perpendicular to the modiolus was stained with hematoxylin-eosin and after Einarson. Neuron distribution density on a standard area was determined separately for the basal median and apical helixes. Perikaryon volume was estimated from the ellipsoid formula and the neurons were referred to different classes depending on this volume. For electron-microscopic examination the spiral ganglion was prefixed in 2.5% glutaraldehyde and then in 1% osmium oxide and decalcinated in EDTA solutions. After dehydration the material was embedded in an Epon-Araldite mixture. Contrast-stained ultrathin sections were examined under a JEM-100S electron microscope. Perikaryon and granular endoplasmic reticulum membrane surface area was determined using a standard morphometric net with a 10 mm spacing at a ×5000 magnification; the degree of endoplasmic reticulum granulation and the coefficient of its fragmentation, as well as ribosome and polysome number were assessed at a ×30,000 magnification. Comprehensive assessment of the spiral ganglion neurocytes was performed with due consideration for the coefficient of activity of the protein biosynthesis apparatus. All the resultant numerical values were expressed by the arithmetic mean and the standard error of the mean. The reliability of the differences was assessed by the Student test.

RESULTS

The morphophysiological studies demonstrated three stages which may be distinguished in the postnatal course of spiral ganglion maturation in normally developing cats: I) formation of a neurocyte protein-synthesizing apparatus (days 1-30); II) formation of the acoustic ganglion neurons as a physiologically

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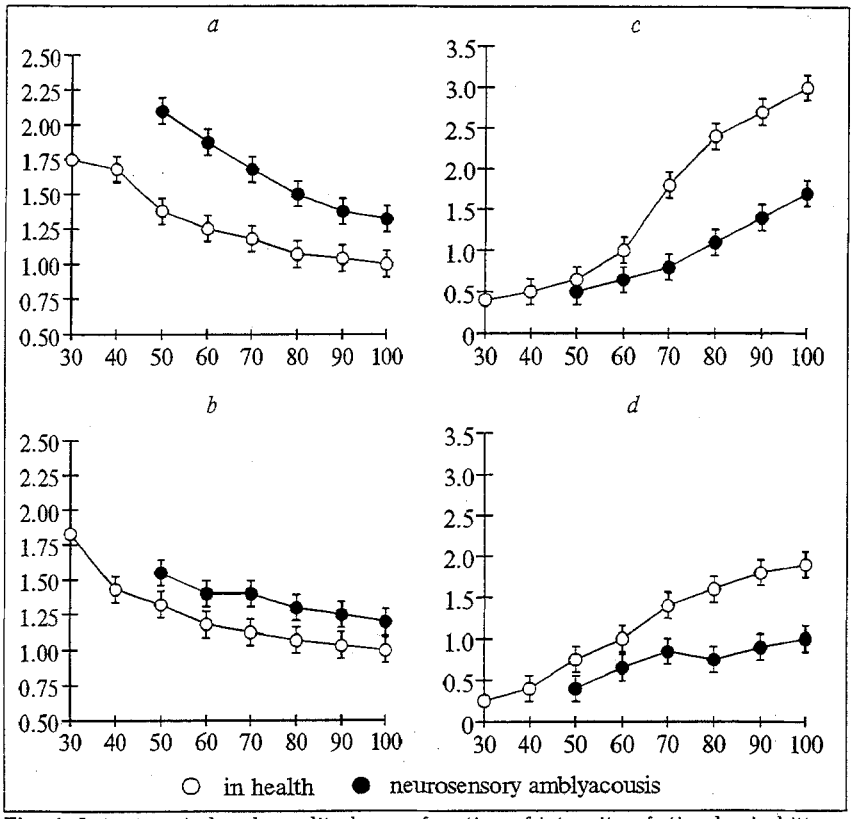

Fig. 1. Latent period and amplitude as a function of intensity of stimulus in kittens (*I*) and adult cats (*II*). Abscissa (*a*–*d*): level of acoustic pressure (dB); ordinate: *a*, *b*) latent periods (msec); *c*, *d*) amplitude of peaks (mm: 1 mm = 0.2 μV).

active unit in acoustic information transfer (days 31-45); III) morphofunctional maturation of the spiral ganglion (3 months).

Neurosensory amblyacousia in kittens aged 3 months. The study of the acoustic analyzer function in 3-month-old kittens administered ototoxic antibiotics starting from the age of 1 month revealed hearing disorders manifested primarily in an increase of the sound perception threshold to 50 dB. The recorded SBEP curves showed a 30-40% reduction of the amplitudes of all the peaks as against those of intact animals, this indicating a lesser number of functioning neurons. The latent periods of the first peak reflecting acoustic nerve excitation lengthened as the stimulation intensity was augmented (Fig. 1, *a*, *b*, *c*).

Light-optic examinations of spiral ganglion preparations showed edema of the nodular stroma, a reduced density of neurocyte distribution per unit of standard area, and increased perikaryon volume. Virtually all the neurons were changed, the majority of them having large perikaryons (Fig. 2, *a*) with tigrolysis phenomena.

Small hyperchromatic neurocytes much more rarely occurred. Cells with nuclear pycnosis and marked vacuolation of the cytoplasm were the third variety in the neurocyte population. It is important to note that the detected changes were similarly expressed in the basal, median, and apical helixes of the cochlea. Electron microscopy showed that the neurocyte cytoplasm was depleted in organelles, and the granular endoplasmic reticulum was represented by widened cisternae with signs of fragmen-

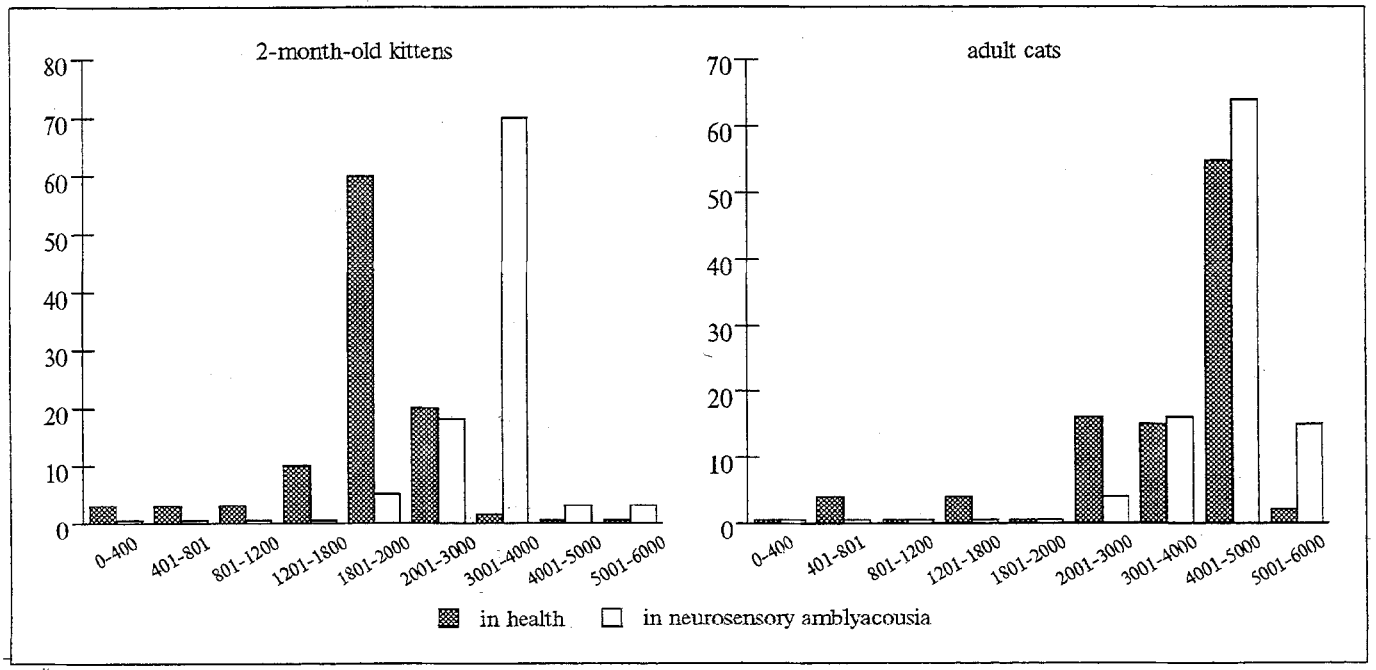

Fig. 2. Distribution of spiral ganglion neurons in normally developing animals and in neurosensory amblyacousia in terms of perikaryon size.

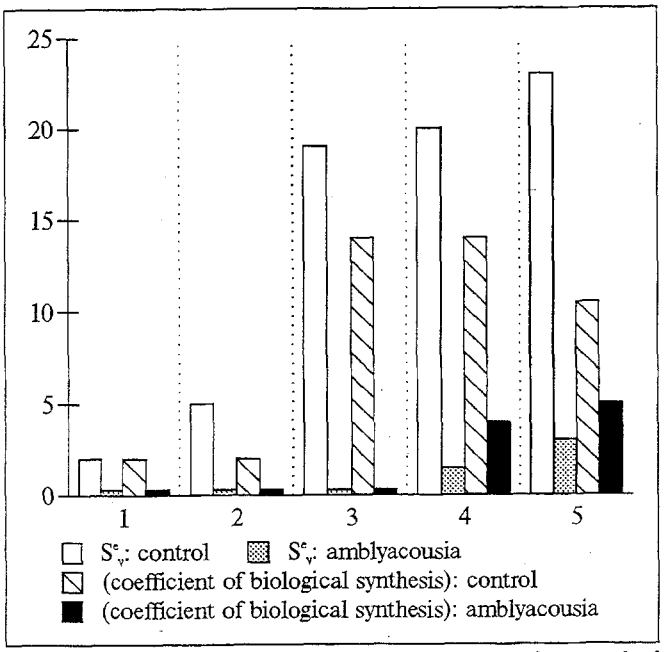

Fig. 3. Dynamics of area of electron-dense cytoplasm and of protein-synthesizing activity of neurocytes in normally developing animals and in neurosensory amblyacousia.

tation. Mitochondrial changes varied within a wide range. In some cases the mitochondria were swollen, with signs of crista disorientation; small or medium-sized mitochondria with an electron-dense matrix were seen. Such changes could be observed even in the same neuron. Sites with a cluster of vacuolated mitochondria were sometimes seen. Some neurons showed an increased content of lipofuchsin granules. The nuclei were as a rule large, with small lumps of condensed chromatin seen over the entire plane of the section. The fibrillar and granular parts of the nucleolus were well-expressed. The nucleolus was sometimes ectopic. The structural components of the nucleus and nucleolus were intact. Morphometric analysis of the ultrastructural changes, presented in Fig. 3, showed a markedly reduced coefficient of biological protein synthesis in the spiral ganglion neurocytes.

Chronic neurosensory amblyacousia in adult cats. Examination of the acoustic function in adult cats administered ototoxic agents revealed a changed configuration of the SBEP waves that was quite characteristic of neurosensory amblyacousia: increased perception thresholds, reduced amplitude, and a relative shortening of the latent periods of the peaks (Fig. 1, *b*, *d*).

Light-optic microscopy revealed mainly the same type of changes in spiral ganglion structure. Stromal and pericellular edema was seen all the time. The neurocyte population was nonuniform: a negligible part of it was just slightly changed, the majority of the cells were large (Fig. 2, *b*) with vacuolated cytoplasm, and the third group of neurocytes was represented by destructively changed cells.

Electron-microscopic examination showed reduced electron density of the cytoplasm in large neurocytes. The granular endoplasmic reticulum was reduced, and what canaliculi there were, were dilated with their ribosomes lost at many sites. Individual ribosomes occurred extremely seldom; they mostly formed rosette aggregations in the hyaloplasm. The mitochondrial matrix was clarified, the cristae fragmented and homogenized. Lipofuchsin bodies were detected in the cytoplasm of many neurons. The nuclei were large, occupying the whole cytoplasm and containing small lumps of condensed chromatin. The nucleolus included fibrillar and granular components. Morphometric assessment of the submicroscopic shifts in the neurons (Fig. 3) demonstrated a reliable drop of the coefficient of biological protein synthesis in the animals.

Hence, analysis of the principal stages of postnatal ontogenesis helped trace the age-specific course of acoustic ganglion formation and showed the nonuniformity of the rate of morphofunctional maturation of the neurocytes. Active morphological formation of the spiral ganglion neurocytes was observed at the age of 1 to 1.5 months, and the definitive structure of the ganglion as a unit of acoustic information transfer was attained by the third month of life.

Antibiotic poisoning of cats in the early postnatal period induces significant deviations in the normal course of spiral ganglion neurocyte development. One of the principal disorders is a low level of metabolic activity: the activity of the protein biosynthesis apparatus in the experimental animals was reduced 3.5-fold by the third month in comparison with that of intact age-matched animals. Delayed neurocyte differentiation has a marked effect on the development of the spiral ganglion as a structural unit of acoustic information transfer, as is confirmed by SBEP data demonstrating much higher values of the latent periods in comparison with both normal values an those in kittens aged 1 month.

Neurosensory amblyacousia simulated in adult cats is also associated with a wide range of cytological rearrangements of spiral ganglion neurocytes, from poorly expressed forms to clear-cut irreversible destructive changes. The principal morphofunctional disorder in spiral ganglion neurocytes is inhibited activity of the protein synthesis apparatus.

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