FREQUENCY CHARACTERISTICS OF IMPULSE TRANSMISSION IN THE CILIARY GANGLION OF CATS IN ONTOGENESIS

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Experiments on cats have shown that action potentials in the short ciliary nerve during stimulation of the oculomotor nerve are recorded from the first day of life. With age an increase in excitability, shortening of the latent period of excitation, and a decrease in the duration of the action potential are observed, the optimum of tetanic stimulation is shifted toward higher frequencies, and the level of functional resistance of cells of the ciliary ganglion to tetanic stimulation is raised.

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The object of this investigation was to study frequency characteristics of impulse transmission in the ciliary ganglion in ontogenesis by recording evoked potentials developing in the short ciliary nerve in response to stimulation of the oculomotor nerve in cats. Studies previously carried out on the mammalian ciliary ganglion have been limited to adult animals.

EXPERIMENTAL METHOD

Experiments were carried out on adult cats and kittens (from the first day after birth until acquisition of vision) anesthetized with nembutal (40 mg/kg, intraperitoneally) and after decerebration.

A periorbital incision was made and the rectus lateralis muscle of the eye exposed, divided at its point of attachment to the eyeball, and drawn posteriorly by a ligature. To facilitate access to the ciliary ganglion the vitreous and lens were removed through an incision in the upper part of the eyeball, which was drawn anteriorly.

Electrodes for recording action potentials were placed on the short ciliary nerve, for most preganglionic fibers run in it. The stimulating electrodes were applied to the intracranial part of the oculomotor nerve, in which the preganglionic fibers run.

EXPERIMENTAL RESULTS

Action potentials in the short ciliary nerve can be recorded during stimulation of the oculomotor nerve in kittens from the first day of life. As Fig. 1 shows, action potentials both in newborn kittens and in adult cats consist of two components: a first of short duration with a short latent period and a second of longer duration and long latent period. When examining the latent period of excitation, consideration was paid to the time of onset of the second, main component of the action potentials, which evidently was due to the response of cells of the ciliary ganglion. The latent period of the second component of the action potential was 20-30 msec in newborn kittens and 10-12 msec in adult cats. The mean duration of the action potential in newborn kittens was 80 msec and in adult cats 20 msec.

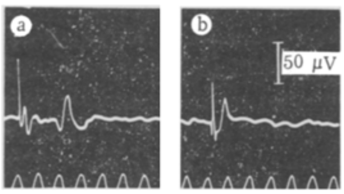

Fig. 1. Action potentials of ciliary ganglion of kitten aged 1 day (a) and of adult cat (b). Parameters of stimulation in a: 0.5 msec, 3 V; in b: 0.2 msec, 1 V. Time marker 20 msec.

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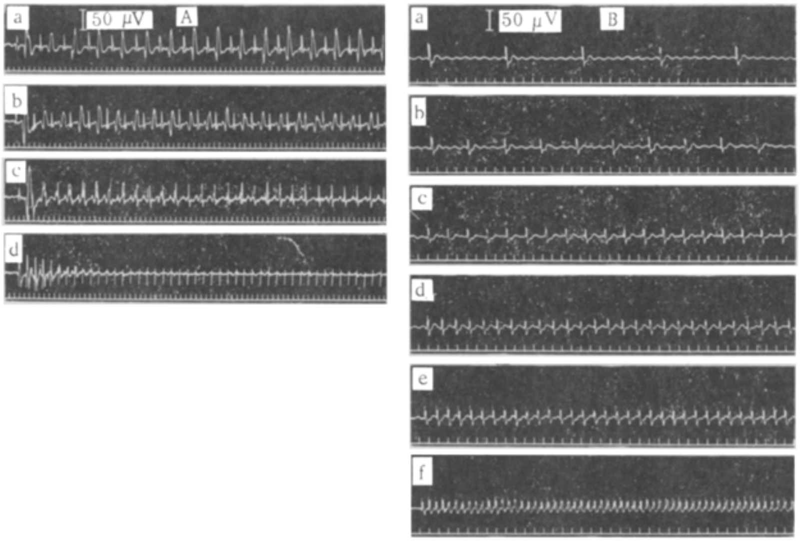

Fig. 2. Action potentials of ciliary ganglion in a kitten aged 5 days (A) and an adult cat (B). Parameters of stimulation in A: 0.5 msec, 3 V, frequency per second: a) 10; b) 15; c) 20; d) 30. Parameters of stimulation in B: 0.2 msec, 1 V, frequency per second: a) 10; b) 15; c) 25; d) 35; e) 45; f) 75. Time marker 20 msec.

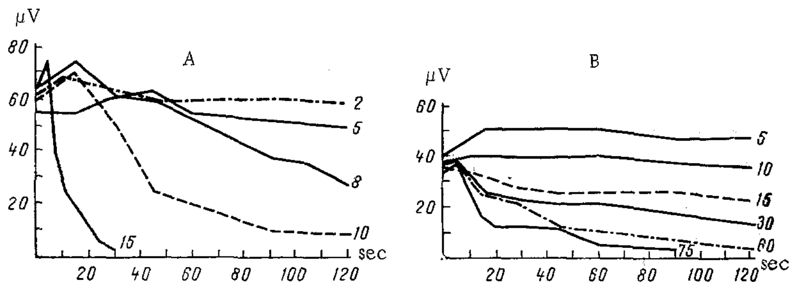

Fig. 3. Resistance of newborn kittens (a) and adult cats (b) to tetanic stimulation at different frequencies. Abscissa: time of stimulation (in sec); ordinate: amplitude of potential (in μV). Numbers by curves indicate frequency of stimulation per second.

The experiments showed that action potentials in newborn kittens arise in response to stimuli of greater strength and longer duration than in adult animals. To produce an action potential in newborn kittens, for instance, the duration of the stimulus must be not less than 0.5 msec for a strength of stimulation of 2-3 V, whereas in adult cats, with the same strength of stimulation, a stimulus 0.1-0.2 msec in duration is sufficient to cause generation of an action potential. When stimuli of longer duration (0.5 msec) were applied, action potentials were generated by adult cats in response to a much lower strength of stimulation (0.4-0.6 V).

Impulses were conducted with constant amplitude in newborn kittens only when stimuli of low frequency were used. Conduction of the second component began to be impaired in kittens in the early postnatal period as soon as the frequency of stimulation reached 15/sec (Fig. 2A). Conduction of the first component in kittens reaches a minimum during stimulation at a frequency of 30/sec. In adult cats (Fig. 2B), conduction of the second component reached a minimum during stimulation at a frequency of 40-50/sec, and for the first component at a frequency of 60-80/sec.

Age differences in conduction of excitation through the ciliary ganglion were still more clearly revealed by the study of functional resistance of the ganglion cells to tetanic stimulation of the preganglion trunk. Changes in the amplitude of the second component of the action potentials during prolonged stimulation of the preganglionic trunk with square pulses of different frequencies are illustrated in Fig. 3. The graphs in Fig. 3 show that frequencies of up to 5/sec are optimal for newborn kittens, this rhythm of stimulation being reproduced unchanged throughout the period of stimulation (2 min). At a frequency of 10/sec, the amplitude of the potentials in newborn kittens fell to one-third of its initial value after 45 sec, and at a frequency of 15/sec the conduction of excitation through the ganglia stopped after 30 sec.

Investigation of functional resistance of the ciliary ganglion cells of adult cats showed that conduction of impulses through the ganglion was unchanged over a long period of time at a frequency of 15/sec. At frequencies of between 30 and 40/sec, an alternating rhythm appeared, and the amplitude fell during tetanization for 2 min by two-thirds of its initial value. At frequencies of more than 40/sec, conduction began to be impaired in the course of prolonged tetanization. At higher frequencies of stimulation (50-60/sec), this impairment of conduction developed more rapidly.

The results described above show that an increase in excitability, shortening of the latent period of excitation and shortening of the duration of the action potential are observed with age, the optimum of tetanic stimulation being shifted toward higher frequencies and the level of functional resistance of the ciliary ganglion cells to tetanic stimulation being raised.