MORPHOLOGY AND PATHOMORPHOLOGY

Morphological Changes in the Pineal Gland of Rats under Conditions of Long-Term Exposure to Bright Light

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Changes in the diurnal light cycle affect the morphofunctional state of the pineal gland. The volume of the nucleus, Golgi apparatus, and mitochondria in pinealocytes decreases after 45-day exposure to bright light. After 90 days. the degree of nuclear polymorphism increased, the specific volume of the Golgi apparatus returned to normal, the volume of the granular endoplasmic reticulum decreased, while the volume of lysosomes, free ribosomes, and polysomes increased. These changes reflect plasticity of pinealocytes and adaptation of the gland to long-term 24-h light exposure.

Key Words: *pinealocytes; morphometry; ultrastructure; 24-h light exposure*

Melatonin synthesis in the pineal gland is suppressed under conditions of 24-h light exposure [1,6,10]. The volume of the nucleus, diameter of the nucleolus, and specific volume of the granular endoplasmic reticulum (GER), Golgi apparatus, and mitochondria in rat pinealocytes decrease after 48-h exposure to bright light. The specific volume of pinealocytes on the section of this gland decreased after 6 weeks [3,4,9]. Functional changes in the pineal gland caused by long-term constant illumination were never studied. It is poorly understood whether bright light has an adverse action on pinealocytes. Here we studied changes in rat pineal gland after 45 and 90 days of 24-h exposure to bright light. The standard morphological markers served as the index of functional activity of the pineal gland [8].

MATERIALS AND METHODS

Experiments were performed on 20 outbred albino female rats weighing 180-200 g. The animals were housed in over-illuminated cages (3500 lx) for 45 days (group 1, n=5) and 90 days (group 2, n=5). The females maintained at a 12:12-h light/dark cycle (200 lx during daytime) served as the control. The samples were obtained after decapitation of animals under ether narcosis at 11-12 a.m. The pineal glands were fixed in 2.5% glutaraldehyde in cacodylate buffer (pH=7.4), postfixed in 1% OsO_4, dehydrated in ethanol, and embedded in Epon. Semithin sections were prepared on an LKB-III ultratome and stained with 1% toluidine blue. Ultrathin sections were contrasted with uranyl acetate and lead citrate. The sections were examined under a JEM-100 CX II electron microscope. Morphometric study was performed using an ocular grid and AM-9-2 ocular screw micrometer (method of point calculation). The significance of differences was evaluated by nonparametric Mann–Whitney test.

RESULTS

Table 1 shows the changes in morphometric parameters of functional activity of the pineal gland. The specific number of pinealocytes in the section of the

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TABLE 1. Morphometric Parameters for the Functional State of the Pineal Gland in Rats under Long-term Light Exposure (*M*±*m*; *n*=20)

Parameter	Time of bright light exposure in rats			
	45 days		90 days	
	experimental	control	experimental	control
Specific number of pinealocytes per section (S=900 μ²)	6.62±0.34	6.95±0.33	6.42±0.29	6.84±0.32
Relative content of light pinealocytes, %	77.4±4.9	80.3±4.1	76.2±4.7	78.3±3.9
Glial/pineal index, %	6.42±0.30*	5.88±0.29	7.18±0.34*	5.94±0.28
Volume of the pinealocyte nucleus, μ³	136.5±6.69*	178.6±8.35	124.7±5.98*	175.4±8.0
Diameter of the pinealocyte nucleolus, μ	2.08±0.10	2.02±0.09	2.03±0.09	1.97±0.11
Specific volume of the pinealocyte cytoplasm, %:				
granular endoplasmic reticulum	4.02±0.19	3.95±0.18	3.26±0.15*	3.72±0.17
Golgi apparatus	1.72±0.08*	2.17±0.10	2.35±0.12	2.08±0.09
mitochondria	5.68±0.28*	8.24±0.39	5.43±0.26*	8.15±0.32
lysosomes	2.30±0.09	1.81±0.07	4.32±0.22*	1.68±0.08

Note. *p<0.05 compared to the control.

pineal gland, relative content of light cells (type I), and diameter of the nucleolus under conditions of long-term 24-h exposure to bright light did not differ from the control. The glia/pineal index increased. The volume of the nucleus and mitochondria decreased. The specific volume of the Golgi apparatus and GER decreased (after 45 and 90 days, respectively), while the specific volume of lysosomes increased.

After 45 days, complexes of elongated GER cisternae, dictyosomes with short narrow cisternae, single light vesicles near the Golgi apparatus, and small mitochondria were seen in the perinuclear cytoplasm of light pinealocytes. The number of vesicles with a flocculent agent, free ribosomes, and polysomes increased in the peripheral region of the perikaryon (Fig. 1). Long-term light exposure is probably accompanied by transition of pinealocytes to the rest state and form the protein-synthesizing apparatus of the cytoplasm from the nucleus material. Its long-term functional "inoperativeness" leads to the release of some ribosomes, complexation of GER cisternae, and secretion of vesicles with a flocculent agent. These changes illustrate ependymal secretion and suppression of the neurosecretion-like mechanism [8].

The precapillary space was expanded after 90 days. It was related to swelling of processes in supporting glial cells and pronounced growth of the loose connective tissue. A small number of fine granular synaptic vesicles were found in the neuroglandular endings. Long-term 24-h exposure of rats to bright light is probably followed by the induction of sympathetic stimulation of pinealocytes. This conclusion was derived from the presence of degenerated nerve fibers and terminals in the pineal gland. It cannot be excluded that some of them are the terminals of axons of inhibitory neurons in the circadian system, which comprises the pineal gland, suprachiasmatic nucleus, and paraventricular nucleus of the hypothalamus [2].

Nuclear polymorphism of pinealocytes increased after 90 days, which resulted from a folded structure of the nuclear membrane. Marginal condensation of chromatin was observed. The ribosomes, lysosomes, and

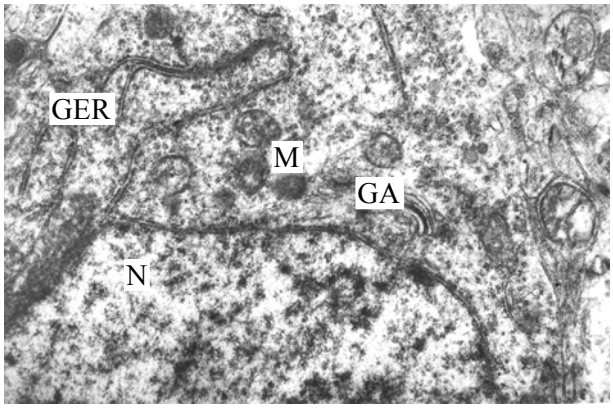

Fig. 1. Pinealocyte after 45-day exposure to bright light (×28,000). N, nucleus; GA, Golgi apparatus; M, mitochondria.

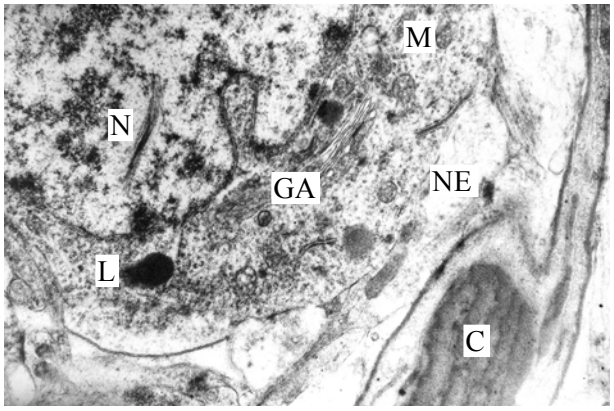

Fig. 2. Ultrastructure of the pineal gland after 90-day exposure to bright light (×23,000). N, pinealocyte nucleus; L, lysosome; NE, neuroglandular ending; C, capillary.

dense-core vesicles were agglomerated in the perinuclear region of the cytoplasm. Dictyosomal cisternae with dilated margins were of considerable length in some pinealocytes. By contrast, GER was presented by narrow and short cisternae. Lamellar structures with single small light vesicles were revealed around the neuroglandular endings in the pinealocyte cytoplasm (Fig. 2). These changes are similar to the age-related and compensatory variations typical of pineal gland hypofunction [4,5,7].

Therefore, the pineal gland in is adapted to 24-h light exposure due to high plasticity of pinealocytes. The pineal gland serves as a bright light exposure-resistant component of the circadian system.

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