MORPHOLOGY AND PATHOMORPHOLOGY

Initial Morphofunctional Asymmetry of the Adrenal Glands in CBA/Lacy Mice

V. M. Perel'muter and Yu. M. Paderov

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 137, No. 4, pp. 444-446, April, 2004
Original article submitted August 15, 2003

We performed morphological examination of the adrenal glands from intact CBA/Lacy mice. Morphometry, histochemistry, and electron microscopy revealed predominance of functional activity of the right adrenal gland. This phenomenon was associated with adaptive state of the animals. The observed differences are probably related to specific pattern of functioning of paired organs determined during embryogenesis.

Key Words: *adrenal glands; functional morphology; asymmetry*

The adrenal glands constitute a component of the hypothalamic-hypophyseal-adrenal system responsible for homeostasis maintenance. The adrenal glands are extremely labile organs that stereotypically react to environmental changes. Much attention was given to the adrenal glands in studying stress and adaptation [6,8,9]. The initial morphofunctional characteristics of the adrenal glands should be evaluated in details.

Here we studied morphofunctional indexes of the adrenal glands from intact animals.

MATERIALS AND METHODS

Experiments were performed on 42 adult male CBA/Lacy mice weighing 18-20 g and obtained from Rassvet nursery. The animals were divided into 3 groups (14 mice per each). They were examined in winter (January), spring (April), and summer (June).

The mice were decapitated. The surrounding connective tissue was removed, the adrenals were weighted, fixed in calcium-formalin for histological and histochemical examination (measurement of lipid content and total ketosteroid concentration). For electron microscopy fragments of the adrenal glands were fixed with glutaraldehyde in cacodylate buffer (pH 7.2) by the method of Sabatini. Ultrathin sections (20-40 nm) were stained with 2% uranyl acetate in 5% ethanol and lead citrate (by the method of Reynolds). Functional state of the adrenal glands was estimated telemetrically (×300). We measured the volume of nuclei [3] in endocrine cells of the cortex and chromaffin cells of the medulla.

Functional state of mice was evaluated by body weight, count of blood cells, and number of karyocytes in the thymus.

The results were analyzed by Student's t test for dependent and independent variables, Wilcoxon test, Mann—Whitney test, and correlation and discrimination analyses. The method of statistical analysis was selected depending on data distribution in the variational series (Kolmogorov—Smirnov test).

RESULTS

No differences were revealed in the weight of contralateral adrenal glands in mice of various groups. The adrenal glands from CBA/Lacy mice were characterized by clearly developed zona reticularis that was not clearly identified in mice of other strains [7]. The study of the volume of nuclei and the distribution of lipids and ketosteroids showed that external and central re-

Siberian State Medical University, Russian Ministry of Health, Tomsk. ***Address for correspondence:***alfedval@mail.ru. Paderov Yu. M.

0007-4888/04/1374-0392

TABLE 1. Absolute Volume of Nuclei in Adrenocorticocytes and Chromaffin Cells of the Adrenal Glands in CBA/Lacy Mice (μ^3, $M\pm m$)

Object		Period of examination		
		January	April	June
Glomerular zone	LAG	53.6±4.2*	44.5±3.0*	49.5±3.9*
	RAG	77.5±3.9	67.9±3.8	84.0±4.5
Zona fasciculata	LAG	64.4±5.1**	52.1±3.9*	55.9±3.4*
	RAG	87.4±3.3	76.7±4.3	94.7±3.2
Zona reticularis	LAG	35.8±2.4	32.9±2.3	36.6±3.5
	RAG	44.6±2.1	40.4±1.7	48.7±4.6
Medulla	LAG	112.6±8.3**	98.3±8.4	96.5±6.2*
	RAG	155.3±8.9	124.0±5.0	159.0±8.0

Note. Here and in Tables 2 and 3: $^*p<0.001$ and $^{**}p<0.01$ compared to RAG.

gions of the zona fasciculata possess high biosynthetic activity. Comparison of karyometric indexes of the right (RAG) and left adrenal glands (LAG) revealed higher volume of nuclei of endocrine cells in different functional zones of the cortex and chromaffin cells of the medulla in RAG at various terms of examination (Table 1).

The general accepted theory postulates that the increase in functional activity of the organ is followed by enlargement of its cells. Published data also showed that the volume of nuclei directly depends on functional state of cells [5]. Therefore, the initial morphofunctional asymmetry of contralateral adrenal glands in intact animals is manifested in significant predominance of the volume of cell nuclei in the cortex and medulla. Therefore, functional activity of RAG is higher than that of LAG.

Histological study of preparations for total ketosteroid content confirmed this conclusion.

The volume density of functionally activated cells in RAG surpassed that in LAG (Table 2).

RAG was characterized by pronounced delipidation (Table 2).

Electron microscopy of endocrine cells in central regions of the zona fasciculata showed that RAG and LAG have different functional activity.

The area of nuclei, number and volume density of mitochondria, and volume density of the endoplasmic reticulum in RAG were higher than in LAG. However, the volume density of liposomes in RAG was lower than in LAG (Table 3).

Despite genetic homogeneity, the population of CBA/Lacy mice was divided into 3 subpopulations depending on predominant functional activity of endocrine cells. Functional activity of RAG prevailed in most animals (61.7%). Predominance of LAG was observed in 23.4% mice. The volume of endocrine cells was similar in LAG and RAG of 14.9% animals.

The phenomenon of morphofunctional asymmetry of the adrenal glands is closely related to the adaptive state of animals. Body weight was minimum in mice with RAG predominance. Higher degree of stress reactivity in these animals was confirmed by lymphopenia and lower count of cells in the thymus. These characteristics can be associated with high concentration of adrenal hormones in the blood, which is confirmed by higher secretory activity of RAG [1,2].

Morphofunctional asymmetry of the adrenal glands is most likely determined by their development during embryogenesis [4]. Genetically homogenous mice can be divided into subpopulations with different morphofunctional state of the contralateral adrenal glands and various adaptive reactions. This reflects the dynamic nature of this phenomenon and illustrates the possibility of changing the sign of asymmetry. This phenomenon should be taken into account when studying the response of an organ to various factors to avoid misinterpretation of the experimental data.

TABLE 2. Total Ketosteroid Content and Concentration of Sudanophilic Lipids in the Adrenal Cortex of CBA/Lacy Mice ($M\pm m$)

Object	Volume density of total ketosteroids, %			Volume density of lipids, %	
	high content	low content	no staining	high content	low content
LAG	48.1±4.8	38.7±4.6**	13.1±3.2	82.6±4.3**	17.3±4.4**
RAG	31.9±2.9	54.3±2.9	13.7±2.1	64.3±2.1	35.6±2.5

TABLE 3. Ultrastructural Characteristics of Endocrine Cells in the Zona fasciculata ($M\pm m$)

Index	LAG	RAG
Volume of nucleus, nm^2	212.70±16.03	321.1±30.6
Volume density of nucleolus, %	0.067±0.010	0.074±0.010
Count of liposomes, per 1000 nm^2	0.094±0.040	0.061±0.010
Volume density of liposomes, %	8.12±0.39*	4.92±0.40
Count of mitochondria, per 1000 nm^2	0.028±0.010**	0.074±0.010
Volume density of mitochondria, %	2.95±0.26*	7.59±0.40
Volume density of endoplasmic reticulum, %	0.056±0.010	0.09±0.02

REFERENCES

1. V. V. Abramov and T. Ya. Abramova, *Asymmetry of the Nervous, Endocrine, and Immune Systems* [in Russian], Novosibirsk (1996).
2. V. V. Abramov, O. L. Karmatskikh, V. A. Kozlov, and I. N. Os'kina, *Dokl. Ros. Akad. Nauk*, **347**, No. 6, 831-833 (1996).
3. G. G. Avtandilov, *Medical Morphometry* [in Russian], Moscow (1990).
4. N. N. Bragina and T. A. Dobrokhotova, *Functional Asymmetry in Humans* [in Russian], Moscow (1988).
5. A. I. Strukov, O. K. Khmel'nitskii, and V. P. Petlenko, *Morphological Equivalent of Function* [in Russian], Moscow (1983).
6. L. N. Trut, L. A. Prasolova, A. V. Kharlamova, and I. Z. Plyusnina, *Byull. Eksp. Biol. Med.*, **133**, No. 5, 585-588 (2002).
7. H. Frith Carles, *Endocrine System*, Berlin (1983), pp. 8-12.
8. B. D. Rana, R. Advani, B. K. Soni, *et al.*, *J. Anim. Morphol. Physiol.*, **31**, Nos. 1-2, 243-250 (1984).
9. E. Szigethy, Y. Conwell, N. T. Forbes, *et al.*, *Biol. Psychiatry*, **36**, 374-380 (1994).