Morphofunctional State of the Adrenal Glands in Albino Rats under Conditions of Toxic Stress Caused by Cadmium Salt in Winter and Summer Periods

S. V. Kotelnikova, M. V. Kargina, and A.V. Kotelnikov

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We studied the morphology and function of the adrenal glands in male and female albino rats in cadmium intoxication during winter and summer periods (January and July). In animals of the control group, sex-related differences in the total area of the adrenal glands and in the size of their zones were revealed. In females, zones of adrenal gland were larger than in males. In winter months, these differences were most pronounced. Analysis of seasonal differences in the area of the adrenal glands in males revealed no significant differences in winter and summer months. Irrespective of the season and gender, cadmium chloride treatment led to an increase in the size of the adrenal glands. Cadmium salts caused more pronounced functional strain in males in winter months and in females in summer.

Key Words: *cadmium chloride; seasons; adrenal glands*

Cadmium is a widespread environmental pollutant that can cause serious changes in the organism. Cadmium pollution of soil, water and air as a result of industrial activity is steadily increasing [8]. Cadmium, even in low doses, can cause chemical stress and has a toxic effect on the body [2,4,7]. Interaction of the adrenocortical and adrenomedullary systems plays an important role in the development of stress reaction and ultimately determines the quality of adaptive changes. Reserve capabilities of the adaptive systems closely correlate with animal gender, which confirms the existence of sexual dimorphism in adrenal weight observed in the majority of mammals. Sexual dimorphism is considered as a peculiar structural consequence of adaptation. The physiological reaction to stress is "fixed" at the morphological level by responding to the increased need for steroids by growth of glandular tissue [3]. It should also be noted that the functional state of organs and systems largely depends on the season. In light of this, the aim of the work was to study the morphological structure reflecting functional state of the adrenal glands of male and female albino rats under conditions of cadmium intoxication in the most contrasting months of the year, *i.e.* January and July.

MATERIALS AND METHODS

The studies were carried out on 89 outbred albino rats *Rattus norvegicus* (mean body weight at the beginning of the experiment 180 g). Cadmium chloride was administered *per os* through a tube daily for 15 days in winter (January) and summer (July) months. The dose was 2 mg/100 g body weight; the total dose was 30 mg/100 g body weight, representing one third of the LD_{50} (94 mg/kg). This route ensures absorption of about 5% of administered cadmium chloride [1]. At the end of the experiment, the animals were decapitated under chloral hydrate anesthesia (25 mg/100 g body weight injected intraperitoneally). The adrenal

Astrakhan State Technical University, Russia. ***Address for correspondence:*** kotas@inbox.ru. A. V. Kotelnikov

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glands were removed, fixed in Bouin's fluid, and embedded in paraffin. Serial sections (5 μ) were stained with Harris' hematoxylin and eosin. For evaluation of morphological parameters, section images (×600) were digitized and processed using the Measure Tool (Adobe Photoshop). Total cross-section areas of the adrenal gland and the area of the cortex and medulla were measured (Fig. 1).

Area of the adrenal gland and medulla were calculated by the formula:

$$S=\frac{\pi}{4}D\times d,$$

where D and d are two perpendicular measurements. Each section was measured three times and the means of each parameter were calculated. The area of the cortex was determined as the difference between the areas of the adrenal gland and the medulla.

The data were statistically processed using Student's t test.

RESULTS

In males, the areas of adrenal glands were practically identical during the winter and summer months (Table 1). At the same time, the medulla/cortex ratios were different (0.26 in July and 0.16 in January) with a relative decrease in the area of the medulla (by 30.5%, $p<0.05$) and increase in the area of the cortex (by 23.7%, $p<0.05$) compared to the corresponding parameters in July.

On the contrary, the area of the adrenal glands in control females in January was by 29.6% higher compared to that in July ($p<0.01$). This increase occurred mainly at the expense of the cortex: the area of the cortex in January was greater by 33.6% ($p<0.001$).

It is obvious the interaction of the adrenocortical and adrenomedullary systems underwent different changes in males and females during the year. The common feature was strengthening of the adrenocortical system in winter (more pronounced in females), which can be explained by restructuring of the energy reserves of the body with the onset of cold season and transition of organism's systems to another mode of functioning.

Seasonal changes in the function of the adrenal glands affect sexual dimorphism, which in our experiment was pronounced only in winter. The area of the adrenal glands in control females was higher than in males by 27.6% ($p<0.05$). This confirms the fact that functioning of the adrenal glands in males is less stable [6], while the area of the adrenal cortex in females was greater than in males both in winter and summer: by 18.6 and 28% in July and January, respectively ($p<0.05$). Areas of the medulla in males and females did not differ in summer, but in winter the area of the medulla in females was greater than in males by 24.8% ($p<0.05$). Thus, reserve capacity of the adrenocortical system in females is greater than in males, irrespective of the season. Enlargement of the adrenal glands in females in the cold season occurs at the expense of both the adrenocortical and adrenomedullary systems.

Cadmium chloride causes an increase in the area of the adrenal glands and widening of the cortical zone in both males and females in both seasons. Hyperactivity of the adrenal cortex can be regarded as a universal unspecific reaction, which is a common mechanism of the system response to adverse factor [5]. However, the effect of the toxic agent was characterized by seasonal and sexual peculiarities.

Thus, the increase in the area of the adrenal glands caused by treatment with cadmium salt in winter was more pronounced in males (62% compared with control, $p<0.001$) and was characterized by involvement of both the cortex and medulla in the reaction (an increase by 1.9 times compared to the control, $p<0.001$). During this period, females responded to cadmium chloride treatment by a slight increase in the area of the adrenal gland (by 16.9%, $p<0.05$) at the expense of cortical zone widening (by 21%, $p<0.05$).

In summer we observed an opposite situation: the increase in the area of the adrenals was more pronounced in females (by 53.8%, $p<0.001$) with a significant increase in the percentage of both the cortex and medulla (by 1.9 times, $p<0.001$). In males, only the area of the cortex increased in summer (by 28%, $p<0.01$), which led to an increase in the entire area of the adrenal gland (by 23.7%, $p<0.05$).

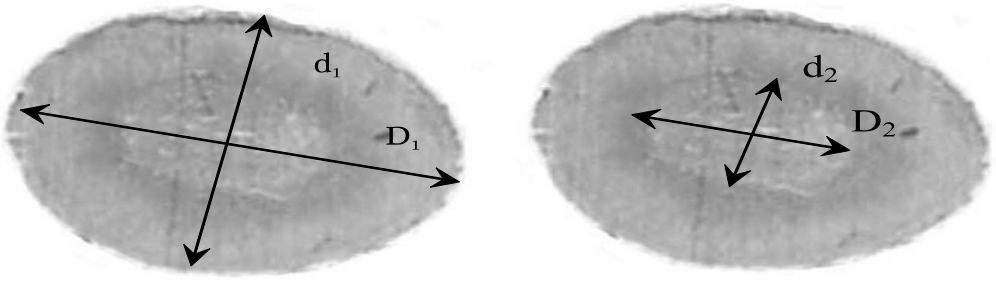

Fig. 1. Measurement of the area of adrenal gland and medulla.

TABLE 1. Effect of Cadmium Salts on the Size of Adrenal Glands Zones (*M±m*)

Month	Sex	Group	Total area of the adrenal gland, mm²	Area of the medulla, mm²	Area of the cortex, mm²
July	Males	Control	4.33±0.167	0.86±0.045^{+}	3.27±0.143^{+}
		Cadmium chloride	5.11±0.304 *	0.92±0.062	4.20±0.254**
	Females	Control	4.63±0.227 $^{+++}$	0.76±0.034	3.88±0.206^{o+++}
		Cadmium chloride	7.12±0.339***	1.42±0.087***	5.71±0.276***
January	Males	Control	4.71±0.314	0.66±0.051	4.05±0.289
		Cadmium chloride	7.64±0.402***	1.26±0.074***	6.38±0.375***
	Females	Control	6.01±0.229^{o}	0.83±0.040 ^{o}	5.18±0.205^{o}
		Cadmium chloride	7.02±0.337*	0.76±0.042	6.26±0.314*

Note. $^{+}p<0.05$, $^{+++}p<0.001$ compared to the parameter in January; $^{o}p<0.05$ compared to males; $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$ compared to the control.

Thus, we can conclude that the development of toxic stress caused by cadmium treatment in males mostly occurs in winter and in females in summer.

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