DIURNAL CHANGES IN PROTEIN METABOLISM AND MITOTIC ACTIVITY OF ADRENAL CORTICAL CELLS

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By comparison with diurnal changes in hormonal activity [11-14, 18] and cell proliferation [1, 3, 5, 16] of the adrenal cortex, the diurnal changes in its metabolism have received far less study. Only isolated investigations have been published indicating the existence of a diurnal rhythm in oxygen consumption of the adrenal tissue [7, 19], in the activity of certain enzymes [10], and in synthesis of nucleoproteins [15].

The author has shown previously [6] that synthesis of sulfur-containing proteins in the adrenal cortex of rats takes place most actively in the morning. However, this investigation was carried out on limited material (only 12 animals were used) and tests were carried out at intervals of 6 h.

The object of the present investigation was to make a more detailed study of the diurnal changes in incorporation of methionine-S^{35} into cells of the different zones of the adrenal cortex and to compare the results obtained with diurnal changes in mitotic activity.

EXPERIMENTAL METHOD

Experiments were carried out on 122 male albino rats weighing 180-230 g in March during natural illumination. For the autoradiographic investigation, 24 rats were divided into 8 groups with 3 animals in each group. A solution of methionine-S^{35} was injected subcutaneously in a dose of 1 μCi/g body weight every 3 h from 9 a.m. until 6 a.m. The rats of all groups were sacrificed 3 h after injection of the isotope. Animals intended for study of the mitotic activity of the cells (from 10-16 at each time) were sacrificed at the same times.

Paraffin sections 7 μ in thickness were treated by the usual histological and histoautoradiographic [4] methods. The number of tracks in 100 squares of the ocular grid (area of one square 44 μ^2) was counted separately for the zona glomerulosa, zona fasciculata and zona reticularis of the cortex. Mitoses were counted separately in the zona glomerulosa and the outer portion of the zona fasciculata in not less than 6000 cells. In the deeper part of the cortex no mitoses were found. The results were analyzed by statistical methods.

Diurnal Changes in Mitotic Activity of Cells in Different Zones of the Adrenal Cortex (M±m)

Time of day	No. of animals	MC (in %)	
		zona glomerulosa	outer portion of zona fasciculata
noon	16	0,14±0,03	0,59±0,11
3 p.m.	11	0,23±0,05	0,62±0,14
6 p.m.	10	0,76±0,19	0,27±0,07
9 p.m.	10	0,83±0,11	0,31±0,08
12 midnight	11	0,33±0,06	0,41±0,11
3 a.m.	11	0,63±0,09	0,21±0,04
6 a.m.	13	0,49±0,07	0,40±0,07
9 a.m.	16	0,13±0,03	0,42±0,07
Mean data for the 24 hours		0,44	0,40

EXPERIMENTAL RESULTS

The experimental results showing diurnal changes in synthesis of sulfur-containing proteins in the adrenal cortex are given in Figs. 1 and 2. Analysis of these data gives the following results. The intensity of incorporation of methionine-S^{35} into the adrenal cortex gradually increases in the direction from the zona glomerulosa to the zona reticularis; in all zones a statistically significant ($P < 0.05$) peak of incorporation of the isotope occurs from 9 a.m. to 12 noon. Taking the mean level for the 24 h as 100, the intensity of protein synthesis in this peak period in the zona glomerulosa is 153%,

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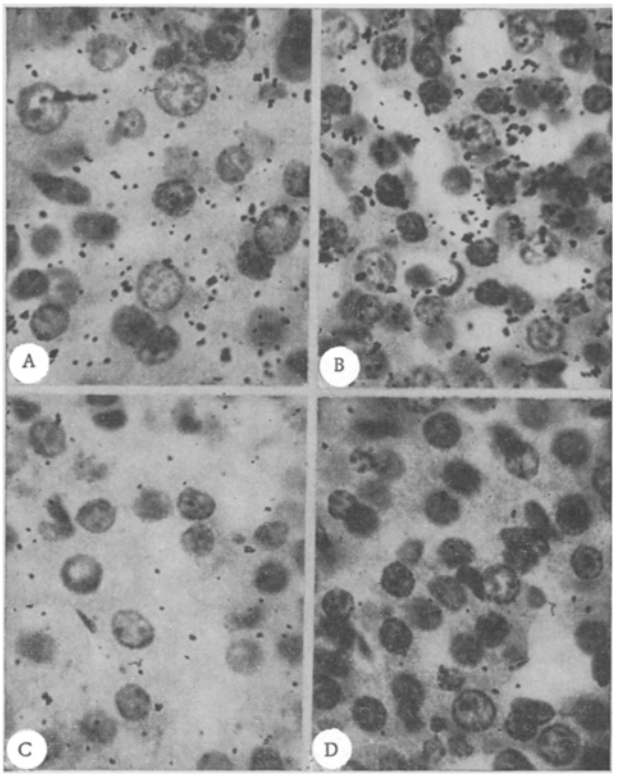

Fig. 1. Diurnal changes in intensity of incorporation of methionine-S^{35} into different zones of the adrenal cortex. A) Zona fasciculata; B) zona reticularis of the adrenal cortex of a rat from group 1 (9 a.m.-12 noon); C) zona fasciculata; D) zona reticularis of adrenal cortex of a rat from group 5 (9 p.m. - 12 midnight). Mayer's hematoxylin. Objective 90, ocular 10.

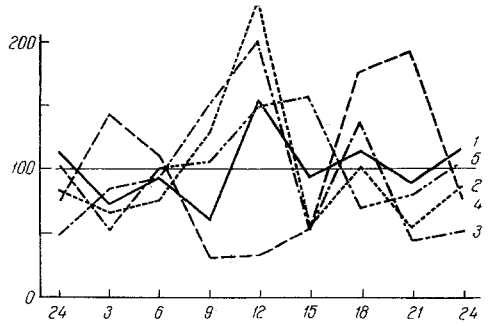

Fig. 2. Diurnal changes in intensity of protein metabolism and mitotic activity of cells in different zones of the adrenal cortex. 1) Level of incorporation of methionine-S^{35} into zona glomerulosa; 2) into zona fasciculata; 3) into zona reticularis; 4) mitotic activity of cells in zona glomerulosa; 5) in outer portion of zona fasciculata. Abscissa) time of day; ordinate) changes in indices (in %) relative to mean level for the 24 h period taken as 100.

in the zona fasciculata 231%, and in the zona reticularis 200%. Hence, protein synthesis in the adrenal cortex follows a distinctly rhythmic pattern. In their most general features these results are in agreement with published data [2] indicating that protein synthesis follows a cyclic pattern in glandular cells and in neurons.

Data for the diurnal changes in mitotic activity of the cortical cells are given in the table. In the zona glomerulosa maximal values of the mitotic coefficient (MC) are found at between 3 and 6 a.m. and minimal values between 9 a.m. and 12 noon. Conversely, in the outer portion of the zona fasciculata the MC reaches its maximum at between 12 noon and 3 p.m. These results, indicating the unsynchronized diurnal rhythm of mitotic activity of the cells in different zones of the adrenal cortex are in agreement with published data [3]. Hence, in contrast to diurnal changes in protein metabolism, which follow a parallel course in the different zones of the adrenal cortex, the changes in mitotic activity of the cells in the zona glomerulosa and zona fasciculata are not synchronized. On the basis of these data there are no grounds for considering that any definite connection exists in the organ between diurnal changes in metabolism of sulfur-containing protein, on the one hand, and mitotic activity on the other.

These rhythmic changes in metabolic processes in the adrenal cortex are evidently based on integrative influences of the organism as a whole, ultimately determining the cyclic changes in functional activity of the different zones of this organ. In this connection it is interesting to note that the synthesis of sulfur-containing proteins in the adrenal cortex reaches its maximum at a time of minimal general activity of rats, when the corticosterone concentration in their peripheral blood is low [14, 18]. Further investigations are needed to elucidate the precise correlating mechanisms taking part in the coordination of individual metabolic processes.

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