Screening one leg caused a considerable increase in survival rate in the mice of both groups. The question arises: Does the level of colony formation remain relatively low with an increase in survival in the radioresistant mice in accordance with their nature, or do the relations between survival rate and colony formation change under these conditions?

The experiments showed that the number of colonies reached high values not only in noninbred mice (Fig. 1A), but also in the inbred mice (Fig. 1B), in which a substantial gap was observed under other conditions between survival and colony formation. In the inbred radioresistant mice, protected by screening, correlation between survival and splenic colony formation was thus just the same as in noninbred radiosensitive mice.

These results are evidence that colony formation does not always correspond to the survival rate of mice and that the relation between these phenomena may depend on different causes and, in particular, on specific features of the change in resistance.

LITERATURE CITED

1. N. L. Aizina, V. G. Ovakimov, and S. P. Yaromenko, Radiobiologiya, No. 6, 929 (1973).
2. N. F. Gronskaya and G. S. Strelin, Radiobiologiya, No. 2, 259 (1980).
3. A. G. Konoplyannikov, in: Radiation and the Organism [in Russian], Obninsk (1973), p. 12.
4. A. G. Konoplyannikov and R. L. Maslennikova, Radiobiologiya, No. 4, 515 (1977).
5. O. A. Konoplyannikova and A. G. Konoplyannikov, Radiobiologiya, No. 1, 35 (1980).
6. R. V. Petrov and R. M. Khaitov, Radiobiologiya, No. 1, 69 (1972).
7. J. E. Till and E. A. McCulloch, Ann. N. Y. Acad. Sci., 114, 115 (1964).
8. G. E. Hanks and E. J. Ainsworth, Radiat. Res., 32, 367 (1964).

MORPHOLOGICAL CHARACTERISTICS OF STEROID-PRODUCING GLANDS IN ALIMENTARY OBESITY

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Alimentary obesity is frequently the cause of a decrease or total loss of working capacity during productive years, and it may also lead to shortening of the life span [5]. The powers of adaptation of obese patients are depressed, and this is particularly clear in stress situations when all the defensive mechanisms of the body are mobilized.

Effectiveness of prophylaxis and treatment of obesity depends primarily on knowledge of the pathogenesis of the disease. Although hormonal and metabolic changes during prolonged excessive intake of energy-producing substances have been studied sufficiently well by biochemical methods of investigation, the morphological features of organs controlling metabolism have virtually not been studied at all in obesity. This applies in particular to the endocrine glands producing steroid hormones, the essential role of which in the pathogenesis of disease has frequently been demonstrated [3, 7-10].

In the investigation described below morphological criteria were used to study the character of function of steroid-producing structures of the adrenal glands and ovaries in animals with alimentary obesity.

EXPERIMENTAL METHOD

The model developed by a team of workers directed by Academician of the Academy of Medical Sciences of the USSR V. G. Baranov [2] was suitable for the purposes of the investigation.

The experiments were carried out in the spring and summer on 60 male Wistar albino rats weighing initially 60-70 g. Control animals were kept on the ordinary laboratory diet. The experiment lasted 5 months. Material was taken every 4 days 1.5 months after the beginning of feeding, so that the effect of the increase in body weight on the morphological and functional state of the test organs, depending on the duration of the disease, was being taken into account.

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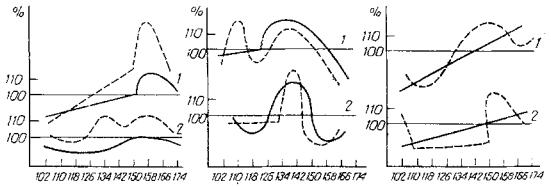

Fig. 1 Fig. 2 Fig. 3

Fig. 1. Trend of changes in size of adrenocorticocytes in zona fasciculata. 1) Dimensions of cytoplasm, 2) of nucleus. Here and in Figs. 2 and 3 continuous line represents control; broken line, experiment.

Fig. 2. Trend of changes in enzyme concentration in adrenocorticocytes of zona fasciculata. 1) G6PDH content, 2) 3β-HSDH concentration.

Fig. 3. Trend of changes in enzyme content in glandulocyte of ovaries. 1) NADPH-DH content, 2) G6PDH content.

The adrenals and ovaries were studied by means of a group of criteria of qualitative and quantitative analysis: histological, histochemical, morphometric, and enzyme-histochemical.

Paraffin sections were stained with hematoxylin and eosin, by the PAS reaction by McManus' method, the Feulgen reaction, and with gallocyanin and chrome alum by Einarson's method. An optical projection method was used for the morphometric investigation. Reactions for lipids and key oxidation–reduction enzymes of specific and energy metabolism in the adrenocorticocytes of the adrenal glands and in the glandulocytes of the ovaries – lactate dehydrogenase (LDH EC 1.1.1.27), glucose-6-phosphate dehydrogenase (G6PDH; EC 1.1.1.49), reduced NAD dehydrogenase (NADH-DH; EC 1.6.99.3); reduced NADP dehydrogenase (NADP dehydrogenase (NADPH-DH; EC 1.6.99.1), and 3β-hydroxysteroid dehydrogenase (3β-HSDH; EC 1.1.1.51)– were carried out on unfixed sections.

Comparative quantitative estimation of changes in the concentrations of enzymes and lipids were carried out by the plug method on a cytospectrophotometer with FMEL-1 optical attachment. Measurements were made at the wavelength according to Avtandilov's table [1].

Numerical results were subjected to statistical analysis by the nonparametric method of calculating the sliding mean, using the Wilcoxon–Mann–Whitney U test [4].

EXPERIMENTAL RESULTS

Comparison of the results revealed changes of a unique type in the structures producing steroid hormones. The greatest changes during progressive obesity were found in the adrenal cortex. Evidence of a moderate increase in activity of the adrenocorticocytes of the zona glomerulosa and zona reticularis was not always clearly visible and did not always correlate, so that these changes could not be regarded as regular deviations of the mineralocorticoids and androgenic functions of the adrenals during progressive obesity.

In the zona fasiculata of the obese animals signs of hyperfunction of the adrenocorticocytes were regular and interdependent, as shown by the following evidence: The dimensions of the hormone-producing cells in this zone exceeded the control level ($P < 0.001$) throughout the experiment (Fig. 1).

The content of enzymes participating in steroid production was increased ($P < 0.05$), especially on the 98th-118th days of life, on account of an additional increase in G6PDH activity and preservation of the unchanged content of 3β-HSDH, whereas in the control animals these parameters were reduced in value (Fig. 2).

An interesting phenomenon was noted. Whereas in the control animals the pattern of activity of the adrenocarticocytes, as reflected in enzyme histochemical indices, showed a uniform alternation between periods of increase and decrease enzyme activity, in the obese animals this pattern was disturbed on account of an additional rise in the G6PDH content toward the 110th day of life, maintenance of a stable content of 3β-HSDH on the 98th-128th days of life, and a maximal increase of reduced duration in the G6PDH and 3β-HSDH content toward the 138th day of life (Fig. 2).

The principal load on restoration of the disturbed balance between steroid hormones in obese subjects, revealed previously by biochemical methods, thus falls in male rats on the zona fasiculata, where glucocorticoid hormones are produced. The cortex not only functions with increased activity, but it is also marked by a disturbance of the rhythm of changes in the parameters of steroid production by the adrenocorticocytes characteristic of this zone in ontogeny.

The function of the ovarian glandulocytes was studied by the use of similar criteria, for the cells of these organs have common mechanisms of hormone synthesis. Comparison of the gravimetric, morphometric, and enzyme-histochemical parameters revealed indistinct signs of increased functional activity of the ovarian glandulocytes, which were minimal when expressed numerically, and assessed as changes within normal physiological limits or as a tendency toward hyperfunction. However, the character of the change in the content of certain enzymes in animals with obesity differed from that in the control rats. The trend of the change in the content of G6PDH and NADPH-DH, which participate in steroid production, was shown by a straight line in the control animals, but by a wavy line in the obese animals (Fig. 3). The results indicated changes in the pattern of activity of the glandulocytes characteristic of control animals with the development of obesity.

This combined study thus showed that an increase in body weight through the deposition of fat had an unequal effect on the functions of structures concerned in steroid production. During progressive obesity in male rats it can be stated confidently that there is an increase in the glucocorticoid activity of the adrenal cortex. In other parts of the adrenal cortex (zona glomerulosa, zona reticularis) and in the ovarian glandulocytes, the changes were not so clear in character. The fact that the pattern of activity of the adrenocorticocytes in the zona fasciculata and of the ovarian glandulocytes is modified is particularly interesting.

These structures placed under an increased functional load may be more sensitive to additional factors owing to a disturbance of the steroid balance in the body. Clinical confirmation of this hypothesis is given by the increased anesthesiologic risk of obese subjects and the greater frequency of complications in them under the influence of stress factors [6].

LITERATURE CITED

1. G. G. Avtandilov, Morphometry in Pathology [in Russian], Moscow (1973).
2. V. G. Baranov, D. S. Tendler, and I. A. Fashchevskaya, Probl. Endokrinol., No. 2, 108 (1977).
3. E. A. Vasyukov and A. M. Granovskaya-Tsvetkova, Klin. Med., No. 4, 124 (1977).
4. E. V. Gubler and A. A. Genkin, The Use of Nonparametric Statistical Criteria in Medico-Biological Research [in Russian], Leningrad (1973).
5. M. A. Samsonov and E. A. Beyul, Klin. Med., No. 4, 9 (1979).
6. L. Ya. Shurygin, P. O. Vyazitskii, and K. A. Sidorov, Obesity [in Russian], Leningrad (1980).
7. E. V. Epshtein, Vrach. Delo, No. 2, 60 (1978).
8. E. Cacciari, A. Cicognani, P. Pirazzoli, et al., J. Clin. Endocrinol., 40, 802 (1975).
9. L. Herberg and D. L. Coleman, Metabolism, 26, 59 (1977).
10. M. O'Connell, E. J. Danforth, and E. S. Horton, J. Clin. Endocrinol., 36, 323 (1973).