PATHOMORPHOLOGY OF THE KIDNEYS IN RATS AFTER PROLONGED INGESTION OF IRRADIATED FOODS

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Structural changes of membranous-proliferative glomerulonephritis type, possible autoimmune in character, were shown to develop in the kidneys of rats fed for a long time with food irradiated with γ rays. The severity of the disturbances depends on the dose of irradiation of the foods.

KEY WORDS: kidney; effect of irradiated food; γ rays.

In many countries nowadays certain foodstuffs are irradiated with γ rays to lengthen their storage life. Conflicting views have developed regarding the consequences of this method of preservation. In particular, some workers consider that the prolonged ingestion of food consisting even in part of irradiated products can lead to definite functional and structural disturbances [2-6, 12-18].

The object of this investigation was a morphological study of various organs and tissues of noninbred albino rats fed for 20 months solely on irradiated food, in order to obtain a clearer idea of the after-effects of feeding with irradiated foodstuffs.

EXPERIMENTAL METHOD

Experiments were carried out on 240 rats of both sexes used at the age of 1 month. The animals were divided into four groups, with 30 males and 30 females in each group, and were kept on the ordinary animal house diet, as drawn up for research institutes by decree of the Ministry of Health of the USSR dated March 10, 1966. The animals of group 1 received food irradiated on the K-300 γ ray apparatus in doses 10 times higher than the optimal doses for preservation (0.25-5.6 Mrad). The rats of group 2 received food irradiated in optimal doses (25-500 rad) and those of group 3 received food irradiated in doses of one tenth the optimal level (2.5-56 krad). The animals of group 4 (control) were kept on a natural diet. The progeny of these rats (240) ate irradiated foods for a correspondingly shorter time (14 months) than their parents. At the end of the experiment all the animals (306) were decapitated for pathological examination. The kidneys were fixed in 10% neutral formalin solution and paraffin sections were stained with hematoxylin–eosin, picrofuchsin, and Schiff's reagent with amylase control. In sections cut on a freezing microtome the distribution of lipids was determined by staining with Scharlach red, and acid and alkaline phosphatase activity was determined by the azo-coupling method. By means of a special grid [1] the number of glomeruli per field of vision and the number of nuclei in the glomeruli were counted; the ratio between the area of a renal corpuscle and glomerulus was determined, and by means of an ocular micrometer the thickness of the membranes of the glomerular capillaries and layers of the capsule was measured. The results were subjected to statistical analysis.

EXPERIMENTAL RESULTS

In all the experimental animals regardless of the type of food the kidneys were flabby in consistency and slightly livid in color compared with those of the control rats. Microscopic investigation showed irregular thickening and loosening of the fibers of the basement membranes of the capillaries and of both layers of the capsule of the glomeruli on account of the accumulation of PAS-positive substances (1 μ in the control, 5-10 μ in the experiment), an increase in the number of nuclei in the glomeruli, the presence of serous fluid in the lumen of the capsule, and a shift in the ratio between the area of the renal corpuscle and the glomerulus (Fig. 1A).

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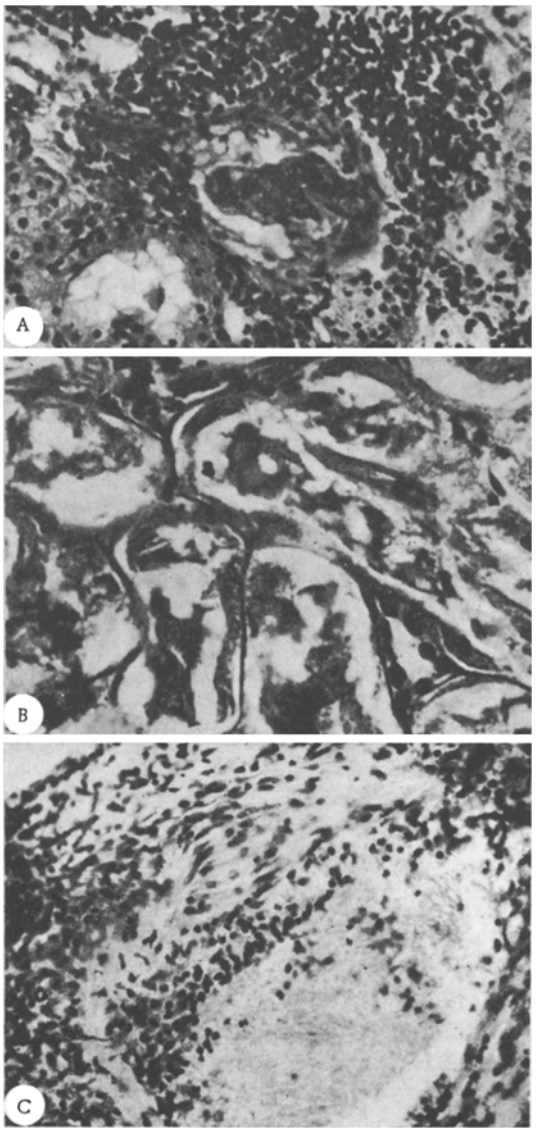

Fig. 1. Kidneys of rat after prolonged ingestion of foods irradiated in doses of 25-500 krad (group 2). A) Membranous-proliferative glomerulitis, infiltration of stroma with lymphocytes and histiocytes, cloudy swelling and intracellular edema of epithelium of convoluted tubules. Hematoxylin–eosin, 140 ×; B) necrosis and necrobiotic changes in epithelium of convoluted tubules. Hematoxylin, 280×; C) fibrinoid necrosis of arterial wall in zone of infiltration by lymphocytes, histiocytes, and eosinophils. Hematoxylin–eosin, 140×.

In the convoluted and straight tubules marked degenerative changes were found in the epithelium with thickening of the basement membranes; in the proximal portions of the tubules cloudy swelling was the predominant change, whereas in the distal portions it was intracellular edema combined with severe necrobiotic disturbances and death of the epithelium (Fig. 1B). In the straight tubules signs of cloudy swelling and fatty degeneration, with tiny intracellular lipid droplets, desquamation of the epithelium, the presence of hyaline casts, and tiny particles of lime in the cytoplasm of the epithelium with the formation of calcified casts were observed. The interstitial tissue was always infiltrated by lymphocytes and histiocytes, together with a few eosinophils and

neutrophils, the collagen fibers were coarser and more numerous, the content of PAS-positive materials in the ground substance was increased, the thickness of the walls of the small arteries was increased on account of permeation with PAS-positive materials, and alkaline phosphatase activity was increased.

However, the severity of these changes was directly dependent on the dose of irradiation of the food products. For instance, in animals eating food irradiated in a dose of 0.25-5.6 Mrad the severest degenerative and necrobiotic changes were observed, and the number of cells in the glomeruli was sharply increased. Sclerosis of the stroma was more marked, and for that reason the number of glomeruli per field of vision was reduced compared with the control to a statistically significant degree. Vessels of the juxtamedullary zone (Fig. 1C) showed changes of the periarteritis nodosa type. In animals consuming food irradiated in a dose of 2.5-560 krad, the sclerotic changes developed more slowly, the response was mainly cellular with, in particular, infiltration by eosinophils, and small interstitial hemorrhages were observed. The number of glomeruli per field of vision in these rats was increased ($P < 0.05$).

Investigation of the kidneys of the offspring of the rats showed similar changes with the same dependence of their severity on the dose of irradiation of the foodstuffs. The only difference was that the structural changes in the testes were less marked in the progeny than in their parents. For example, in the animals of group 1 the thickness of the basement membrane reached 10 μ, but only 6 μ in their offspring, and severe necrobiotic changes of the epithelial cells of the convoluted tubules were hardly observed.

Prolonged feeding with irradiated food thus causes changes of the membranous-proliferative glomerulitis type in the kidneys, with infiltration of the interstitial tissue with lymphocytes, histiocytes, and eosinophils, accumulation of PAS-positive substances in the mesangium, capillary membranes, and walls of the blood vessels, and with cloudy swelling of the tubular epithelium. Morphological changes of this type are known to be characteristic of autoimmune processes in the kidneys [8-11]. Furthermore, the work of Kuzin [7] and his collaborators has shown that substances (radiotoxins) formed in irradiated cells and tissues can simulate the action of radiation, including the development of postradiation sterility. It can therefore be suggested that these elements of the irradiated foods form antigenic complexes with the body proteins, which react with the corresponding antibodies on the basement membranes of the renal glomeruli; the results of the observations showed, moreover, that in this case the reaction between autoantigen and autoantibody can also develop in other organs, notably the testes.

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