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EFFECT OF GALVANIC CURRENT AND X-RAY-IRRADIATION ON THE TISSUE REACTION OF THYMUS

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We observed in earlier experiments that the tissue reaction of the thymus gland was uniform howewer different stimuli had elicited it [1, 2, 3, 4, 5, 7, 9, 10, 11, 12]. The thymus of tumorous, pregnant and tuberculous rats showed characteristic changes which, depending on the gravity or stage of the causative process were a contraction of the epithelial reticulum, the accumulation of epithelial cells, epithelial cysts containing a PAS positive substance; simultaneously, mast cells appeared. — These phenomena were always observed in experiments where processes of tissue proliferation were taking place in the organism, where the normal harmony and normal structure of the tissues seemed to be disturbed. Such observations led us to assume a correlation between tissue proliferation and the described reaction of the thymus. The problem nevertheless seemed unsolved considering that stressor stimuli elicited quite similar although weaker responses.

The present experiments, in which the effect of galvanic current eliciting intensive stress and X-ray irradiation destroying part of the tissues was studied, were aimed at settling the above problem.

Method

We used 44 rats of the Wistar strain, weighing about 200 g each. They were divided into 3 groups.

(i) *First group.* 10 animals were treated once with galvanic current of 2 mA for 4.5 minutes. One pole was a wet metal plate forming the floor of the cage and being thus in connection with the paws of the animals. The other pole was a bent lead plate applied to the wet tail of the animals.

(ii) *Second group.* 12 animals were irradiated with 200 r of X-rays (Siemens "Stabilivolt" apparatus; 180 Kv; 6 ma; 2.5 mm aluminium filtre; 50 cm target distance) in a cage with a 5 mm thick plexiglass cover. Irradiation lasted 4½ min.

(iii) *Third group.* 22 animals were treated with both galvanic current and irradiation.

Thymus and spleen were taken out 24 to 27 hours after treatment, fixed in Carnoy's fluid, embedded in paraffin, sectioned at two levels 2 mm apart and stained with PAS, Giemsa and toluidine blue.

Results

(i) *Galvanic current*

The thymus revealed no gross changes. Its average weight was 199 mg, about 10 to 20 per cent less than in untreated animals of the same body weight. Of the 10 specimens, in 5 there were marked signs of excitation under the microscope. Slight signs of incipient evacuation were observed especially in the marginal lobes. An increased number of mast cells was seen especially in the capsule and the cortex of the marginal lobes. Some of the lobes underwent complete mast cell transformation (Figs. 1, 2), a phenomenon to be interpreted as an intensive mast-cell reaction. In one case there was a cyst formed of columnar epithelium and filled with PAS-positive substance.

(ii) *X-ray irradiation*

The weight of the thymus was considerably reduced, on the average to 108.2 mg, which is not even half the weight recorded in the untreated controls. Under the microscope, the thymus seemed to be completely loosened up so that in some parts its normal structure was almost unrecognizable. A remarkable feature was the advanced evacuation. There were occasional cysts but these were smaller than that observed in the first group, nor did they contain as much PAS-positive substance. The number of mast cells was increased but they were in a state of degeneration especially in the connective tissue; there were many vacuolated and hypergranulated forms, most of which had disintegrated into granules.

(iii) *Combined treatment with galvanic current and X-rays*

The weight of the thymus was considerably below normal, 105 mg on the average. Under the microscope the tissues seemed more or less intact, the structure characteristic, the cortex well distinguishable from the medulla. Seven out of the 22 specimens contained cysts made up of a layer of columnar epithelium and filled with PAS-positive substance. The number of mast cells was increased (Fig. 3). Most of them were found beneath the capsule and seemed to be unimpaired; there were only a few disintegrated forms.

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We examined also the spleen of the animals in all the three groups. This organ was generally poorer in cells than the spleen of untreated animals: we were, however, unable to establish any connection between this phenomenon and the evacuation of the thymus. No abnormal increase in the number of mast cells was observable in the spleen.

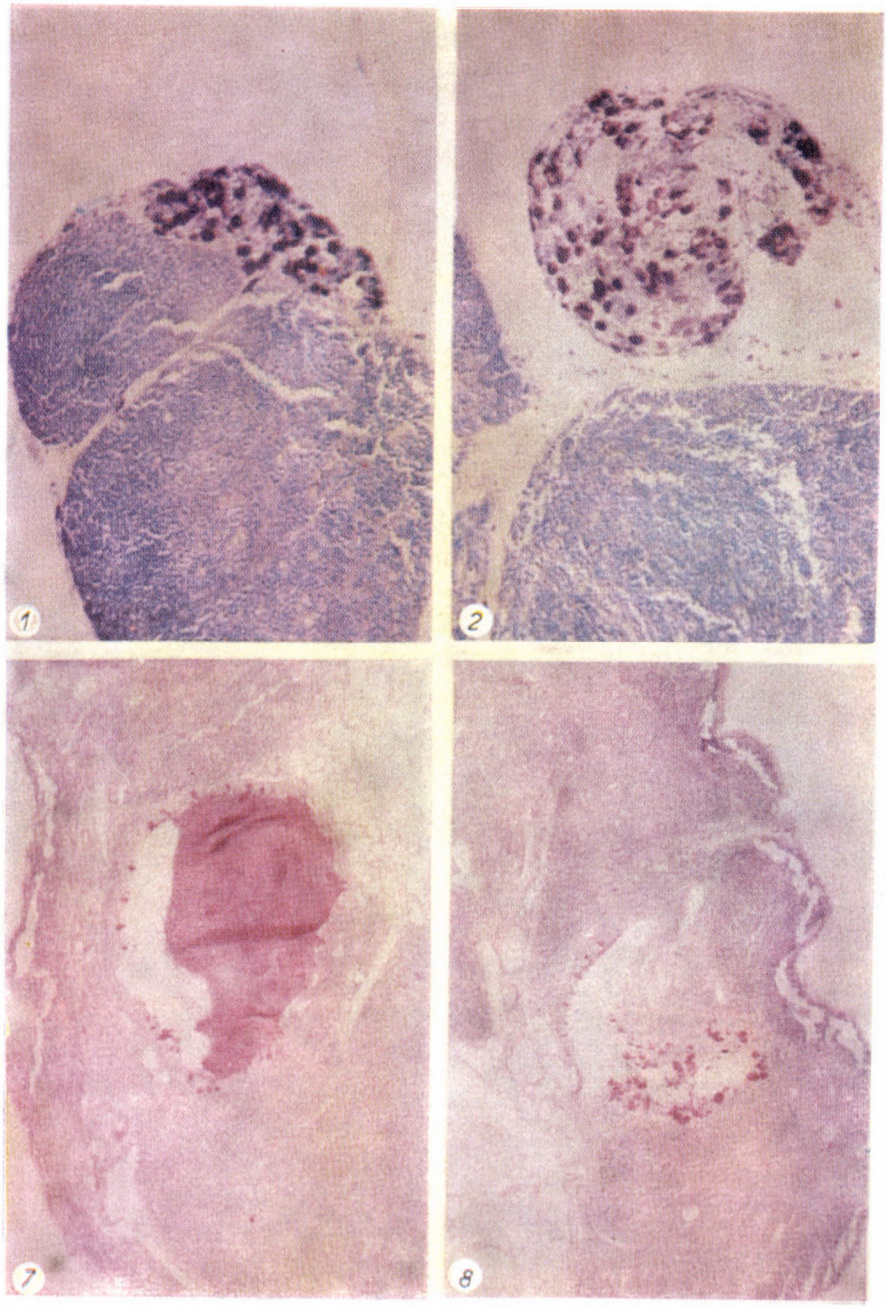

Fig. 1. Section of thymus from animal treated with galvanic current. The marginal portion of the lobe has completely transformed into mast cells. Toluidine blue, ×60

Fig. 2. Section of thymus removed from an animal treated with galvanic current. Complete transformation of a thymus lobe into mast cells. Toluidine blue, ×60

Figs. 7—8. Two sections of the same cyst, 2 mm apart. PAS, ×60

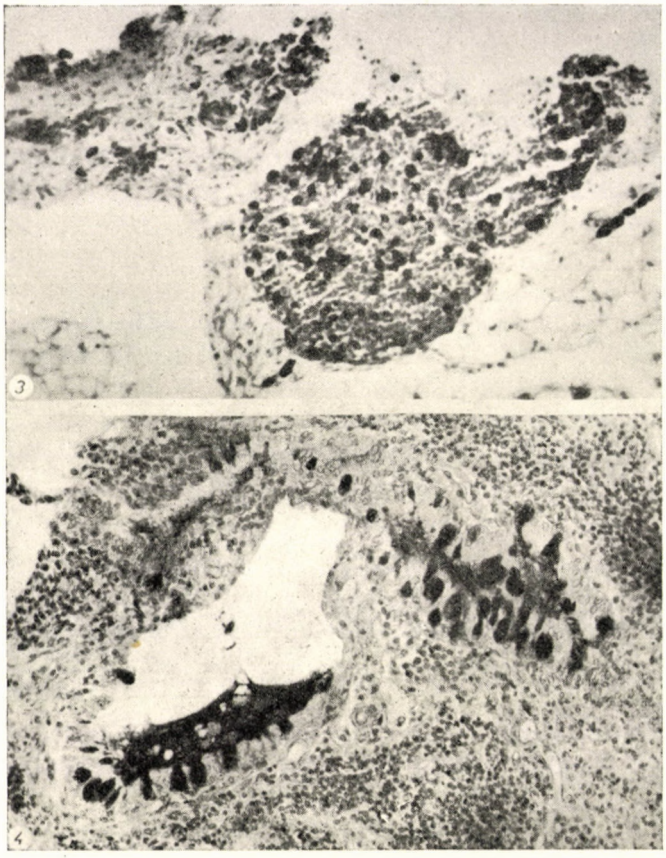

Fig. 3. Section of thymus removed from animal treated with galvanic current and X-rays. Complete transformation of a marginal lobe into mast cells. Toluidine blue, ×60

Fig. 4. A presumably incipient cyst in the thymus of an animal treated with galvanic current and X-rays. Cylindrical cells and their PAS-positive secretion well visible in the right upper corner. A complete cyst with goblet cells, somewhat to the left. PAS, ×60

Discussion

The chief effect of galvanic current in our experiments was an increase in the number of mast cells in the thymus. Entire lobes were seen to have undergone mast cell transformation (Figs. 1, 2, 3). An interpretation of this phenomenon — one which is in good agreement with the results of our experiments now in progress — would be that the galvanic current releases the process of mast-cell formation; since the tissues are not seriously damaged, there is no stimulus to cause a migration "en masse" of the mast cells which, thus, remain in the thymus. This would be the way how galvanic current is responsible for the accumulation of mast cells in the thymus, and it is for this

reason that treatment with galvanic current is a most suitable method for observing the transformation of thymocytes into mast cells.

X-ray irradiation is a much rougher intervention which causes marked destruction of the tissues not merely on the periphery but also in the central parts. In addition to being newly formed, the mast cells become engorged with metachromatic matter, and most of them show signs of disintegration. This phenomenon may have two reasons. Either the whole of the thymus has suffered grave damage or else the X-rays are responsible for the transformation: increased amounts of heparin are taken up by the cells in excess so that they are transformed into mast cells and disintegrate into granules. A similar phenomenon produced by X-rays was described by SMITH and LEWIS [8]. Further experiments will have to elucidate this question. What our observations in all three groups seem to prove beyond doubt is that the effect of the above factors on the thymus is to transform the thymocytes into mast cells.

The evidence of these observations makes it possible to follow the formation of cysts. There are several among our sections which show quite clearly that the PAS-positive substance is secreted by the thymic epithelium; accumulated, this substance pushes apart the cells of the reticulum so that cysts are produced (Fig. 4). A comparison of a series of sections makes it apparent that the PAS-positive matter is stored by the cells only for some time and is then eliminated. Structures resembling goblet cells are observable among the epithelial cells in several cysts; these structures have a basally situated nucleus, their apex is filled with PAS-positive substance which seems to be in direct contact with the content of the cyst (Fig. 5). The impression one gains from these pictures is that the cells are just emptying their PAS-positive contents into the cyst. Our results substantiate those of DIDERHOLM and HELLMANN [6] obtained by means of autoradiography, although we want to emphasize that the substance contained in the cysts has not proved to be metachromatic either in the present or in any of our earlier experiments. We are nevertheless convinced that the PAS-positive substance is actively secreted (Fig. 6). The cysts are fairly large. The fact that two sections in Figs. 7 and 8, made of the same thymus at two different levels 2 mm apart, show the same cyst, proves that at least one diameter of this cyst must have been 2 mm long. The number of cysts was highest in Group 3 (combined treatment). The experiments afforded no clue to show why this was so.

The above-described experimental results justify the claim that the uniform tissue reaction characteristic of the thymus appears not only in processes involving a tissue disharmony, but arises under the influence of stress-like stimuli as well, although not all components of the reaction are present and its intensity shows quantitative variations in such cases. Tissue proliferation is undoubtedly the strongest and most usual stimulus to elicit the complete reaction.

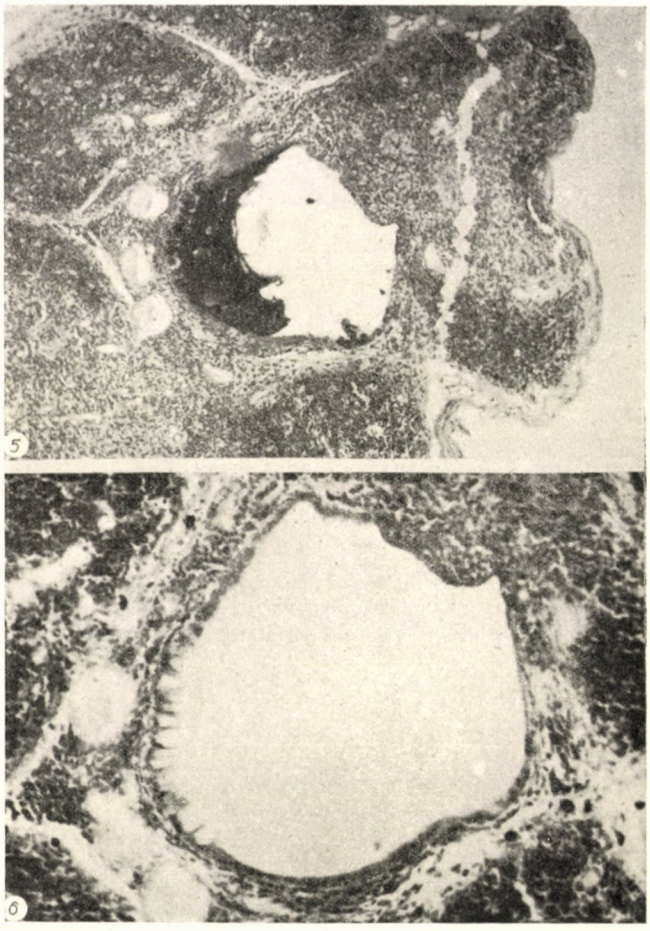

Fig. 5. Complete thymus cyst containing PAS-positive substance, from an animal treated with galvanic current and X-rays. Close connection between goblet cells and cyst. PAS, ×60

Fig. 6. Same cyst as in Fig. 5 under high power. No toluidine metachromasia. Row of goblet cells visible. Toluidine blue, ×60

Summary

The effect of galvanic current, X-ray irradiation, and the combined effect of both, on the thymus of rats were studied. Such stimuli elicit the well-known characteristic reaction of the thymus. The tissue reaction consists of various components which are more or less pronounced according to the nature and intensity of the stimulus. Even the combined application of a galvanic current and X-rays failed to elicit a tissue reaction as marked as is encountered in cases with intensive tissue proliferation.

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ДЕЙСТВИЕ ГАЛЬВАНИЧЕСКОГО ТОКА И РЕНТГЕНОВСКОГО ОБЛУЧЕНИЯ НА ТКАНЕВУЮ РЕАКЦИЮ ЗОБНОЙ ЖЕЛЕЗЫ

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Авторы исследовали на зобной железе крыс действие гальванического тока, рентгеновского облучения и одновременного применения этих двух способов воздействия. Описанные воздействия обусловливают уже раньше описанные авторами типичные реакции зобной железы. В зависимости от качества и от силы воздействия различные компоненты тканевой реакции в различной степены выражены. Совместным применением гальванического тока и рентгеновского облучения также не удалось вызвать сильной тканевой реакции, наблюдаемой в состояниях с значительным разрастанием тканей.

DIE WIRKUNG VON GALVANISCHEM STROM UND RÖNTGENBESTRAHLUNG AUF DIE GEWEBSREAKTIONEN DES THYMUS

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Die Wirkung von Galvanstrom, Röntgenbestrahlung und der gleichzeitigen Anwendung dieser beiden Behandlungen am Rattenthymus wurde untersucht. Die Einwirkungen lösten die von den Verfassern bereits früher beschriebene charakteristische Reaktion des Thymus aus. Die verschiedenen Komponente der Gewebsreaktionen waren in Abhängigkeit von der Art und Stärke der Einwirkung in verschiedenem Maße ausgeprägt. Auch bei gleichzeitiger Anwendung von Galvanstrom und Röntgenbestrahlung gelang es keine so intensive Gewebsreaktion hervorzurufen, wie dies bei den mit starker Gewebswucherung einhergehenden Zuständen beobachtet wird.

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