MORPHOLOGICAL AND FUNCTIONAL STATE OF THE THYMUS AND LYMPHATIC SYSTEM DURING DEVELOPMENT OF ADAPTIVE REACTIONS TO ELECTRICAL STIMULATION OF EMOTIOGENIC BRAIN STRUCTURES

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Mental stress, and negative emotions forming physicoemotional stress, lead to disturbances of the immune status or even to the formation of immunodeficiency states [4]. A characteristic feature of stress is hypoplasia of lymphoid tissue of the thymus and lymph nodes. Besides stress, the general nonspecific adaptive response (GNAR) to any extremal or strong stimuli, the GNAR to various stimuli of physiological parameters, namely weak, or threshold strength — the training reaction [2, 3], and stimuli of average strength — and the activation reaction [1], differing qualitatively from stress, have been described. During the training reaction moderate functional activity is observed in the thymus and lymphatic system (TLS), and the architectonics of the structures of TLS corresponds to the pattern given in textbooks of histology, whereas in the activation reactions, there is high functional activity, expressed mainly as hyperplasia of lymphoid tissue [5].

The aim of this investigation was to study the possibility of inducing different kinds of GNAR by electrical stimulation of emotiogenic structures of the brain, to discover how the type of induced GNAR depends on the character of the brain emotiogenic structures stimulated (positive or negative), and to discover the features distinguishing the morphological and functional state of the TLS during these procedures.

EXPERIMENTAL METHOD

Experiments were carried out on noninbred male albino rats weighing 250-300 g. Bipolar stimulating electrodes were inserted into deep brain structures 10 days before the experiment under general anesthesia (ether), using stereotaxic coordinates taken from Krieg's atlas: in one group into a "positive" emotiogenic structure, namely the nucleus lateralis septi (LS), in the other group, into the "negative" globus pallidus (GP) [8, 11]. Animals of the experimental and control groups were kept throughout the experiment in the animal house under crowded conditions, which acted as a stress factor. Stimulation was applied daily for 2 months with a pulsed current (2 pulses/sec, 0.3 mA, duration 10 sec). Throughout the experiments the character of GNAR was judged by the specially calculated leukocytic formula [2, 12]. Blood was taken from the femoral vein. At the end of the experiment the animals were decapitated, organs of the TLS and brain were taken for morphological investigation, and the location of the electrodes was verified. Sections through organs of the TLS were stained by Brachet's method in Simakova's modification [6].

TABLE 1. Representation of GNAR (in %) During 2 Months of Stimulation

Adaptive reaction	Experimental conditions			p_{1-2}	p_{1-3}	p_{2-3}
	control (1)	LS (2)	GP (3)			
Training	26±4	11±8	38±21	>0,05	>0,05	<0,05
Activation	26±4	83±3	54±21	<0,001	<0,05	<0,05
Stress	47±4	6±6	8±10	<0,001	<0,001	>0,05

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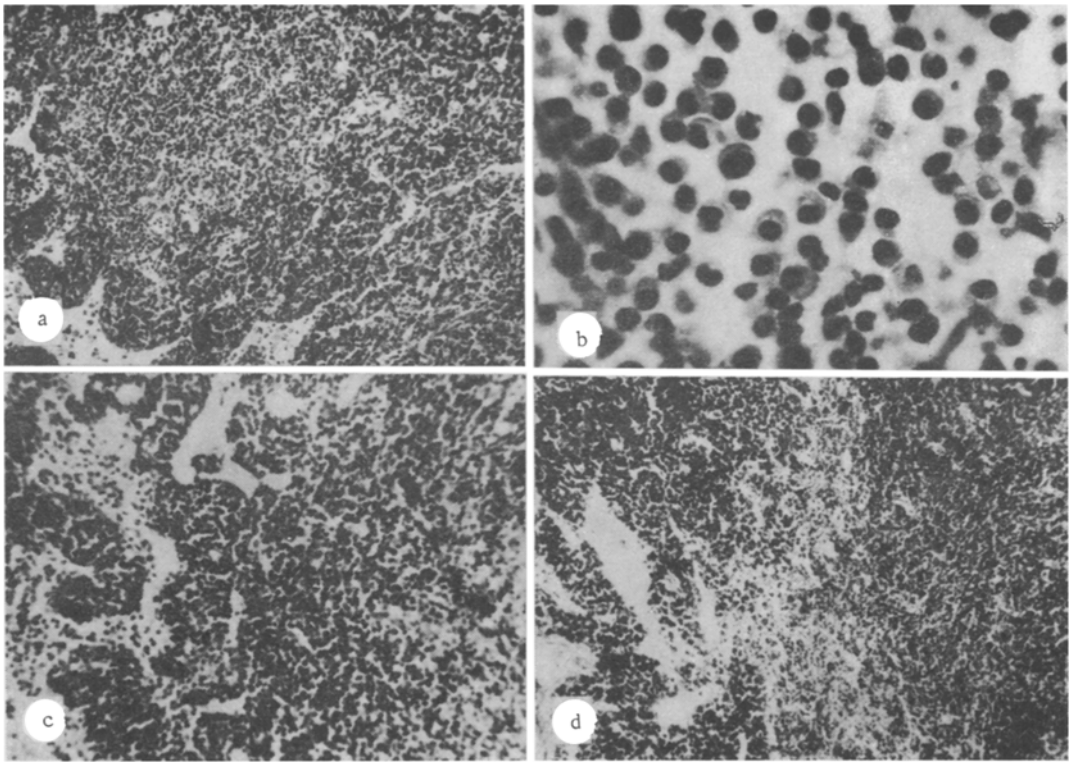

Fig. 1. Hyperplasia of lymphoid tissue in lymph nodes of control rats (c) and of rats after electrical stimulation of "positive" (a, b) and "negative" (d) emotiogenic zones. a) Most intensive hyperplasia of lymphoid tissue, considerable widening of cortex, almost complete fusion of thickened medullary cords. 56 ×; b) Plasmatization of medullary cords. Methyl green—pyronine. 280 ×.

EXPERIMENTAL RESULTS

The experimental results showed that irrespective of the initial GNAR (training, activation, stress) the leukocyte formula of all animals 24 h before the first stimulation of LS showed an activation reaction, whereas 24 h after stimulation of GP, a training reaction also was recorded in all the animals. Meanwhile all three reactions were represented in the control in about the same proportions as in the experimental groups before the beginning of stimulation. The uniformity of the responses in the experimental groups was observed only after the first electrical stimulation. During daily stimulation for 2 months, alternation of different GNAR was observed. However, activation reactions were represented differently in animals of the experimental groups compared with the control. The percentage of activation reactions in electrically stimulated animals was significantly higher than in the control. Conversely, the percentage of cases of stress was very small compared with the control, in which this parameter was about half of the total number. In addition, differences also were observed between the experimental groups. Comparison of the experimental groups showed that animals receiving electrical stimulation of LS were mainly in an activation reaction, whereas animals receiving electrical stimulation of GP had a higher percentage of training reactions (Table 1).

During the activation reaction evoked by electrical stimulation of GP and LS, hyperplasia of the lymphoid structures in TLS, characteristic of this reaction, was observed (Fig. 1). However, microscopic study of the lymphoid organs revealed some distinguishing features characteristic of each of the groups investigated. In the thymus, for instance, after stimulation of GP most of the lobules were enlarged, and the cortex was larger than the medulla. In the lymph nodes and spleen the number of follicles was increased, a moderate number of immature lymphocytes and mitotically dividing blast cells was observed in the pale centers, and some follicles in the cortex and medullary cords (in the medulla) were fused into a continuous mass, consisting mainly of mature (small) lymphocytes. In animals also in the activation reaction, but after stimulation of LS, the morphological parameters of high

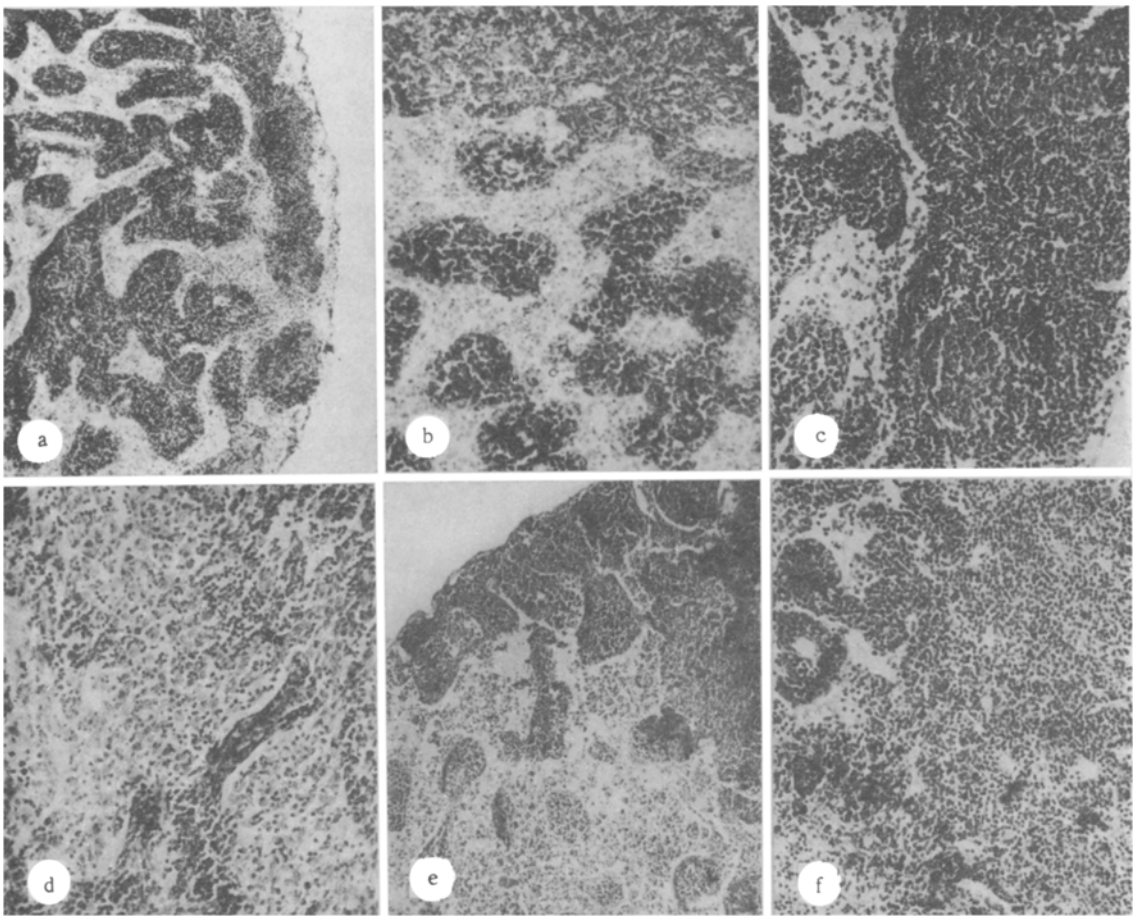

Fig. 2. Training (a-c) and stress (d-f) reactions. a, b) Distinct architectonics of cortex and medulla of lymph nodes of control animals (a) and of groups receiving electrical stimulation of "negative" zones (b), clear separation of medullary cords by intermediate sinuses; c) enlargement of follicles, of their pale centers and outer layers, fusion of some follicles, focal widening of the paracortical zone, thickening of medullary cords in lymph nodes of animals receiving electrical stimulation of "positive" zones; d) considerable hypoplasia of lymphoid tissue in lymph nodes of rats of control group; e) weaker degree of hypoplasia in rats receiving electrical stimulation of "negative" zones; f) weakest degree of hypoplasia in rats with electrical stimulation of "positive" zones (methyl green–pyronine). Magnification: a, e) 40; c, d, f) 56.

functional activity of these organs were more marked than after stimulation of GP and in the control. The hypertrophied cortex insinuated itself in bands into the medulla, which also was infiltrated by lymphocytes. The number of blast cells and mitotic figures was considerable in the cortical zones of the thymus lobules, the numerous centers of the lymph node follicles, and the white pump of the spleen. Fused medullary cords in the lymph nodes formed extensive conglomerates of lymphoid tissue with areas of plasmatization (Fig. 1a, b). The pyroninophilic reticulo-endothelial and endothelial structures were hypertrophied.

During the training reaction in the course of stimulation of GP and in the control equal proportions of cortical and medullary substance and clear demarcation between them were observed in most thymus lobules even when hypertrophy of some lobules was present; the architectonics in the lymph nodes also was clearly defined (Fig. 2a, b), with clear demarcation between follicles, cortex and medulla, and the narrow intermediate sinuses and medullary cords, consisting mainly of undifferentiated lymphoid cells. In the white pulp of the spleen the follicles and lymphoid sheaths were few in number, mainly small in size, and contained a moderate or small number of mitotically dividing pyroninophilic blast cells, while the lymphoid tissue in the red pulp was represented by a few scattered microcolonies of lymphocytes.

During the training reaction after stimulation of LS, the microscopic picture of the organ was similar as regards certain features to the morphological picture during the activation reaction. This was particularly well marked in the lymph nodes, in some of which there was an increase in the number and size of the follicles with fusion of their outer layers, pyroninophilia and intensive mitotic division of blast cells in the pale centers, focal widening of the paracortical zone, and thickening of the medullary cords (Fig. 2c).

In cases of predominance of stress in animals of the two experimental groups, the features of stress in the organs studied were indistinct, unlike in the control, where marked hypoplasia of the lymphoid tissue was observed. This was particularly characteristic of animals after stimulation of "positive" centers, in which elements of stress included in the spectrum of stressor features (a decrease in size of the thymus lobules and splenic follicles, a decrease in thickness of the cortical zones and medullary bands, and widening of the sinuses in the lymph nodes, focal degeneration of lymphocytes) were combined with features characteristic of the activation reaction: predominance of cortical substance, densely infiltrated with lymphocytes, over the medulla even in the small lobules of the thymus, and preservation of some follicles with pale centers and mitotically dividing cells and also of extensive areas of lymphoid tissue in the cortical plateau of the lymph nodes.

After stimulation of GP, morphological stressor features were found in a rather larger number of animals than after stimulation of LS, but smaller than in the control group, and as a rule they were combined with morphological features of the training reaction.

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