CHANGES IN CATECHOLAMINE LEVELS INDUCED BY IMMOBILIZATION STRESS IN INDIVIDUAL BRAIN NUCLEI OF RATS DIFFERING IN ZOOSOCIAL POSITION

T. I. Belova, R. Kvetnansky, A. V. Kotov,
E. I. Ivanov, M. Dobrakovova, Z. Oprsalova,
A. V. Gorbunova, T. M. Ivanova, and N. V. Petrova

UDC 612.826.5:018:577.175.522].06
:613.863-02:612.766.2].019:316.06

Key words: catecholamines; zoosocial hierarchy; stress; central nervous system.

The considerable individual variability of changes in physiological functions under identical conditions of emotional stress has necessitated the study of the neurochemical mechanisms of resistance of organisms [4]. Research into the possible connection of central regulation of physiological functions during stress with the individual features of animals, such as the level of emotional behavior, and position in the zoosocial hierarchy, assumes great importance.

Our previous investigations showed that neurochemical processes lying at the basis of the central regulation of blood pressure during immobilization stress differ in animals differing in their levels of emotional behavior [2]. In this paper we give data on changes in catecholamine levels in brain nuclei involved in the central regulation of blood pressure, arising under conditions of immobilization stress in rats differing in their positions in the zoosocial hierarchy. This information is a further step forward in our research aimed at elucidating the causes and mechanisms of specific responses of organisms to emotional stress.

EXPERIMENTAL METHOD

Experiments were carried out on male Wistar rats weighing 180-230 g. A multicomponent analysis of the strategy of food-getting behavior and its success under conditions of competition for food was undertaken in chronic experiments on 16 triads of rats. After testing for 1 month and statistical analysis of the parameters of food-getting behavior, the rats in each triad were identified as dominant (D), subdominant (SD), and submissive (S).

Rats of all ranks were subjected to immobilization for 6.5 h by the method in [5]. During immobilization the blood pressure was measured every hour through a catheter inserted into the caudal artery 24 h before immobilization. After the end of immobilization the rats were decapitated and the brain quickly removed and frozen with dry ice. Frozen sections 300 μm thick were cut and, with the aid of special hollow needles [6] the following regions were taken for microbiochemical determination of catecholamines: A_1, A_2, A_6 (locus coeruleus), A_7 (nucleus subcoeruleus), A_9 (substantia nigra), A_{12} (nucleus arcuatus), A_{14} (nucleus periventricularis), and also the lateral hypothalamus and anterior zones of the neocortex. Catecholamine concentrations were determined by highly sensitive radioenzyme assay [8, 7].

Rats of all zoosocial ranks, characterized by a normotensive response of their blood pressure, namely with deviation of arterial pressure during immobilization by not more than 15 mm Hg from the control values — were chosen for catecholamine determination. Rats kept under the same animal house conditions, but with free access to food and not subjected to immobilization were used as the control.

P. K. Anokhin Institute of Normal Physiology, Academy of Medical Sciences of the USSR, Moscow. Institute of Experimental Endocrinology, Physiological Sciences Center, Slovak Academy of Sciences, Bratislava, Czechoslovakia. (Presented by Academician of the Academy of Medical Sciences of the USSR K. V. Sudakov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 109, No. 4, pp. 323-324, April, 1990. Original article submitted October 21, 1989.

 0007-4888/90/0004-0418$12.50

TABLE 1. Catecholamine Concentrations in Brain Nuclei of Rats Differing in Zoosocial Rank, under Conditions of Immobilization Stress (ng/mg) ($M \pm m$)

Brain nuclei	CA	Control	Stress		
			dominant	subdominant	submissive
A_{14}	A	0,66±0,14	0,50±0,12^{z}	0,19±0,07^{z}	0,50±0,30
	NA	31,47±3,28	23,30±5,57	13,43±4,13*	14,1±2,78*
	DA	3,93±0,53	6,63±2,73	2,35±0,97	2,82±1,0
A_{12}	A	0,43±0,06	0.15±0,08*	0,1 ±0,0*^{z}	0,18±0,03*^{z}
	NA	19,83±3,17	17,03±3,54^{oz}	6,78±2,40*^{z}	10,22±1,36*^{z}
	DA	6,98±1,35	2,97±0,85	1,13±0,73*	1,73±0,38*
A_6	A	0,2±0,03	0,1±0	0,21±0,08	0,12±0,03
	NA	16,67±2,54	13,73±2,42	15,30±11,77	14,45±3,67
	DA	1,04±0,21	0,47±0,15	0,73±0,27	0,78±0,28
A_7	A	0,12±0,04	0,18±0,11	0,04±0,02	0,08±0,06
	NA	9,16±2,20	8,57±2,89^{oz}	2,58±0,76^{o}	3,50±0,95^{z}
	DA	0,54±0,18	2,00±0,84^{oz}	0,11±0,05^{o}	0,19±0,09^{z}

Legend. Asterisk indicates significant difference compared with control; $p < 0.05^{o,z}$) Significant difference between groups of rats differing in zoosocial rank, $p < 0.05$.

EXPERIMENTAL RESULTS

Previously [1], to study the role of catecholamines in individual brain nuclei in the central regulation of blood pressure during emotional stress, changes in brain catecholamine levels induced by immobilization during emotional stress were studied in relation to the time course of the blood pressure. Three groups of rats showing different responses of blood pressure to immobilization stress were distinguished: hypertensive, normotensive, and hypotensive. Stress-induced changes in catecholamines were compared with the time course of the blood pressure. Since in the present investigation the model of immobilization used was the same as in [1], we thought it worth while to compare results obtained during analysis of changes in catecholamine levels in D, SD, and S rats separately, with the total for the group, which, like animals chosen for investigation in the present study, were characterized by a normotensive blood pressure response.

After immobilization stress the greatest differences in catecholamine levels between the zoosocial groups were found in two dopamine-synthesizing nuclei in the hypothalamus (n. arcuatus, n. periventricularis) and in the noradrenalin-synthesizing nucleus n. subcoeruleus (Table 1). Analysis both collectively and separately on D, SD, and S rats revealed no differences compared with the control. However, significant differences were found in the level of noradrenalin and dopamine between the zoosocial groups. In the locus coeruleus (Table 1) analysis of D, SD, and S rats separately, just as in the case of the whole normotensive group together, revealed no differences in catecholamine levels after immobilization compared with the control. In n. arcuatus all zoosocial groups showed a significant fall of the adrenalin level after immobilization. In the case of the whole group, the trend was the same, but amounted to a strong tendency. As regards the noradrenalin level in n. arcuatus, significant differences were discovered between D, on the one hand, and SD and S on the other hand. In the D rats the noradrenalin level after immobilization remained the same as the control, whereas in SD and S it fell significantly. Similar changes were found in the dopamine level. In the complete normotensive group, noradrenalin and dopamine levels did not differ significantly from the control.

Similar changes in the noradrenalin level after immobilization were characteristic of another dopamine-synthesizing hypothalamic nucleus, namely n. periventricularis. Just as in n. arcuatus, in the SD and S rats the noradrenalin level fell after immobilization stress, whereas in D it remained virtually the same as in the control. Differences were found between the zoosocial groups also for the adrenalin level in this nucleus. We know that n. arcuatus is more deeply involved than other hypothalamic and extrahypothalamic structures in the regulation of hormonal functions through its nervous and humoral connections with the median eminence. N. periventricularis sends axons to n. arcuatus and the median eminence. In addition, the fact that n. periventricularis lies immediately next to the vascular organ of the lamina terminalis determines the humoral pathway of its action on the state of the physiological functions of the body. Noradrenergic fibers reach hypothalamic nuclei mainly via the ventral noradrenergic bundle, in the organization of which n. subcoeruleus plays a much more important role than the locus coeruleus.

Consequently, the results show that rats of different zoosocial rank are characterized by a definite specific pattern of central regulation of their hormonal functions during stress, mediated by the noradrenalin- and dopamine-synthesizing brain structures listed above.

In all cases when significant differences were observed between zoosocial groups, a higher catecholamine level was characteristic of the D rats. Similar results also have been obtained by other workers [3]. Since a high catecholamine level in the brain nuclei may be evidence of reduced release of this substance, it can be tentatively suggested that activity of catecholamine-synthesizing structures involved in the central regulation of hormonal functions during stress is lower in the D rats than in rats of the other ranks. Meanwhile, the possibility of differences in the level of catecholamine metabolism in rats of different zoosocial position cannot be ruled out.

LITERATURE CITED

1. T. I. Belova and R. Kvetnansky, Usp. Fiziol. Nauk, **12**, No. 2, 67 (1981).
2. T. I. Belova, M. Dobrakovova, T. M. Ivanova, et al., Fiziol. Zh. SSSR, **71**, No. 7, 813 (1985).
3. L. I. Serova, D. G. Sakharov, and E. V. Naumenko, Abstracts of Proceedings of an International Conference [in Russian], Novosibirsk (1988), pp. 171-172.
4. K. V. Sudakov, Emotional Stress and Arterial Hypertension [in Russian], Moscow (1976).
5. R. Kvetnansky and L. Mikulaj, Endocrinology, **87**, 738 (1970).
6. M. Balcovits, Brain Res., **59**, 449 (1973).
7. G. D. Peuler and G. A. Johnson, Life Sci., **21**, 625 (1977).
8. K. K. Weise and I. J. Kopin, Life Sci., **19**, 1673 (1976).

EFFECT OF COMBAT STRESS AND CAPITULATION STRESS ON RESISTANCE OF HEART MUSCLE TO EXCESS CALCIUM

F. Z. Meerson, V. I. Vovk, and V. G. Saltykova

UDC 612.172.06:613.863].014.46:546.41

Key words: stress; calcium; resistance; antioxidative system.

During long-term exposure to a stress situation the initial (adaptive) effect of stress, during which activation of the antioxidative system takes place [1], may be converted into a damaging effect due to the overactivation of lipases, phospholipases, and processes of free-radical oxidation by catecholamines [5]. This has been proved mainly in relation to combat stress, the type most frequently observed under real conditions. In emotional-painful stress, as in [9], during which the rat unsuccessfully, but persistently, realizes an electric shock avoidance reflex, exposure for 1 h leads to an increase in the force and rate of contraction, and to an even greater degree, of relaxation, of the isolated heart, but also to an increase in its resistance to hypoxia. Exposure to stress for 6 h induces the directly opposite effect. This rule was discovered in a study of the contractile function of isolated hearts of animals under isovolumic, aerobic conditions, and in the presence of a normal Ca^{2+} concentration [4].

The aims of the present investigation were, first, to discover how the adaptive effect of stress changes into a damaging effect relative to resistance of the isolated heart to the contracture-inducing action of high Ca^{2+} concentrations, and second,

Research Institute of General Pathology and Pathological Physiology, Academy of Medical Sciences of the USSR, Moscow.

(Presented by Academician of the Academy of Medical Sciences of the USSR G. N. Kryzhanovskii.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 109, No. 4, pp. 325-327, April, 1990. Original article submitted July 10, 1989.

0007-4888/90/0004-0420$12.50