DEPENDENCE OF THE EFFECT OF ACUTE STRESS ON LATERALIZATION OF LIPID PEROXIDATION PRODUCTS IN THE BRAIN ON BEHAVIORAL TYPOLOGY OF RATS

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Resistance to stress in animals is related to typology of individual behavior [2, 8]. Previous investigations of brain levels of lipid peroxidation (LPO) products in rats differing in the character of their higher nervous activity (HNA) during stress as a rule have been limited to determination of products reacting with thiobarbituric acid (TBA), whereas Desiderato's model of relatively long-term stress examined LPO activation in the brain [1, 4].

Several important aspects of the problem have not been completely explained: detailed characteristics of HNA of animals, obtained by the use of appropriate methods, have not been described, a more complete study of LPO and of the lipid component of the brain has not been studied, considering that TBA activity is not always an adequate indicator of LPO [5]; lateralization of LPO likewise has not been taken into account, nor has any investigation been conducted in the first stage of acute stress, during which LPO is inhibited in the brain, only to be replaced later by activation [3, 6]. This paper describes an attempt to solve these problems.

EXPERIMENTAL METHOD

Experiments were carried out on 40 noninbred male albino rats weighing 150-200 g. The animals were selected by an emotional resonance test [7], using stimuli appropriate for rats: a closed and open space, and a signal of painful stimulation of another rat. In response to the cry of a rat victim, some animals (group 1) did not run away from it, preferring to remain in an enclosed space, despite the fact that the victim's cry ceased on emergence into the open space. Other rats (group 2, control) in response to the victim's cry preferred an open space, i.e., they exhibited the "emotional resonance" phenomenon. An open field test was carried out on these same animals [1]. Half of the animals were subjected to stress induced by painful electrical stimulation (4 mA, 1-2 stimuli in 10 sec) 2 weeks after the end of the behavioral experiments. Immediately after exposure the rats were decapitated, the cortex of the right and left cerebral hemispheres was removed separately, the tissue was homogenized, and the concentrations of TBA-active products [10], conjugated dienes [5], superoxide scavenging activity (SSA) [9], and cholesterol and phospholipid levels [11] were determined in the homogenates. The concentration of LPO products and SSA also was determined in blood serum taken during decapitation.

EXPERIMENTAL RESULTS

Table 1 shows that the rats of group 1 were characterized by passive defensive behavior, those of group 2 by active, investigative behavior, in an open field.

In the animals of group 2 the level of LPO products in the brain and the cholesterol concentration were higher than in group 1, whereas the concentration and oxidizability of phospholipids were lower. The control animals were found to be left-sided with respect to LPO parameters: the coefficient of asymmetry calculated as the ratio between values of this parameter in the left and right hemispheres, exceeded 1.0 (Table 2).

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TABLE 1. Behavior of Noninbred Albino Rats in Emotional Resonance and Open Field Tests (period of observation 300 sec)

Parameter	Group 1 (n = 18)	Group 2 (n = 17)
Emotional resonance test:		
time spent in dark compartment, sec	272,2±23,9	44,5±28,4**
time spent in light compartment, sec	27,8±23,9	256,1±28,5**
Behavior in open field:		
horizontal activity		
number of squares crossed	102,0±55,8	164,8±63,7*
number of visits to center	2,9±2,6	5,0±3,6*
vertical activity	15,2±9,5	20,0±8,1*
number of defecations	7,9±4,7	5,3±5,0*

Legend. Only parameters showing significant differences between groups are given: *$p < 0.05$, **$p < 0.01$.

TABLE 2. Characteristics of LPO and Lipid Component of Brain in Rats with Different Types of Behavior in Control and during Stress

Parameter	Control		Stress	
	group 1	group 2	group 1	group 2
TBA-active products, mg/g tissue	2,56 (2,50—2,65)	2,99* (2,93—3,10)	0,54 (0,48—0,58)	0,33* (0,30—0,40)
Coefficient of asymmetry	1,12 (1,02—1,22)	1,11 (1,07—1,21)	1,6 (1,33—1,75)	0,54* (0,44—0,71)
Conjugated dienes, mg/g tissue	0,79* (0,70—0,88)	1,02* (0,98—1,08)	0,37 (0,28—0,40)	0,54* (0,53—0,60)
Coefficient of asymmetry	1,34 (1,14—1,62)	1,47 (1,39—1,53)	2,6 (2,20—4,33)	0,65* (0,50—0,75)
Schiff bases, conventional units	57 (56—58)	65* (64—67)	29 (28—31)	28 (27—30)
Coefficient of asymmetry	1,08 (1,02—1,13)	1,07 (1,03—1,11)	1,17 (1,07—1,27)	0,81* (0,77—0,83)
SSA, conventional units	30,4 (20,8—32,1)	30,1 (28,9—34,0)	78,0 (76,8—78,6)	89,3* (87,5—91,8)
Coefficient of asymmetry	0,7 (0,60—0,80)	1,4 (1,12—1,67)	0,95 (0,91—1,00)	1,04 (1,00—1,98)
Cholesterol concentration, mg/g total lipids	236,0 (213,8—243,6)	268* (264,9—293,2)	147,2 (139,3—152,2)	136,8 (133,1—153,9)
Coefficient of asymmetry	0,95 (0,86—1,02)	0,91 (0,86—0,94)	1,21 (1,09—1,37)	0,81* (0,72—1,00)
Phospholipid concentration, mg/g				
Phospholipid concentration, mg/g total lipids	669,1 (649,8—684,0)	598,6* (558,6—627,0)	788,9 (767,2—808,3)	785,5 (776,3—798,0)
Coefficient of asymmetry	1,03 (1,00—1,04)	1,19* (1,13—1,24)	0,9 (0,84—0,92)	1,1* (1,06—1,12)
Cholesterol/phospholipid ratio (mmoles/moles)	0,57 (0,55—0,60)	0,82* (0,80—0,85)	0,33 (0,30—0,35)	0,31 (0,29—0,33)
Coefficient of asymmetry	0,93 (0,83—1,02)	0,77* (0,75—0,79)	1,36 (1,19—1,63)	0,8* (0,67—0,94)
Oxidizability of phospholipids, conv. units	1,59—1,68	1,44—1,53	1,79—1,89	1,87—1,90
Coefficient of asymmetry	0,93—1,03	1,03—1,20	0,87—1,02	0,98—1,03

Legend. Differences between 1c and 1s, and 2c and 2s are significant ($p < 0.01$) in all cases except 2c and 2s for cholesterol and the cholesterol: phospholipids ratio, and 1c and 1s for oxidizability. Asterisk indicates significant ($p < 0.01$) differences between 1c and 2c, and 1s and 2s. 2) Oxidizability of phospholipids gives ratio of content of readily oxidized (phosphatidylethanolamine + phosphatidylserine + phosphatidylinositol + cardiolipin) and sparingly oxidized (phosphatidylserine + sphingomyelin) phospholipids.

TABLE 3. Serum Levels of LPO Products and Nonenzymic SSA in Rats with Different Types of Behavior

Parameters	Control		Stress	
	1c	2к	1s	2s
TBA-active products, mg/ml serum	1,16 (1,10—1,28)	1,30* (1,23—1,35)	0,28 (0,25—0,35)	0,72* (0,03—0,20)
Conjugated dienes, mg/ml serum	0,43 (0,38—0,45)	0,50 (0,38—0,53)	0,20 (0,15—0,25)	0,34* (0,33—0,35)
Nonenzymic SSA, conventional units	55,5 (48,0—58,9)	46,6 (48,0—58,9)	71,9 (69,2—72,6)	86,3* (85,1—87,9)

Legend. Differences between 1c and 1s, and 2c and 2s significant at $p < 0.001$, between 1c and 2c, and 1s and 1s, at $p < 0.01$.

In both groups stress caused inhibition of LPO with an increase in SSA, a decrease in the cholesterol concentration, and accumulation of readily oxidized phospholipids. The unequal degree of the fall of the brain levels of different LPO products in the rats of groups 1 and 2 indicates different effects of stress in different stages of LPO. The most important difference in the response to stress was that in the animals of group 1 left-sided asymmetry for LPO products was intensified, whereas in the animals of group 2, right-sided asymmetry appeared (predominance of LPO products in the right hemisphere). After stress, in rats of group 1 cholesterol predominated in the left, and in those of group 2 in the right hemisphere (Table 2). Despite these diverging tendencies, differences in the serum LPO level were not significant, and changes during stress corresponded to those in the brain (Table 3).

Thus inborn differences in the mechanisms of urgent adaptation in rats of groups 1 and 2 correspond to an initially different brain LPO level, and also to fundamentally different responses of the right and left hemispheres to acute stress by the establishment of different LPO levels and different lipid composition in the two cerebral hemispheres. In other words, initially minor (but significant) quantitative differences in the properties of the brain membranes of animals with particular individual-typologic features of their HNA under acute stress conditions are converted into qualitative differences (changes of lateralization), against the background of general changes, independent of the type of behavior (depression of LPO, cholesterol level, and so on).

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