6. F. Z. Meerson, Adaptation, Stress and Prophylaxis [in Russian], Moscow (1981).
7. M. M. Melkonyan, A. G. Arakelyan, and V. G. Mkhitaryan, Biol. Zh. Armenii, No. 10, 818 (1983).
8. P. V. Simonov, A Neurophysiological Approach to the Analysis of Intraspecific Behavior [in Russian], Moscow (1976), p. 6.
9. N. M. Khonicheva, I. L. Dmitrieva, N. L. Krushinskaya, and T. A. Voronina, Zh. Vyssh. Nerv. Deyat., No. 3, 537 (1984).
10. J. Fridovich, in: Oxygen Living Processes. An Interdisciplinary Approach, ed. by D. L. Gilbert, Springer (1981), pp. 250-275.
11. H. P. Misra and J. Fridovich, J. Biochem., 247, 3170 (1972).
12. N. Nishikimi and N. A. Rao, Biochem. Biophys. Res. Commun., 46, 849 (1972).
13. H. Ohkava, N. Ohishi, and J. Kunio, Anal. Biochem., 95, 351 (1979).
14. R. C. Tryon, J. Comp. Psychol., 32, 407 (1941).
15. D. Wahlstein, Crit. Rev. Biol., 7, 143 (1972).

EFFECT OF ABLATION OF THE SOMATOSENSORY CORTEX ON PAIN SENSITIVITY IN CATS

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KEY WORDS: first and second somatosensory cortical areas; nociception.

An important role in the formation of the complex of pain-related sensations is ascribed to the cerebral cortex and, in particular, to its orbitofrontal and somatosensory divisions [1, 4, 6]. The most convincing data on the role of the orbitofrontal cortex in the formation of the emotional-affective component of pain consists of clinical observations which show that patients undergoing frontal lobotomy, with division of connections between the frontal cortex and thalamus, no longer complain of severe, distressing pain, no longer ask for pain-relieving drugs, and do not exhibit unease, although they continue to feel pain [1, 11]. The role of the somatosensory cortex in the formation of the sensory-discriminative component of pain has been demonstrated by numerous clinical and experimental studies [1, 4, 6, 12]. The existence of a double organization of the somatosensory projection zone raises the question of the importance of the first (SI) and second (SII) somatosensory areas in the mechanisms of integrative evaluation of pain sensitivity.

The aim of this investigation was to study changes in pain sensitivity of animals after ablation of area SI and area SII in unrestrained animals.

EXPERIMENTAL METHOD

Experiments were carried out on 15 adult cats unrestrained in the experimental chamber. Nociceptive electrical stimulation was applied through bipolar electrodes inserted into the dorsal part of the forearm of both forelimbs by bursts of pulses (frequency of pulses in the burst 5/sec, duration of pulse 1 msec, of burst 1 sec). The intensity of stimulation was gradually increased from 100 mV to 30 V. The results were expressed on a conventional scale, as used with rats and rabbits [1, 2], and adopted by the writers for recording the nociceptive response in freely behaving cats (Table 1). The significance of the results was estimated by Student's test. Unilateral ablation of the cortical areas was done by electrical coagulation under hexobarbital anesthesia (30 mg/kg, intraperitoneally). To remove area SI the posterior sigmoid and coronal gyri were coagulated (6 animals), and to remove area SII, the anterior ectosylvian gyrus was destroyed [6]. Part of the lateal and suprasylvian gyri of the parietal association cortex were destroyed in animals of the control group. Before extirpation of the cortical areas all cats were tested to determine their nociceptive response profile, and tests after cortical ablation began on the 8th day. At the end of the investigation the dimensions of the coagulated cortical areas were studied.

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TABLE 1. Levels and Characteristics of Nociceptive Responses to Stimulation of Increasing Intensity

Level of response	Characteristics of response
1	Threshold of response – twitching of eyelids, flexion of stimulated limb
2	Flexion of stimulated limb, head shaking, closing the eyes tightly, pressing back the ears
3	Shaking of the whole body, licking, change of posture, isolated movements, vocalization
4	Intensity of frequent crying, continuous movement, unease
5	Generalized movements, running accompanied by crying, aggressiveness

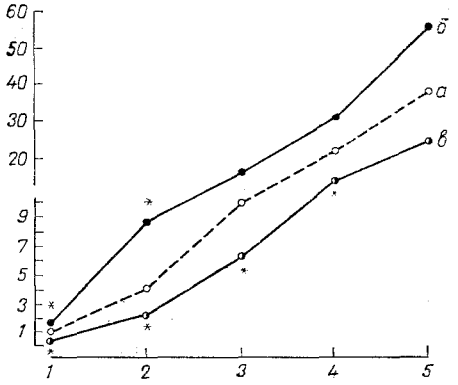

Fig. 1. Changes in nociceptive response profile after ablation in areas SI and SII. Abscissa, level of response; ordinate, intensity of stimulation (in thresholds). a) Nociceptive response profile of intact animals, b) after removal of area SI, c) of area SII. *P < 0.05.

EXPERIMENTAL RESULTS

Repeated testing before cortical ablation showed that the response thresholds for each level of the conventional scale were sufficiently stable in time in the same animal, although individual pain response profiles could vary considerably. Thresholds of responses for each level were virtually the same to stimulation of the right and left forelimbs, and differences between them were not significant.

Removal of area SI raised the response thresholds for each level (Fig. 1) on the contralateral side. The nociceptive response profile was unchanged on the ipsilateral side. Destruction of area SII, however, lowered the response thresholds on the contralateral side (Fig. 1) and preserved thresholds on the side of ablation. Partial destruction of the lateral and supravylvian gyri of the parietal association cortex did not change the profile of pain sensitivity of the animals.

Changes in the nociceptive response profile after ablation of area SI or SII were reversible in character, and by the end of the third week after the operation the thresholds of pain sensitivity had returned to the control values and stabilized. This compensation of the lost functions evidently took place through enhanced functional activity in zones symmetrically opposite to the lesion, and also in the cortical association areas [3], and it is a general feature of the central nervous system.

These results indicating significant differences in the changes in nociceptive response thresholds after ablation of area SI, compared with the corresponding parameters after ablation of area SII, are evidence of the dissimilar functions of areas SI and SII with respect

to nociceptive stimulus evaluation. Area SII, as the structure responsible for distinguishing biologically meaningful stimuli and undertaking primary situational analysis [6], evidently assesses the intensity of the nociceptive stimulus and forms a group of protective behavioral responses, aimed at stopping the action of the noxious factor, by activating the endogenous antinociceptive system under these circumstances [4, 5, 7, 8]. Area SII, which takes part in fine discriminative analysis of somatic sensation, in this case determines the site of action and the quality of the noxious factor. After removal of area SI, response thresholds are thus raised at all levels, accompanied by worsening of general somatic sensitivity [12]. Conversely, ablation of area SII, which determines the degree of response to an applied stimulus, makes the animals unable to respond adequately to them and induces a more generalized and more marked response even to trivial stimulation.

The results of this investigation are in clear contradiction to those of another study, which showed that ablation of area SI leads to an increase in stimulus avoidance time, whereas the removal of SII raises the threshold of avoidance [9]. On this basis the authors cited conclude that area SII is responsible for perception of nociceptive stimuli, but area SI is responsible for regulation of the motor act in response to nociceptive stimulation. These differences, in our view, can be explained on the grounds that we used short stimuli of equal duration to determine pain thresholds, and changed only their amplitude, whereas the authors cited above used a constant current and determined the avoidance threshold according to the strength of the constant current, and disregarded the duration of its action. However, in that method the avoidance threshold ought to be measured, not by the amplitude of the current, but by the intensity of the stimulation, which is determined by two parameters: strength of current and duration of its action. Consequently, lengthening of the avoidance time after ablation of area SI is evidence of raising of the avoidance threshold, for a longer period of action was needed in order to obtain a behavioral response.

As regards the results obtained by the authors cited after removal of area SII, it can be tentatively suggested that during stimulation of steadily increasing intensity, when the unexpected stimulus necessary for generation of the behavioral response is absent from the beginning, the biological meaningfulness of the stimulus is reduced and the avoidance threshold correspondingly raised.

These results are in good agreement with clinical observations in the patients with cortical lesions. For instance, trauma to area SI not only impairs tactile, temperature, vibrational, and kinesthetic sensitivity, but also raises pain thresholds [13], whereas an isolated lesion of area SII gives rise to a state of hyperpathia [10, 13].

Area SII, which participates in fine discriminative analysis of somatic sensitivity, is thus responsible for perception and formation of sensations associated with primary epicritic pain. Area SII, as the structure responsible for primary situational analysis, determines the degree of response to a nociceptive stimulus, estimating its intensity and monitoring the input of nociceptive impulses by its modulating influence on activity of the endogenous antinociceptive system [4, 5, 7, 8].

LITERATURE CITED

1. A. V. Val'dman and Yu. D. Ignatov, Central Mechanics of Pain [in Russian], Leningrad (1976).
2. Yu. N. Vasil'ev, Yu. D. Ignatov, A. T. Kachan, and N. N. Bogdanov, Byull. Éksp. Biol. Med., No. 11, 566 (1979).
3. V. P. Dobrynin, Z. F. Zvereva, E. N. Pogozheva, and A. N. Sovetov, Byull. Éksp. Biol. Med., No. 10, 413 (1980).
4. R. A. Durinyan, Vest. Akad. Med. Nauk SSSR, No. 9, 38 (1980).
5. R. A. Durinyan, M. L. Kukushkin, and V. K. Reshetnyak, Patol. Fiziol., No. 1, 63 (1984).
6. A. G. Rabin and R. A. Durinyan, Central Mechanisms of General Sensitivity [in Russian], Leningrad (1975).
7. V. K. Reshetnyak, E. E. Meizerov, and R. A. Durinyan, Byull. Éksp. Biol. Med., No. 3, 5 (1982).
8. V. K. Reshetnyak, M. L. Kukushkin, and R. A. Durinyan, Byull. Éksp. Biol. Med., No. 7, 14 (1983).
9. K. J. Berkley and R. Parmer, Exp. Brain Res., 20, 363 (1974).
10. A. Biemond, Arch. Neurol. Psychiat., 75, 231 (1956).
11. W. Freeman and J. W. Watts, Ann. Intern. Med., 28, 747 (1948).

12. U. Norssell, Physiol. Rev., 60, 327 (1980).
13. W. H. Sweet, New Perspectives in Cerebral Localization, New York (1982), pp. 205-242.

MORPHOLOGICAL INVESTIGATION OF THE INTRAVASCULAR RED CELL DISTRIBUTION IN THE AORTIC ARCH

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Qualitative and quantitative correlation is known to exist between the blood supply and function of various organs [4]. A high intensity of its metabolism and negligible reserves of energy substrates and oxygen are the reasons why the brain is particularly sensitive to hemocirculatory disturbances and render strict control of its blood supply essential. However, exposure to hypoxia does not simultaneously block the various functions of parts of the CNS. The high safety factor of the blood supply is due to unique mechanisms of compensation and unique features of the circulation in the brain [1]. At the same time, the possible presence of additional mechanisms, ensuring that mainly the brain is supplied with oxygen, cannot be ruled out. These mechanisms may be associated with qualitative differences in the composition of the blood responsible for nutrition of the cells of the brain and peripheral organs. We know that the profile of average velocities of blood flow in different parts of the aorta is virtually flat, but the symmetry of the profile diminishes as the blood flow travels along the ascending aorta into its arch, and division of the blood flow is observed where the vessels branch [6, 7]. It can be postulated that after division of the flow, blood entering the side branches and blood continuing to flow along the main trunk of the aorta differ qualitatively.

In the investigation described below the distribution of red blood cells by degree of maturity was determined in the bloodstream.

EXPERIMENTAL METHOD

Experiments were carried out on 18 mongrel dogs of both sexes weighing 4.5-5 kg. Blood (2 ml) was taken for investigation from the carotid and femoral arteries of the dogs under pentobarbital (40 mg/kg, intravenously) anesthesia. These arteries were chosen because skeletal muscle at rest has a lower oxygen consumption than brain. The following parameters of age of the cells were chosen: volume, surface area [11], and diameter of the red cell [2], and its hemoglobin content [12]. The hemoglobin content was determined relative to dry weight of red cells, because under normal conditions hemoglobin accounts for 95% of their dry weight [8]. Dry weight was measured by interferometry on a Biolar-PI microscope (Poland). The interferometric investigations were carried out in a chamber, in which the diameter of the cells and the difference in optical path for 50 arbitrarily chosen red cells were measured [3]. Dry weight was calculated by the equation:

$$m = \frac{\psi \cdot S}{100 \cdot \alpha},$$

where ψ denotes the difference in optical path, S the area of the cell, and α is the specific increment of the refractive index, which for hemoglobin is 0.00193.

To determine the red cell count and hematocrit index traditional methods of hematology were used. The volume and average thickness of the cells were calculated by Todorov's method [9]. The results were subjected to statistical analysis by Student's and Kolmogorov–Smirnov tests.

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