The population of low-amplitude signals forming a separate peak at the beginning of the histogram (Fig. 2) is particularly interesting. This population of signals was formed by fields 1 and 5 on the scatter diagram and was due to activity of distal areas of the nerve ending.

Secretion of quanta of transmitter from spatially separate areas of the nerve ending may thus lead to the appearance of a population of low-amplitude MEPP and of polymodality in the distribution of MEPP amplitudes. The results contradict the subquantum hypothesis of transmitter release in the neuromuscular synapse.

LITERATURE CITED

1. A. L. Zefirov and E. L. Stolov, Neirofiziologiya, 14, 233 (1982).
2. J. D. Cooke and D. M. J. Quastel, J. Physiol. (London), 228, 377 (1973).
3. J. Del Castillo and B. Katz, J. Physiol. (London), 132, 630 (1956).
4. P. Fatt and B. Katz, J. Physiol. (London), 115, 320 (1951).
5. M. E. Kriebel and C. E. Gross, J. Gen. Physiol., 64, 85 (1974).
6. M. E. Kriebel, F. Llados, and D. R. Matteson, J. Physiol. (London), 262, 553 (1976).
7. A. Wernig, Brain Res., 118, 63 (1976).
8. A. Wernig and H. Stirner, Nature, 269, 820 (1977).

EFFECT OF ANIMALS' PRE-EXPERIMENTAL EMOTIONAL STATE ON THE SYSTEMIC HEMODYNAMICS

S. A. Martyuk and V. A. Tsyrlin

UDC 612.13-06:613.863

KEY WORDS: hemodynamics; reflex regulation; emotional stress.

Emotional stress is accompanied by marked hemodynamic changes: elevation of the arterial pressure (BP), an increase in heart rate (HR) and in cardiac output [2, 5, 7]. Prolonged elevation of BP is observed even after brief emotional stress [3]. However, the role of central regulation of the circulation in the mechanism of onset of this hypertension and in neurogenic control of the hemodynamics after termination of emotional stress has not been explained.

The object of this investigation was to compare the initial hemodynamics and reflex changes in the circulation in cats in acute experiments on animals whose emotional state before the experiment differed.

EXPERIMENTAL METHOD

Altogether 70 cats were used. Seventeen cats which, before the experiment, had been in a tranquil state were kept in a cage for 10-15 min, 30 min before the beginning of operative preparation for the experiment, with a dog, precautions being taken to ensure that no direct contact between the animals was possible. Of 53 cats not exposed before the experiment deliberately to emotional stress, 28 animals were described as quiet, domesticated, and the rest as aggressive, malicious, and wild.

Under halothane anesthesia the femoral arteries and veins of all the animals were catheterized, and the left greater splanchnic and renal nerves were isolated extraperitoneally. After the end of dissection, muscle relaxants were injected and the artificial respiration system connected. BP, HR, and electrical activity of one branch of the renal nerve were recorded 60 min after the end of anesthesia, in the initial state and during stimulation of the

Department of Pharmacology, Central Research Laboratory, I. P. Pavlov First Leningrad Medical Institute. Department of Experimental Cardiology, Research Institute of Cardiology, Leningrad. (Presented by Academician of the Academy of Medical Sciences of the USSR P. N. Veselkin.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 95, No. 5, pp. 8-11, May, 1983. Original article submitted September 23, 1982.

 0007-4888/83/9505-0570$07.50

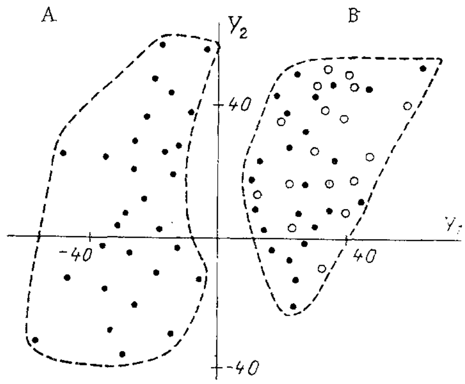

Fig. 1. Reflection of position of objects in 4-dimensional space of hemodynamic characteristics on a 2-dimensional distribution. Coordinates: axes represent individual distance between objects in 4-dimensional space. Empty circles — animals exposed deliberately to emotional stress. Remainder of explanation in text.

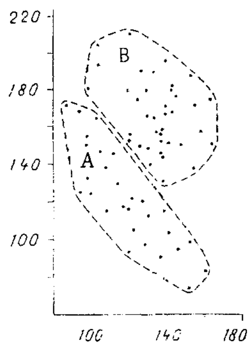

Fig. 2. Relationship between HR and BP in a group of quiet (A) and spontaneously aggressive (B) animals exposed to emotional stress. Abscissa, BP (in mm Hg); ordinate, HR, beats/min.

central end of the divided splanchnic nerve (4 V, 0.2 msec, 10 Hz). To test the baroreceptor reflex the abdominal aorta was occluded below the origin of the renal arteries.

To objectivize the difference between parameters of the animals relative to those of the cardiovascular system recorded initially, depending on the pre-experimental emotional state, the method of nonlinear transformation of a space of characteristics [1, 4], whereby the mutual arrangement of objects in the initial multidimensional space can be represented on a two-dimensional diagram. For analysis of the experimental results the method of regression and correlation analysis was used.

EXPERIMENTAL RESULTS

Analysis of initial values of BP, HR, and the amplitude and frequency of discharges in the renal nerve, using the method of linear transformation of a space of characteristics, showed that the total number of these characteristics in 70 cats forms two regions of points on the plane (Fig. 1) corresponding to the most probable state of the cardiovascular system. In region A (Fig. 1) were found points (each one the result of measurement of four parameters in one animal) corresponding to tranquil animals. In region B, points corresponding to cats subjected to confrontation with a dog before the experiment and initially aggressive animals were found. The result of this analysis enabled all the animals to be divided into two groups.

In quiet cats not exposed to emotional stress before the experiment (group 1) BP was 108 ± 6 mm Hg and HR was 144 ± 3 beats/min. The frequency of spike discharges in the renal

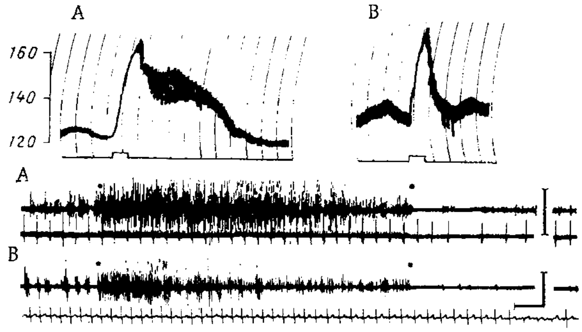

Fig. 3. Reflex changes in BP (A — first type, B — second type) and corresponding changes in electrical activity in renal nerve and on ECG during stimulation of afferent fibers of splanchnic nerve. Kymogram — changes in BP and marker of stimulation (10 sec). Bottom traces show activity in renal nerve (above) and ECG. Beginning and end of stimulation indicated by dots. Calibration: 50 μV, 1 sec.

nerve, forming bursts synchronous with the pulse waves of BP in these animals was 30 ± 1.2 spikes/sec, and their total activity per second was 523 ± 27 μV. Regression analysis showed a linear relationship between HR and BP (Fig. 2A). The linear regression coefficient was 1.105 ± 0.132 ($P < 0.01$) and the coefficient of correlation was 0.85 ($P < 0.01$).

When the abdominal aorta was compressed 1-2 sec after the beginning of occlusion BP reached its maximal level (41 ± 2 mm Hg), after which it began to fall. Stopping occlusion of the aorta led to the rapid development of hypotension, the duration of which was 20-25 sec. Changes in HR were opposite in phase to the dynamics of BP. When BP rose, the heart rate fell by 7.3 ± 1.2 beats/min; during hypotension there was tachycardia. The regression coefficient, reflecting quantitative estimation of the baroreceptor reflex, and representing the ratio of changes in HR to the amplitude of rise of BP on compression of the aorta, was 0.183 ± 0.027 beats/min/mm Hg ($P < 0.001$).

Stimulation of myelinated efferent fibers of the splanchnic nerve led to an increase in BP with a latent period of 1-1.5 sec. In 84% of cases (responses of the first type) the first peak of rise of BP was followed by a second wave of rise of BP 26 ± 7 sec after the beginning of stimulation, but its value did not correlate with the amplitude of the first rise (Fig. 3A). Reflex changes in BP of the second type (Fig. 3B) were observed in 13% of cases. These responses were characterized by absence of a second peak of elevation of BP. In 3% of cases pressor-depressor responses were observed.

Reflex changes in BP were accompanied by a marked change in electrical activity in the renal nerve. Spike activity was sharply intensified 0.15-0.3 sec after the beginning of splanchnic nerve stimulation. During stimulation for 5-7 sec activity became continuous in character, losing its modulation by the BP pulse waves. By the time of formation of the first bursts of discharges the level of hypertension was 40-60% of the maximal rise. After the end of splanchnic nerve stimulation a period of poststimulation depression was recorded, in which discharges were totally inhibited for 6 ± 0.7 min, which was followed by recovery of the original character of activity.

Strengthening of electrical activity in the renal nerve during afferent stimulation was accompanied by tachycardia. HR by the end of stimulation was 10-20 beats/min higher than the initial value.

In cats exposed to emotional stress before the experiment and also in initially aggressive animals (group 2) the BP level after the end of operative preparation and cessation of anesthesia was 143 ± 3 mm Hg, HR was 180 ± 4 beats/min, and the discharge frequency in the renal nerve was 21 ± 1 spikes/sec, with total activity per second of 334 ± 16 μV. By contrast with experiments on quiet cats, in the animals of this group no relationship could be found between BP and HR (Fig. 1B).

During compression of the abdominal aorta bradycardia developed in response to the hypertension (BP rose by 46 ± 4 mm Hg). HR decreased by 23 ± 4 beats/min. The regression coefficient was 0.495 ± 0.021 beats/min/mm Hg ($P < 0.001$).

During electrical stimulation of myelinated afferent fibers of the splanchnic nerve pressor responses developed, chiefly (76%) of the second type. Responses of the first type were observed in 19%, and pressor-depressor responses in 5% of cases. During the period of elevation of BP the heart rate was slowed, to reach 16 ± 0.7 beats/min by the end of stimulation. Starting from the time of ending of stimulation a sharp decrease was observed in HR, the degree of which correlated positively with the amplitude of hypertension. Restoration of the initial HR was observed by the time of completion of the BP changes.

The character of changes in electrical activity in the renal nerve during stimulation of myelinated fibers of the splanchnic nerve did not differ in principle in animals of the two groups.

The investigations showed that even a long time after emotional stress (despite subsequent anesthesia and the operation) not only a higher level of BP and HR was observed in the animals of group 2, but also a change in the character of the movements of these parameters in response to afferent nerve stimulation and to baroreceptor activation. Reflex bradycardia in these cats in response to baroreceptor activation, incidentally, was more marked than in tranquil animals. Depression of baroreceptor reflexes at the time of emotional stress [6] is evidently followed by enhancement of activity of these mechanisms. It can be concluded from the results that emotional stress causes long-lasting changes in the central mechanisms of regulation of the circulation.

LITERATURE CITED

1. A. G. Arkad'eva and É. M. Braverman, Instruction on Computers for Classifying Objects [in Russian], Moscow (1971).
2. A. V. Val'dman and V. A. Tsyrlin, in: Hemodynamics under Normal and Pathological Conditions [in Russian], Leningrad (1978), p. 5.
3. M. M. Kozlovskaya and A. Beshimov, in: Pharmacological Study of Hypotensive Agents with Central Action [in Russian], Leningrad (1975), p. 16.
4. S. V. Romanov and E. P. Popechitelev, in: Techniques of Means of Communication. General Technical Series, No. 3 (7) [in Russian], Moscow (1977), p. 107.
5. K. V. Sudakov, Patol. Fiziol., No. 1, 3 (1975).
6. V. A. Tsyrlin, M. F. Bravkov, and B. G. Bershadskii, Fiziol. Zh. SSSR, No. 5, 626 (1978).
7. B. Folkow and E. H. Rubinstein, Acta Physiol. Scand., 68, 48 (1966).