THE ROLE OF QUANTITATIVE AND QUALITATIVE FACTORS IN THE FORMATION OF REFLEX VASOMOTOR REACTION TYPES

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There are two points of view regarding the formation of quality in the reflex reactions of the blood pressure. Several workers [1, 7, 2, 3, 4, 16] consider that the quality of vasomotor reactions is determined by a quantitative factor, in other words by the intensity of the flow of afferent impulses to the vasomotor center. Under these circumstances they stress the importance of the number of nerve elements (afferent fibers, neurones) involved in the reaction [8, 9, 3]. According to the statements of the supporters of this point of view, the vasomotor afferent fibers, like the corresponding center, are functionally homogenous.

According to the other point of view the nature of vasomotor reflex reactions depends on a qualitative factor, on the specific organization of the elements of the reflex arc. There are reports of a connection between the quality of a reflex vasomotor reaction with both stimulation of the receptors of definite reflexogenic zones and with excitation of particular afferent conductors, and with the possible presence in the central nervous system of narrowly specialized formations affecting the blood pressure in a particular manner [5, 6, 15, 19, 10 and others].

In the present research we studied the role of quantitative and qualitative factors in the formation of vasomotor reflex reactions of pressor or depressor type.

EXPERIMENTAL METHOD

The work was done on dogs, cats and rabbits. The experiments on dogs were carried out under morphine-urethane anesthesia (1-2 cm^3 of 1% morphine and 1 g/kg of urethane), and those on cats and rabbits under urethane anesthesia (1 g/kg). We investigated the reflex vasomotor reactions elicited by stimulation of the nerve trunks separated from the vagus nerve in the neck. The level of the blood pressure in the right carotid artery was measured with a mercury manometer. The respiration was recorded simultaneously by means of a Marey's capsule. The central ends of the separated nerve trunks were stimulated with an induction current of varying strength (current voltage in the primary coil 4.8 v). The frequency of stimulation in the experiments was constant. In all the experiments the vagus and aortic nerves on the opposite side were divided in order to exclude the effect of reflex changes in cardiac activity.

EXPERIMENTAL RESULTS

As a result of the separation of the nerve pathways of the vagus system (16 experiments on dogs, 12 on rabbits and 6 on cats) nerve conductors were isolated from the central ends of which either purely depressor or pressor reactions, sometimes also connected with changes in respiration, were observed in response to various strengths of stimulation with the induction current. In the latter case the type of the vasomotor reactions was not determined by the accompanying changes in respiration; both pressor and depressor reactions took place on

a background of unaltered respiration, and also when respiration was stimulated or depressed. The quality of these vasomotor effects was not affected by changes in the strength of stimulation of the nerve conductors, and hence the presence of narrowly specialized vasomotor afferent pathways in the vagus nerve system was postulated. From the point of view of the "quantitative" hypothesis, however, the varying nature of the reactions of

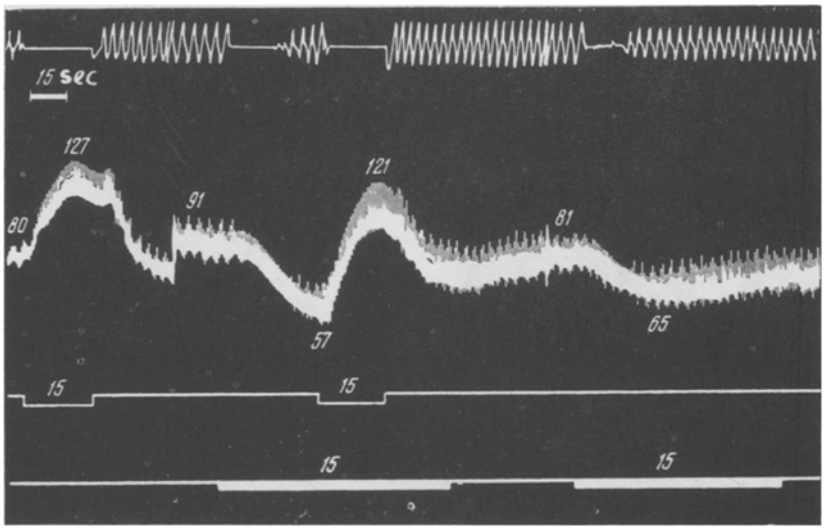

Fig. 1. Changes in the reflex vasomotor reactions in a dog (weight 6.5 kg). Anesthesia: 1 cm^3 1% morphine and 1.4 g/kg urethane. Significance of the curves (from above down): respiration, arterial pressure, stimulation marker. The figures above the stimulation marker show the strength of stimulation in cm (distance between the coils of the induction apparatus). Stimulation of part of the left vagosympathetic trunk, increasing the arterial pressure (upper marker) on a background of the depressor influence from the conductor separated from the right vagosympathetic trunk (lower marker). A weakening of the depressor effect is observed.

the blood pressure observed in response to stimulation of the conductors indicated could only be explained by a difference in the number of vasomotor fibers in these nerves. In order to test this assumption, in subsequent experiments we stimulated the functionally "different" and "similar" vasomotor nerve conductors which we had found jointly, one on the background of the other. For this purpose we used two independent circuits with separate sources of current (7 experiments on dogs, rabbits and cats — 42 combined stimuli).

In response to combined stimulation of the pressor and depressor nerve conductors, weakening of the changes in blood pressure took place in all the species of experimental animals (Figs. 1 and 2). Complete disappearance of the reaction was observed in those cases when the pressor and depressor conductors were stimulated simultaneously in strengths which separately caused equal and opposite effects (Fig. 3). The combined stimulation of two pressor or depressor conductors in the same experiments enhanced the corresponding pressor or depressor effect.

It follows from these findings that an increase in the number of vasomotor afferent fibers involved in the reaction during combined stimulation of conductors with opposite effects on the blood pressure was functionally not equivalent to the same increase in the number of exicted vasomotor fibers during the combined stimulation of "pressor" or "depressor" afferent pathways alone.

These results are evidence against the explanation of the formation of the quality of reflex vasomotor reactions by means of a quantitative factor alone, i.e., by a change in the number of excited neurones in a functionally homogenoeous vasomotor center or by a variation in the strength of the afferent impulses reaching it.

Furthermore, in response to stimulation of mixed vasomotor nerve conductors with varying strengths of current in dogs, the action of the smaller strength was to cause depressor reactions in the animal; stronger currents led to pressor reactions. In rabbits, on the other hand, weaker currents led to pressor reactions and stronger currents to depressor.

These findings are also difficult to explain from the point of view of a definite role of a quantitative factor in the formation of the type of vasomotor reflex reaction, since an increase in the number of excited vasomotor fibers and in the intensity of the afferent impulses regularly led to replacement, in one case (rabbits) of pressor reactions by depressor, and in another (dogs), on the other hand, of depressor reactions by pressor. Such a difference in the relationahip between the type of the vasomotor reactions and the strength of stimulation could evidently be explained by a difference in the quantitative distribution of the pressor and depressor fibers in the vagus nerve system of these species of animals.

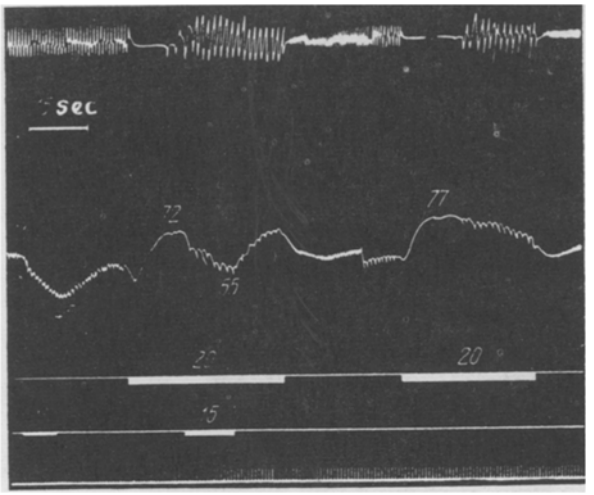

Fig. 2. Changes in the reflex vasomotor reactions in a rabbit (weight 3.5 kg). Left side. Urethane anesthesia 1 g/kg. Significance of the curves (from above down): respiration, arterial pressure, stimulation marker. Stimulation of the depressor nerve (lower marker) on a background of the pressor influence from the vagus nerve (upper marker). A weakening of the pressor effect is seen.

We postulated that the qualitatively different vasomotor nerve conductors which we studied had the same afferent nature, since the central ends of the nerve conductors forming a part of the vagus nerve system were stimulated. It is true that in the experiments on dogs the possibility was not excluded that ascending efferent fibers of sympathetic origin were also stimulated, since in dogs the vagus and sympathetic nerves pass within the same membrane and are difficult to distinguish from each other. Against the sympathetic nature of the vasomotor fibers which we studied during combined stimulation, there was the evidence of our experimental findings that narrowly specialized pressor and depressor pathways were found not only in dogs but also in rabbits, when the central ends of the vagus and aortic nerves in these animals were stimulated. Under these circumstances, in view of the anatomical isolation of the sympathetic fibers in the cervical region, the conditions were not present

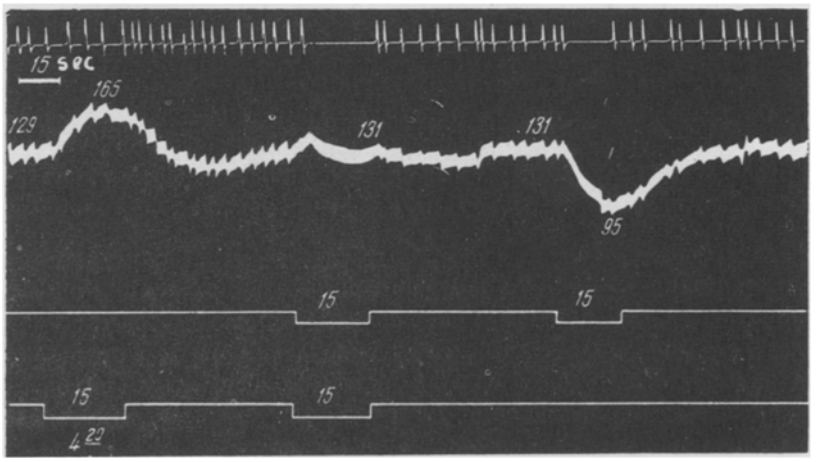

Fig. 3. Changes in the reflex vasomotor reactions in a cat (weight 4.6 kg). Left side. Urethane anesthesia 1.4 g/kg. Significance of the curves (from above down): respiration, arterial pressure, stimulation marker. Mutual weakening of pressor and depressor influences during simultaneous combined stimulation of the vagus (upper marker) and aortic (lower marker) nerves.

for the effecting of sympathetic influences on the blood pressure. That the vasomotor nerve pathways which we studied were not sympathetic was also shown by experiments on cats, in which multiple stimulation of the cervical sympathetic nerve, alone or in combination with the vagus nerve, had no effect on the level of the blood pressure. The absence of an influence of the cervical sympathetic nerve on the blood pressure was also suggested by other workers' results [5, 6, 20, 21, 14]. It may thus be assumed that the qualitatively different vasomotor nerve conductors which we studied (especially in experiments on dogs) were afferent by nature.

So far as the debatable question of the presence of specific reflex reactions of the blood pressure, independent of the number of nerve fibers brought into action, is concerned, it seems to us that our experiments provide new confirmation of the existence of such specific reactions.

Narrowly specialized reflex reactions of a rise and fall in the blood pressure were observed by us in conditions where the influence of receptors was excluded (the central ends of the nerves were stimulated). This showed that the specificity of these reactions was not due to the organization of the receptors. On the other hand, we consider that the quality of reflex changes in the blood pressure is likewise not determined by the structure of the afferent conductors themselves. It follows, for instance, from comparison of the results of our experiments with the action of an induction current on the afferent pathways of the vagus nerve system with the data obtained by a number of workers [19, 10, 17, 18] by direct stimulation of various areas of the medulla oblongata and the hypothalamus, that in both cases the results that took place were the same. This coincidence of the results of two different forms of experiments suggests that the decisive factor in determining the quality of a reflex change in the blood pressure is not the structure of the afferent conductors themselves but the structure of the central formations with which these conductors are connected. There are reports in the literature of the presence of afferent pathways in the vagus nerve system, leading not only to the medulla, but also to the supramedullary nerve formations [11, 12, 13].

On the basis of the foregoing it may be postulated that receptors, excited by adequate stimuli, selectively involve in the reaction one or other afferent nerve pathway of the vagus nerve system. Nerve impulses from this afferent pathway pass to particular narrowly specialized functional nerve formations; the distinctive features of the organization of these formations determine the quality of the reflex vasomotor reaction.

SUMMARY

In dogs, rabbits and cats there are strictly specialized vasomotor afferent pathways connected with the rise or drop of the blood pressure in the vagus nervus system. The quality of the reflex reactions from these pathways does not depend on the number of the nerve fibers excited and the intensity of the afferent impulsation reaching the vasomotor center. The quality of the reflex reactions in stimulating these afferent pathways is evidently determined not by the structure of the conductors proper, but by the features peculiar to the organization of those central formations with which the latter are connected.

LITERATURE CITED

[1] V. E. Delov, V. I. Filistovich, Problems of Corticovisceral Pathology, pp. 206-214, 1952 [In Russian].

[2] D. G. Kvasov, T. A. Trofimova, Byull. Éksptl. Biol. i. Med., 39, No. 1, 19-21 (1955).

[3] B. S. Kulaev, Byull. Éksptl. Biol. i. Med., 45, No. 6, 17-22 (1958).

[4] B. S. Kulaev, Candidate's dissertation, Moscow, 1954 [In Russian].

[5] A. I. Smirnov, Proceedings of the Thirteenth Conference on Physiological Problems, pp. 86-90, 1948 [In Russian].

[6] A. I. Smirnov, V. S. Raevskii, Byull. Éksptl. Biol. i. Med., 25, No. 2, 114-116 [1948).

[7] L. A. Toporkova, Transactions of the All-Union Society of Physiologists, Biochemists and Pharmacologists, 2, pp. 104-106, 1954 [In Russian].

[8] M. G. Udel'nov, Doctorate dissertation, Moscow, 1955 [In Russian]

[9] N. L. Yastrebtsova, Candidate's dissertation, Moscow, 1955 [In Russian].

[10] R. S. Alexander, Neurophysiology, 1946, N 9, p. 205-217.

[11] P. Bard, Am. J. Physiol., 1928, 84, p. 490-515.

[12] D. W. Bronk, F. H. Lewy, M. G. Larrabee, Am. J. Physiol., 1936, 116, p. 15-16.

[13] P. Dell, R. Olson, C. r. Soc. biol., Paris, 145, 13-14 , 1951, p. 1084-1088.

[14] L. M. Freeman, H. B. Schumacker, and L. R. Radigan, Surgery, 1950, 28, No. 2, p. 274-281.

[15] G. Gordon, J. Physiol., 1943, No. 102, p. 95-107.

[16] E. Grastyan, V. Kaldor, L. Molnar, Z. Ruzsonyi and K. Lissak, Acta Physiol., Hungarica, 1951, 2, N 1, p. 1-9.

[17] I. D. McQueen, K. M. Brown and A. E. Walker, Neurology, 1954, No. 4, p. 1-13.

[18] R. I. H. Oberholzer, Klin. Wschr., 1957, 35/9, p. 448-452.

[19] S. W. Ranson, H. W. Magoun, Ergeb. Physiol., 1939, 41.

[20] J. P. Segundo, Garcia Guelfi, An. Fac. Med. Montevideo, 38, No. 11-12, 1953, p. 461-464. Excerpta Medica (Physiology), 8, 372, 1955.

[21] F. D. Threadgill, Surgery, 1947, No. 21, p. 569-574.