VASOMOTOR EFFECTS IN INTERNAL ORGANS DEPENDING ON QUANTITATIVE CHANGES IN IMPULSES FLOWING ALONG POSTGANGLIONIC FIBERS

(UDC 612.187.1/.4:612.893)

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 60, No. 11,
pp. 10-14, November, 1965
Original article submitted June 30, 1964

Previous investigations have shown that an increase and decrease in the blood flow in the abdominal viscera may be brought about by quantitative changes in the flow of impulses following stimulation of the splanchnic nerves, preganglionic fibers of the solar plexus [3, 5]. It has also been found that stimulation of the splanchnic nerve is accompanied by changes in the impulse activity of the postganglionic fibers [4]. These observations have not ruled out the possibility that the dilatation effect arising in response to weak and low-frequency stimulation may be regarded as the result of a lowering of the constrictor tone of the postganglionic neurons.

To elucidate the causes of the development of these various vasomotor effects, a series of experiments was performed in which the postganglionic fibers of the solar plexus were stimulated directly with currents of different frequency, voltage and duration of the volley of impulses.

METHOD

The vascular reactions of the abdominal viscera (intestine, kidneys, spleen) were studied in cats (25 experiments) anesthetized with ether and urethane by means of the resistographic method [6], with simultaneous recording of the general blood pressure in the femoral artery. Vasomotor reactions were evoked by electrical stimulation of the postganglionic fibers of the solar plexus running along the superior mesenteric and splenic arteries. The peripheral fibers running from the solar plexus along these arteries were divided. Individual branches of the plexus, 10-15 mm in length, running along the vessel were dissected and stimulated.

To exclude more completely the connections between the stimulated branch and the central nervous system, besides dividing the greater and lesser splanchnic nerves, the author removed the abdominal sympathetic chain on both sides, with all the ganglia, starting with the 1st lumbar.

According to the findings obtained by A. S. Gusev [1], if the greater splanchnic nerve is divided, the afferent fibers from the abdominal viscera running to the 5th-11th thoracic spinal ganglia and the sympathetic efferent fibers running from the 5th-12th thoracic segments of the spinal cord are severed.

Removal of the ganglia of the abdominal sympathetic chain and division of the lesser splanchnic nerves carrying afferent fibers from the internal organs to the 9th-12th spinal ganglia and efferent fibers from the segments T9-L1, results in the complete isolation of the region of distribution of the nerve fibers of the solar plexus from the central nervous system [1].

The facts described above [1] are in agreement with those reported by other workers [2, 7]. In accordance with these anatomical and functional data, excitation of the postganglionic fibers of the solar plexus mentioned above cannot be transmitted to the central nervous system, and is accompanied by reflex influences on the vessels of the abdominal viscera.

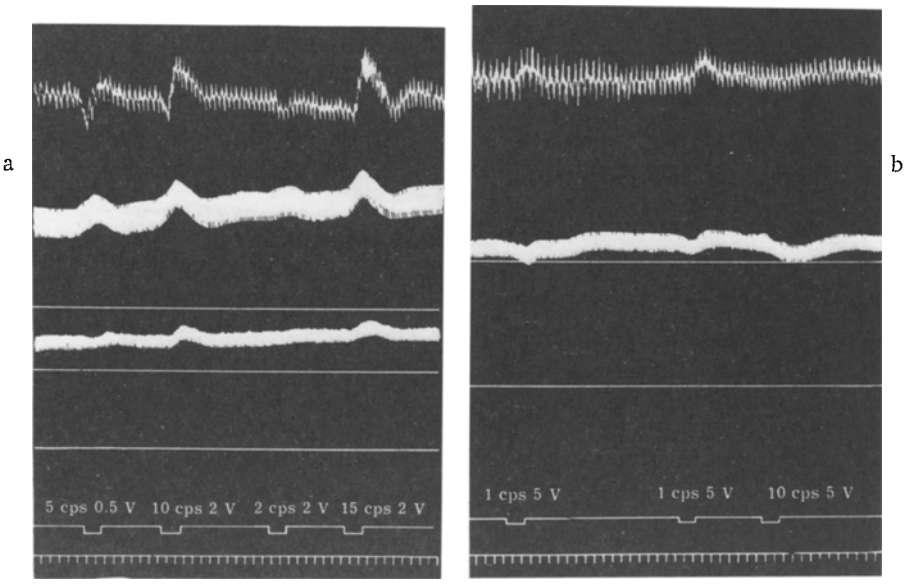

Fig. 1. Relationship between frequency of stimulation and character of vasomotor effect during stimulation of postganglionic fibers of the solar plexus. Significance of the curves (from top to bottom): a) arterial pressure; resistogram of superior mesenteric artery; resistogram of left renal artery; stimulation marker; time marker (5 sec); b) arterial pressure; resistogram of left renal artery; stimulation marker; time marker (5 sec). The straight horizontal lines show zero pressures for these tracings.

RESULTS

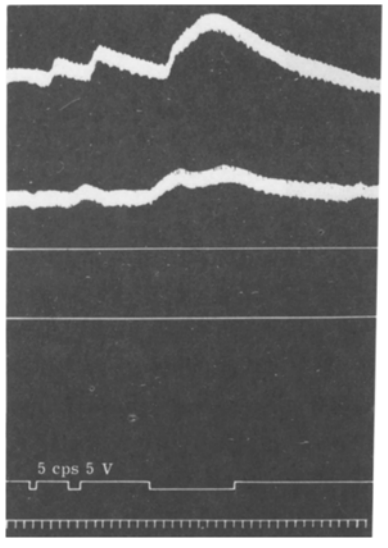

Fig. 2. Relationship between duration of stimulation and character of the vasomotor response during stimulation of the postganglionic fibers of the solar plexus. Significance of the curves as in Fig. 1b .

With a variation in the frequency of stimulation of the postganglionic fibers, dilator effects appeared in response to lower frequencies than constrictor. The reactions of the vessels of the intestine and kidney to stimulation of constant strength (2 V) of the nerve fibers lying along the superior mesenteric artery are illustrated in Fig. 1a. It is clear from Fig. 1 that stimulation with a frequency of 2 cps caused slight constriction of the intestinal vessels but had practically no effect on the renal vessels. Stimulation with a current of a frequency of 5 cps led to a more marked constriction of the intestinal vessels. The renal vessels, on the other hand, dilated. During stimulation with a current of higher frequency (10 and 15 cps), vasoconstriction developed in both sets of vessels.

Some particularly important results were obtained in experiments in which an increase in the frequency of the impulses during stimulation of the the postganglionic fibers within certain limits led to an increase in the severity of the vasodilator effect. The curves in Fig. 1b show that stimulation of the postganglionic nerves of the solar plexus with a current of a frequency of 1 cps and a constant strength of 5 V caused dilatation of the renal vessels, the degree of which increased when the frequency was raised to 10 cps.

Hence, an increase in the frequency of the impulses led to an increase in the strength of the vasodilator effect. The results of this experiment cannot agree with the hypothesis which denies the presence of active vasodilator nervous effects and which postulates that vasodilatation is simply the result of relaxation of the nervous effect which is always vasoconstrictor in

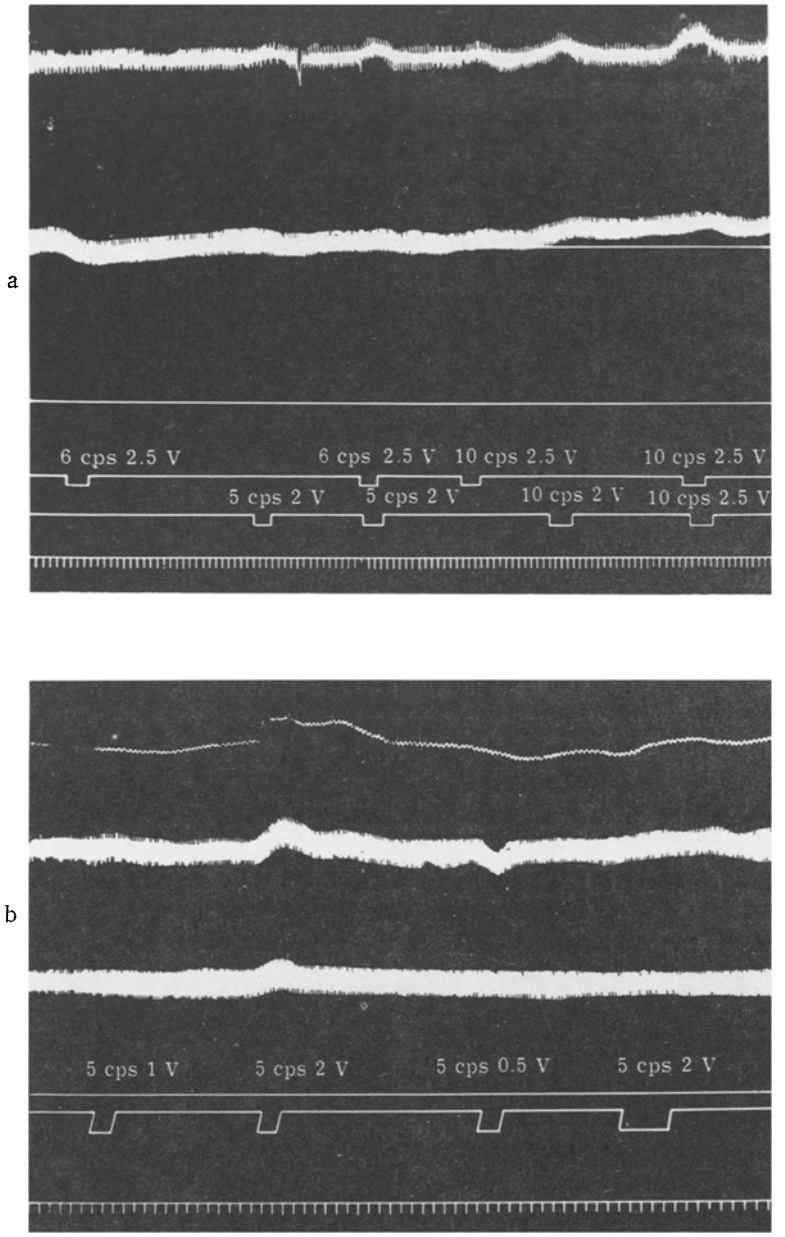

Fig. 3. Relationship between the number of excited fibers and the character of the vasomotor effect during stimulation of the postganglionic fibers of the solar plexus. Significance of the curves (from top to bottom): a) arterial pressure; resistogram of superior mesenteric artery; stimulation marker; time marker (5 sec); b) arterial pressure; resistogram of superior mesenteric artery; resistogram of splenic artery; stimulation marker; time marker (5 sec). The straight horizontal lines are zero pressures for these tracings.

nature. Without ruling out the possibility of a constrictor tone in general, the results of the experiments described above show that dilatation can take place actively as the result of impulse action, and not by its exclusion.

In experiments in which the duration of stimulation was varied while the strength and frequency remained unchanged (the individual pulses of current were constant), dilator effects arose in response to transient stimulation.

Figure 2 shows that stimulation of the nerves running along the superior mesenteric artery by a current of constant frequency (5 cps) and a voltage of 5 V, and of short duration (1.5 sec) was accompanied by dilatation of the renal vessels; with an increase in the duration of stimulation (5 sec) a constrictor effect was observed. The vasoconstriction was stronger still when the duration of the volley of impulses was further increased to 40 sec.

In some experiments different numbers of postganglionic nerve fibers were stimulated (Fig. 3a). In this case the intestinal vessels dilated during stimulation of one of the branches running along the superior mesenteric artery (frequency 6 cps, voltage 2.5 V) and also during stimulation of another branch (frequency 5 cps, strength 2 V). If both branches were stimulated together, however, constriction of the vessels of this organ took place, to a definite but weak degree. In this case,functionally opposite effects were caused by impulse activity in the same fibers running along the mesenteric artery. The difference in the nervous action was merely that when the branches were stimulated separately, relatively fewer nerve fibers were involved in the impulse activity, while when they were stimulated together a larger number of the same fibers was involved.

It is clear from Fig. 3 that stimulation of the same nerve branches separately by a high-frequency current (in both cases 10 cps) led to a constrictor effect, which was increased when both branches were stimulated together by a current of the same parameters.

On the assumption that stimuli of different strength are equivalent to different numbers of excited nerve fibers, the functionally varied vasomotor effects shown in Fig. 3b and arising in response to different strengths of stimulation may have resulted from differences in the number of fibers involved in activity. In this case, during stimulation of the postganglionic fibers, dilatation of the intestinal vessels is observed during weaker stimulation (voltage 0.5 V). An increase in the strength of stimulation to 1 V was accompanied by slight constriction of the vessels in this region. A further increase in the strength of stimulation (2 V) intensified the vasoconstrictor effect. In this experiment the threshold voltage for stimulation of the splenic vessels was 2 V.

The results of these experiments thus show that stimulation of the postganglionic fibers of the solar plexus in a manner permitting the generation of weak discharges of low-frequency impulses and volleys of impulses of short duration is accompanied by vasodilator effects, whereas stimulation with a current of higher voltage and frequency and of longer duration leads to vasoconstrictor effects. These results can be taken to show that the replacement of vasoconstrictor effects by vasodilator is determined by quantitative variations in the excitation in the postganglionic nerve fibers, while ganglionic structures behave in the conditions of a flow of nervous impulses from the central nervous system mainly as an effector transmission apparatus.

SUMMARY

It was shown in experiments on cats under ether-urethane anesthesia with registration of the vascular reactions of the abdominal cavity organs by resistography that stimulation of the postganglionic fibers of the plexus with low frequencies, weak intensities and short-lived stimuli is accompanied by dilatory reactions whereas stimulation of a comparatively greater frequency, intensity and duration produces a constrictive effect. In a number of experiments the growth of impulse frequency within certain limits caused an increase in the markedness of dilatory responses which is at variance with the hypothesis explaining dilation as a consequence of diminution of constrictive nerve influence. The data obtained indicate that the functional sign of the vascular effect is determined by the quantitative variations of stimulation in the postganglionic nerve pathways.

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