CHANGES IN THE ACTIVITY OF VARIOUS PARTS OF THE SYMPATHETIC NERVOUS SYSTEM FOLLOWING STIMULATION OF THE MECHANICORECEPTORS OF THE RECTUM

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A fundamental factor in the explanation of the mechanisms of the pressor and depressor reactions of the arterial pressure to stimulation of various reflexogenic zones is the comparison of the effects of stimulation of these zones in the bladder and rectum. These two organs are innervated by the same nerves—the pelvic, pudendal, and hypogastric nerves, yet stimulation of the mechanicoreceptors of these organs has been shown to give rise to opposite changes in the arterial pressure.

All investigators who have conducted acute and chronic experiments on animals have observed an increase of arterial pressure during filling of the urinary bladder. The same has been observed in healthy persons and patients. Conversely, during filling of the rectum in experiments on animals, most workers have observed a fall of arterial pressure [1, 2, 7, 10], and this has been confirmed by clinical observations [8]. Only occassionally have pressor reactions been observed in addition to depressor in response to stimulation of the mechanicoreceptors of the rectum in experiments on dogs [9], while M. P. Kul'vanovskii has shown that, after division of some of the afferent nerves, pressor reactions are converted into depressor.

In order to elucidate the reasons for these differences it was necessary to analyze the changes in the intensity of the efferent sympathetic impulses passing towards different vascular regions during stimulation of the mechanicoreceptors of the bladder and rectum. These changes during stimulation of the mechanicoreceptors of the bladder have already been investigated by us [4-6]. When comparing the tone of the vessels with the changes in the impulses directed towards them (in the kidneys, skeletal muscles, skin, and hind limbs) we found that depression of the flow of impulses leads to vasodilatation and stimulation to vasoconstriction. The redistribution of the changes in the activity of the sympathetic nervous system thus discovered provides for the development of pressor reactions during stimulation of the receptors of the bladder at all strengths except the weakest, at which in 15% of experiments depressor reactions of the general arterial pressure were observed.

The present paper describes the results of an analysis of the changes in the intensity of sympathetic impulses passing towards various vascular regions, compared with the reactions of the arterial pressure to stimulation of the mechanicoreceptors of the rectum.

EXPERIMENTAL METHOD

Altogether 65 experiments were conducted on cats under urethane anesthesia (1 g/kg body weight, intravenously). To stimulate the mechanicoreceptors of the rectum, a small rubber finger-stall was inserted into the organ and filled with air at a definite pressure. Recordings were made of the pressure in the carotid artery and in the rectum (mercury manometer). Meanwhile the action potentials of any two of the following nerves were recorded on a cathode-ray oscillograph: hypogastric, intestinal, renal, splenic, cardiac, cutaneous (to the skin of the hind limb), and cervical sympathetic trunk. The amplifier used had a linear frequency characteristic between 0.3 and 2000 cps.

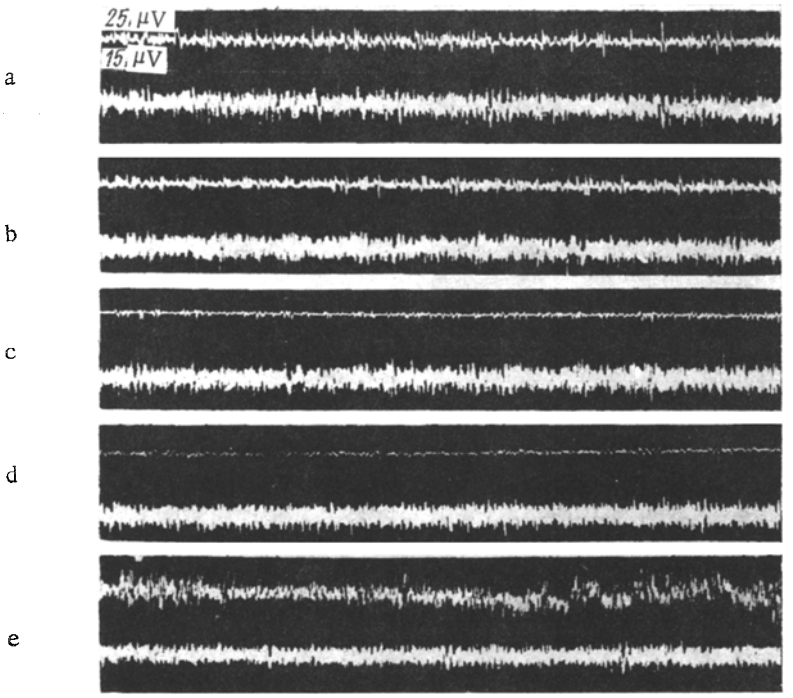

Fig. 1. Changes in intensity of efferent impulses in the hypogastric nerve and cervical sympathetic trunk during various strengths of stimulation of the mechanicoreceptors of the rectum. a) Background activity in both nerves with the rectum empty; b, c) pressure in rectum 18 and 30 mm Hg respectively; flow of impulses in hypogastric nerve inhibited, flow in cervical sympathetic trunk unchanged; d) intrarectal pressure 60 mm Hg, flow of impulses inhibited in both nerves; e) pressure in rectum 82 mm Hg; flow of impulses in hypogastric nerve increased, flow in cervical sympathetic nerve inhibited. Significance of curves (from above down): impulses in central end of hypogastric nerve; time marker (0.01 sec); impulses in central end of cervical sympathetic trunk.

EXPERIMENTAL RESULTS

During stimulation of the mechanicoreceptors of the rectum the changes in the flow of efferent impulses in some nerves took the form of depression in response to application of any effective strength of stimulation whatever (cardiac sympathetic nerves, cutaneous nerves of the hind limb, cervical sympathetic trunk), while in others a biphasic reaction was observed: depression of the flow of impulses in response to weak or moderately strong stimulation and an increase in the intensity of the impulses during strong stimulation (hypogastric, intestinal, renal, and splenic nerves). In very few experiments a third phase of changes in the efferent impulses was observed in the hypogastric (13%) and intestinal (11%) nerves.

Tracings of the efferent impulses in two nerves in which the intensity of flow was altered differently are given in Fig. 1. In the hypogastric nerve it diminished in response to weak (18 mm Hg) and moderately strong (30 and 60 mm Hg) stimulation and increased during strong (82 mm Hg) stimulation. In the cervical sympathetic trunk the flow of impulses always diminished in response to an effective strength of stimulation (60 and 82 mm Hg), and the threshold of onset of changes in the flow of efferent impulses in the hypogastric nerve (18 mm Hg) was much lower than the corresponding threshold of the changes in the impulses in the cervical sympathetic trunk (60 mm Hg).

In the intestinal and splenic nerves biphasic changes took place in the flow of efferent impulses in response to stimulation of increasing strength of the mechanicoreceptors of the rectum (Fig. 2). However, the thresholds of onset of the changes differed to some extent. In the intestinal nerve this threshold was slightly lower than in the splenic, and in response to weak stimulation (20 mm Hg) the flow of efferent impulses in the intestinal nerve thus was inhibited while that in the splenic nerve showed no visible change (Fig. 2b). When the strength of stimulation was in-

creased to 34 mm Hg, inhibition of the flow of efferent impulses was seen in both nerves (Fig. 2c). However, an increase in the strength of stimulation to 68 mm Hg led to the appearance of divergent reactions: in the intestinal nerve the flow of impulses was intensified, while in the splenic nerve the flow was inhibited as before (Fig. 2d). A further increase in the strength of stimulation of the mechanicoreceptors of the rectum caused an increase in the flow of impulses in both nerves (Fig. 2e).

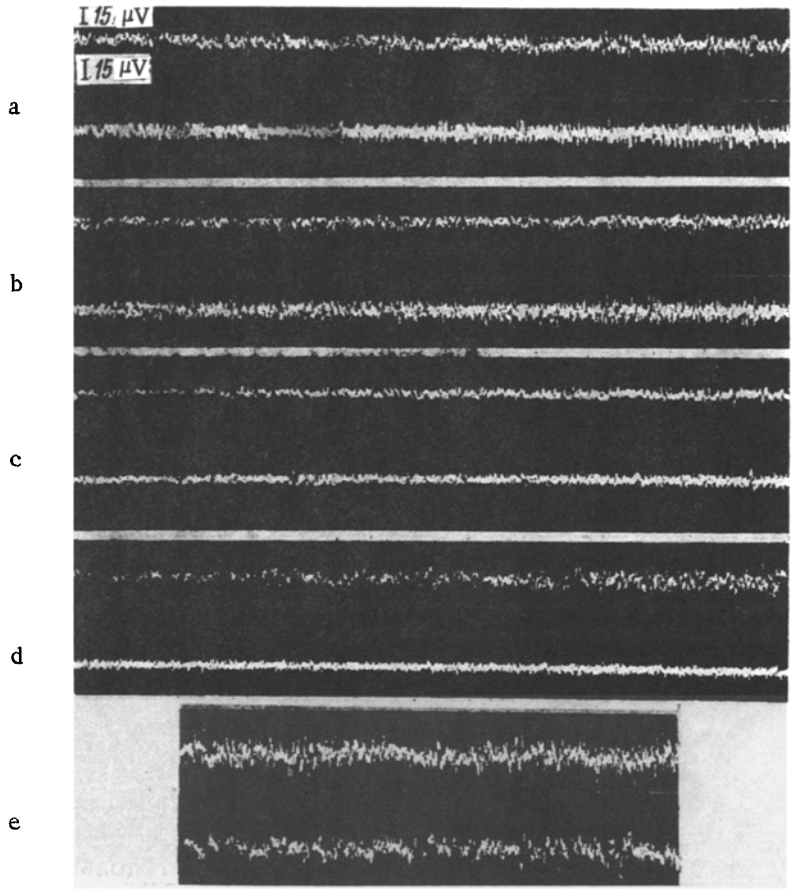

Fig. 2. Changes in intensity of efferent impulses in the intestinal and splenic nerves. a) Background activity in both nerves with the rectum empty; b) pressure in rectum 20 mm Hg, flow of impulses in intestinal nerve inhibited, flow in splenic nerve unchanged; c) pressure in rectum 34 mm Hg, impulses in both nerves inhibited; d) pressure in rectum 68 mm Hg, flow of impulses in intestinal nerve increased, flow in splenic inhibited; e) pressure in rectum 100 mm Hg, flow of impulses in both nerves increased. Significance of curves (from above down): flow of impulses in central end of intestinal nerve; time marker (0.01 sec); flow of impulses in central end of splenic nerve.

Hence, in the cervical sympathetic trunk the flow of impulses was changed only in response to strong stimulation of the rectal mechanicoreceptors, and inhibition took place. Weak and moderately strong stimulation proved ineffective. The same was observed in the cutaneous nerve. In the cardiac sympathetic nerves, in some experiments an increase in the flow of impulses took place in response to the strongest stimulation. In the other nerves (hypogastric, intestinal, renal, and splenic) the flow of impulses was inhibited in response to weak or moderaly strong stimulation and increased in response to strong, while the threshold of the change from the first reaction to the second, like the threshold of onset of the first reaction, differed for each nerve.

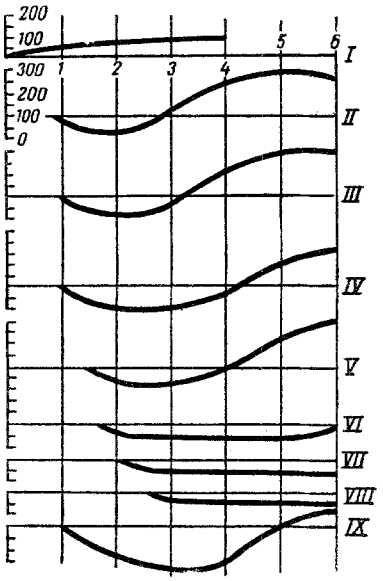

Fig. 3. Effect of stimulation of rectal mechanicoreceptors on flow of afferent (pelvic nerve) and efferent impulses in sympathetic nerves and on corresponding changes in the general arterial pressure. Along the axis of abscissas) strength of stimulation of rectal mechanicoreceptors (in relative units; the strength of stimulation causing a threshold change in general arterial pressure is taken as the unit). Along the axis of ordinates: I) number of afferent impulses per second; II, III, IV, V, VI, VII, and VIII) efferent impulses (as a percentage of initial level) in the hypogastric, intestinal, renal, splenic, cardiac, and cutaneous nerves and in the cervical sympathetic trunk respectively; IX) changes in general arterial pressure (in mm).

It is clear from Fig. 3 that with an increase in the intensity of flow of afferent impulses of the same origin, the flow of efferent impulses underwent different changes in different sympathetic nerves. In the hypogastric nerve it diminished during stimulation at a strength not causing changes in the general arterial pressure. In the intestinal and renal nerves this decrease in the intensity of the flow of impulses coincided with the appearance of a depressor reaction of the general arterial pressure. In the remaining four investigated nerves it was above the threshold of the reaction of the general arterial pressure. The change from inhibition to increased intensity of the flow of efferent impulses also took place at a lower strength of stimulation in the hypogastric nerve than in the other nerves investigated. In each successive nerve (see Fig. 3) this change took place at a greater strength of stimulation of the rectal mechanicoreceptors. Finally, in the cardiac nerve, this change occurred in only 50% of the experiments, and in the other 50% the flow of impulses in response to any strength of stimulation was inhibited. In the cutaneous nerve and the cervical sympathetic trunk, as a rule no such change was noted, and only inhibition of the flow of impulses took place.

The depressor reaction of the general arterial pressure increased as inhibition of the flow of efferent impulses developed in more and more nerves. However, at the same time as this flow of impulses increased in intensity, the depth of the depressor reaction of the general arterial pressure was diminished. Finally, with strong stimulation of the rectal mechanicoreceptors, from 5 to 6 times as strong as that required to cause the appearance of the depressor reaction, in 60% of experiments a pressor reaction of the general arterial pressure developed, and this evidently corresponded to the increase in the intensity of the flow of efferent impulses in the majority of the sympathetic nerves.

Hence, the general principles governing the changes in the flow of efferent sympathetic impulses to different organs and regions of the body during stimulation of the rectal mechanicoreceptors are the same as during stimulation of the mechanicoreceptors of the bladder [4-7]. However, during stimulation of the rectum, as a rule, there was no sign of the third phase of the relationship previously reported, i.e., of depression of the flow of impulses in the hypogastric and intestinal nerves in response to strong stimulation of the receptors.

During stimulation of the rectum, the first stage of inhibition of the flow of impulses was much deeper and covered a wider range of strengths than during stimulation of the receptors of the bladder. Finally, in 50% of the experiments, the second phase of the changes in the flow of impulses (an increase in its intensity) did not develop in the cardiac sympathetic nerves during stimulation of the rectum, whereas this phase was recorded in every case during stimulation of the bladder. This shows that stimulation of the mechanicoreceptors of the rectum has a weaker effect on the flow of efferent sympathetic impulses than stimulation of the mechanicoreceptors of the bladder of the same strength. Since this flow of impulses in fact regulates the vascular tone in the regions to which it is directed, the reaction of the vessels to stimulation of the rectal mechanicoreceptors is less intensive than that to stimulation of the mechanicoreceptors of the bladder of the same strength, and in most regions depressor reactions predominate—i.e., vasodilatation as a result of a decrease in the flow of impulses towards them. One result of this is that stimulation of the rectum causes depressor reactions of the arterial pressure, and only in 60% of experiments very strong stimulation (5-6 times stronger than the threshold for producing a reaction of the arterial pressure) was followed by biphasic pressor reactions. It seems that the fact that several authors observed both depressor and pressor reactions in dogs may be explained by the lower threshold of onset of pressor reactions to stimulation of the rectum in these animals.

It was established that with accurate grading of the strength of stimulation, a reflex decrease or increase of the general arterial pressure, a decrease or increase in the intensity of the flow of sympathetic impulses in the various sympathetic nerves and, corresponding to these changes, dilatation or constriction of the peripheral vessels may be caused from both receptive fields studied in these experiments. The differences described between the reflexogenic zones are determined by the intensity of the flow of afferent impulses arising from them and, consequently, by differences in the thresholds of onset of the various phases of the relationship observed between the character of the reaction and the strength of stimulation. This also accounts for the fact that at moderate strengths of stimulation, such as have usually been employed by other authors, stimulation of the receptors of the bladder caused only pressor reactions, whereas stimulation of the rectal receptors caused depressor reactions.

SUMMARY

Acute experiments were staged on cats. Changes in the efferent sympathetic impulsation in the hypogastric, intestinal, renal, splenic, cardiac nerves and in the saphenous and the cervical sympathetic stem were studied following stimulation of the rectal mechanicoceptors by stimuli of different intensity. The relationship of the nature of changes provoked in the efferent sympathetic impulsation to different organs and body areas to the intensity of stimuli applied to the rectal mechanoceptors proved to be the same as in stimulation of the mechanoceptors of the urinary bladder. However, the threshold of appearance of the impulsation changes following stimulation of the rectal mechanicoceptors was higher than after stimulation of those of the bladder. In rectal stimulation the first stage of impulsation inhibition was much more profound in all the nerves and was observed over a greater intensity range than in stimulation of vesical receptors. Since this impulsation controlled the vascular tone, the dilatation reaction of the vessels in response to rectal stimulation was more, and constriction less intensive than following vesical stimulation; vasodilatory reactions prevailed in the majority of the areas. Due to this fact stimulation of the rectum provokes mainly depressor reactions of systemic arterial pressure, and pressor reactions ensure only in response to stimulation of considerable intensity.

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