STIMULATION OF THE VASCULAR BED OF THE SMALL INTESTINE AS A CAUSE OF REFLEX CHANGES IN ITS MOTILITY IN PERITONITIS

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The development of effective methods for preventing dynamic obstruction in peritonitis is a pressing problem for surgery, since intestinal paresis frequently results in death despite active antibacterial therapy. The mechanism by which paralysis of the motor system develops in this disease has not been sufficiently well studied.

The majority of authors believe that the development of dynamic intestinal destruction is governed by neurogenic factors. In the opinion of some [1, 2, 9], this inhibition of the gastrointestinal motor system results from depression of the parasympathetic nervous system. Other investigators [4, 5] indicate that the motor system is inhibited by overexcitation of the sympathetic nervous system.

Certain authors [3, 6, 8] hold that paralysis of the alimentary motor system is caused by disturbances occurring in the central nervous system as a result of general intoxication of the organism. At the same time, there are indications in the literature that inhibition of the motor system may be caused by the poisonous effect of toxins on the smooth musculature of the intestinal wall [1].

In order to investigate this problem we employed isolated perfusion of an intestinal loop, simultaneously recording the motility of both the perfused loop and an adjacent loop of the small intestine.

EXPERIMENTAL METHOD

The experiments were conducted on dogs weighing 8-15 kg. In acute experiments two segments of the middle third of the small intestine were dissected out; catheters were introduced into the blood vessels of one segment. The perfusion was carried out either from a tank under pressure created by an oxygen supply from a cylinder or from an unanesthetized donor dog, which was preliminarily given heparin (520 units/kg). For the perfusion we used blood from healthy animals and from animals which had been injected intraperitoneally with a 30% fecal suspension in a dose of 0.5 ml/kg of body weight 2-3 days before the perfusion was begun, this leading to the development of fecal peritonitis [2, 7].

In all the experiments we determined the arterial pressure, respiration, and motor activity of the two isolated intestinal loops of the recipient dog. The contractions of the annular musculature were recorded with the aid of a bulb inserted into the lumen of the intestine, while those of the longitudinal musculature were recorded with the aid of an Engel'man lever. In a number of experiments the perfusion pressure was recorded on a kymograph tape.

EXPERIMENTAL RESULTS

In 10 control experiments we investigated the influence of perfusion under a pressure of 110-140 mm Hg on the motility of an isolated intestinal segment. In three experiments the perfusion was carried out from the femoral artery of a donor dog, while in 7 experiments it was conducted from a tank filled with aerated blood from a healthy animal bled immediately before the experiment. In all these experiments no marked change in motility was noted in either the perfused or adjacent loops of the small intestine over a period of 3-4 h. In those cases where the arterial

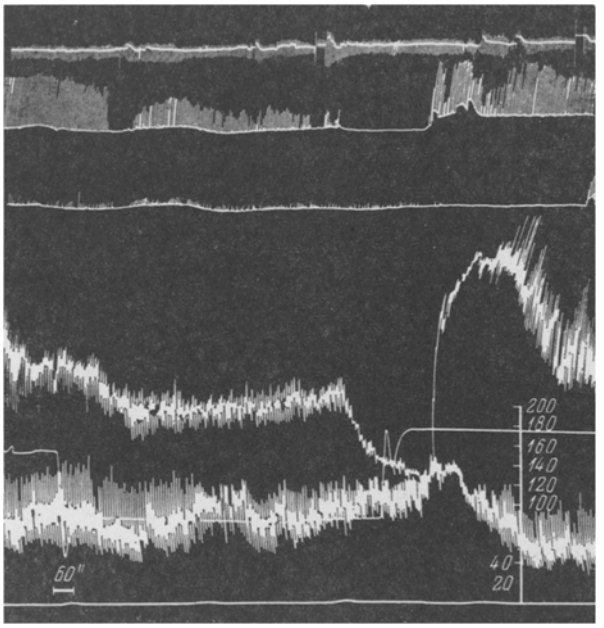

Fig. 1. Influence of a decrease in perfusion pressure on the motility of the small intestine. The curves represent (from top to bottom): respiration, contractions of the annular musculature of the intestinal wall of the perfused loop, contractions of the annular musculature of the wall of the adjacent loop, contraction of the longitudinal musculature of the intestinal wall of the perfused loop, perfusion pressure, contractions of the longitudinal musculature of the wall of the adjacent loop, and the perfusion-pressure zero line.

pressure of the donor dog was reduced to 60-80 mm by the blood-letting, complete inhibition of motility developed in the perfused loop; depression of the motility of the adjacent segment of the intestine set in after 15-20 min. Replacement of the blood lost by the donor dog, which led to reestablishment of the initial arterial pressure, caused complete restoration of motility in both segments of the intestine within 15-20 min.

Analogous data were obtained in the experiments involving perfusion from a tank. Reducing the perfusion pressure to 60 mm Hg caused a stable inhibition of motility in the perfused loop after 1-5 min; depression of the motility of the adjacent, unperfused segment of the small intestine developed 15-20 min later. It must be noted that even after perfusion at low pressure for 2-3 h, raising the perfusion pressure to 120-140 mm Hg for 3-10 min led to a complete restoration of motility in both loops (Fig. 1).

In all the experiments in which perfusion was carried out with blood from a healthy animal a clear dependence was noted between the perfusion pressure and the volume of blood passing through the perfused loop. While an average time of 2 min, 25 sec was required for 10 ml of blood to pass through the loop at a perfusion pressure of 120 mm Hg, an average of 10 min, 45 sec was required for the same quantity of blood to pass through it after the perfusion pressure was reduced. Increasing the perfusion pressure to the initial level led to a restoration of blood flow.

The experiments described above showed that the motor activity of the perfused intestinal segment remained essentially unchanged on prolonged perfusion under a constant pressure of 120-140 mm Hg. It was also established that a decrease in perfusion pressure to 60 mm Hg and the associated reduction in blood flow led to inhibition of the motility of the perfused segment and depression of that of the adjacent, unperfused segment of the small intestine.

In 23 experiments a segment of the small intestine was perfused with blood from animals with experimentally induced peritonitis. Six of these unanesthetized dogs with fully developed fecal peritonitis were used as donors. In all the experiments we noticed a decrease in blood flow through the perfused loop after perfusion began and complete cessation of contraction of the annular and longitudinal musculature of the wall of the perfused loop after 5-10 min. The motility of the adjacent segment of the small intestine also changed at this time: in the longitudinal musculature the periods of contraction were replaced by periods of a severe drop in tonus and the annular musculature did not contract at all; complete inhibition of motility developing in this segment of the small intestine within 30-60 min (Fig. 2A, B, and C).

Since the donor animals exhibited a low (of the order of 60-80 mm) arterial pressure in all these experiments, which might of itself have caused the depression of motility; in the next 17 experiments the loop was perfused from a tank under a constant pressure of 120-140 mm Hg. For the perfusion we used blood from animals killed in the same manner as in the control experiments, by acute exsanguination after 2-3 days of experimental fecal peritonitis.

The experiments showed that the blood flow through the loop decreased progressively at a constant perfusion pressure. While an average of 3 min, 8 sec was required for 10 ml of blood taken from healthy animals to flow through the loop, this index was 5 min 16 sec after perfusion with blood taken from animals with fecal peritonitis was begun, subsequently reaching 10 min, 15 sec; 15 min, 46 sec; 18 min, 22 sec; and 24 min, 9 sec. It must be noted that in these experiments increasing the perfusion pressure to 200-220 mm Hg did not cause the blood flow through the perfused loop to increase. The changes in motility had a similar character and occurred at the same intervals in these experiments.

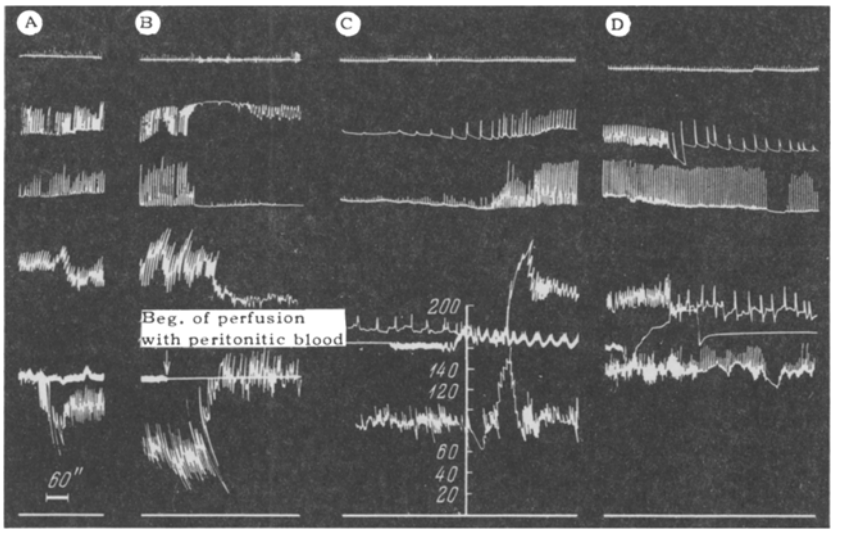

Fig. 2. Influence of perfusion of a loop with blood taken from an animal with fecal peritonitis on the motility of the small intestine. The curves represent the same quantities as in Fig. 1. A) Perfusion of loop with blood taken from healthy animal; B) switch to perfusion with blood taken from animal with fecal peritonitis; C) 40 min after beginning of perfusion with blood taken from animal with fecal peritonitis; switch to perfusion of loop with blood taken from healthy animal; D) switch to perfusion with blood taken from animal with fecal peritonitis.

In order to demonstrate conclusively that the changes which we observed in the blood flow and motility of the perfused loop resulted from the toxic influence of the blood taken from animals with fecal peritonitis, in 12 experiments we bathed the loop in blood taken from healthy animals. For this purpose the arterial catheter was connected to the carotid artery of the recipient dog, i.e., the specimen was transferred to autoperfusion. Immediately thereafter the blood flow through the loop reverted to its initial level, which indicated elimination of the vascular spasm. In this case the motility of the adjacent, unperfused intestinal segment was restored within 3-5 min in all the experiments. The motility of the perfused loop reverted to its initial level in 6 experiments (see Fig. 2), the activity of the annular musculature was reduced in 2 experiments, and motility was not restored at all in 4 experiments.

We have already noted that when the perfused loop exhibited ischemia resulting from a decrease in perfusion pressure or from perfusion with blood taken from an animal with fecal peritonitis the motility of the adjacent, unperfused intestinal segment was also inhibited.

The reflex nature of this inhibition was confirmed in 10 experiments in which the inhibition of the motility of the unperfused loop was eliminated by instituting a ganglionic block. Intravenous injection of the gangliolytic dicholine in doses of 50-250 μg/kg restored the motility of the unperfused intestinal segment in all cases, despite a substantial drop in arterial pressure (Fig. 3b).

Since the stimulation of motility in these experiments can be attributed to the general action of dicholine, in 12 experiments we blocked the receptors of the perfused loop with 2% novocaine against a background of developing inhibition of motility. In all the experiments the motility of the unperfused segment was restored immediately after the novocaine was added to the perfusate (Fig. 3a).

The experiments which we conducted showed that the inhibition of the motility of the perfused loop may be attributed to the decrease in blood flow resulting either from a moderate decrease in perfusion pressure or from the progressive vascular spasm caused by the toxic action of the substances contained in the blood taken from animals with fecal peritonitis.

There is obviously a direct toxic action on the smooth musculature of the intestine in perfusion with blood taken from animals with fecal peritonitis. This is indicated by the fact that the elimination of vascular spasm and

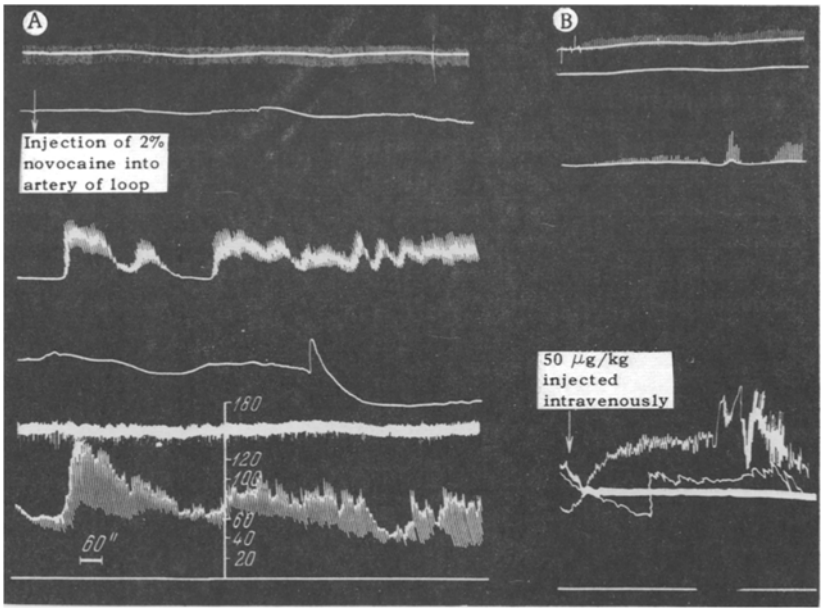

Fig. 3. Elimination of reflex inhibition of the motility of the small intestine on blocking of the receptors of the perfused loop with 2% novocaine (A) and on institution of a ganglionic block (B). The curves represent the same quantities in Fig. 1.

restoration of initial blood flow after shifting to autoperfusion did not lead to reestablishment of the initial motility in half of the experiments. Conversely, a temporary decrease in perfusion pressure did not cause any disruption of the activity of the smooth musculature. This may be seen from the fact that increasing the perfusion pressure to 120 mm Hg caused complete restoration of the motility of the perfused loop, even after a 2-3 h period of inhibition.

The inhibition of the motility of the unperfused segment of the small intestine, both in the experiments involving a decrease in perfusion pressure and in those involving perfusion with blood taken from animals with fecal peritonitis, obvisouly resulted from stimulation of the interoceptors of the perfused loop. There is no doubt about the reflex nature of these changes, since ganglionic blocking and blocking the receptors of the perfused loop with 2% novocaine soon restored its motility.

The results of the experiments conducted enable us to suggest that toxic agents appearing in the blood may play a material role in the pathogenesis of the dynamic intestinal obstruction which develops in peritonitis. These agents not only have a direct inhibitory influence on the smooth musculature of the intestinal wall, but also stimulate the chemoreceptors of the vascular bed and cause a reflex attenuation of the motility of the adjacent segments of the small intestine.

The drop in system blood pressure frequently observed in peritonitis may also play a material role in the inhibition of intestinal motility. Local circulatory disturbances in the intestine may also be of some importance, since a drop in blood pressure in one section leads to reflex attenuation of motility in adjoining segments.

The mechanisms discovered enable us to pose the question of the expediency of instituting a ganglionic block in conjunction with the other measures employed to prevent intoxication, since such a block not only eliminates the reflex component of the inhibition of motility, but to a considerable extent eliminates the inhibitory effects of the drop in blood pressure.

SUMMARY

It was shown in acute experiments on dogs that toxic factors causing motility inhibition of the small intestines are present in the blood of dogs with experimentally induced peritonitis.

This motility inhibition is associated both with the direct toxic action on the smooth musculature of the intestine,

and with the reflex effect from the chemoceptors of the intestinal vessels. It was also experimentally demonstrated that in the intestinal motility inhibition in peritonitis a significant role was possibly played by the arterial pressure drop observed frequently in this infection.

The ascertained mechanisms permit a suggestion that along with the routine means of intoxication control it would be expedient to employ the ganglionic block eliminating the reflex component of the motility inhibition and removing, in a large degree, the inhibitory effects resulting from the blood pressure reduction.

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