Thus the results are evidence that inhibition of the surface-active properties of SL takes place in newborn rats whose mothers were poisoned with alcohol before and during pregnancy, reduction of the surface activity of SL is evidently linked both with the direct damaging action of ethyl alcohol, which passes freely through the placental barrier, on the surface-active film and also with inactivation of the surface-active substance by blood plasma proteins, entering the alveolus on account of increased permeability of the components of ABB. Inhibition of the surface-active properties of SL under these circumstances is accompanied by enhanced functional activity of the type II alveolocytes, responsible for SL production, with the appearance of hypertrophied forms of these cells.

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EFFECT OF TEMPERATURE ON STATE OF THE SMALL INTESTINAL MICROCIRCULATION DURING ACUTE ISCHEMIA

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Preservation of the viability of an intestinal loop after total or partial interruption of its blood flow (thrombosis, compression of the vessels) is largely dependent on the state of the microcirculation, and under clinical conditions, besides other methods, this may be improved by the use of Kerte's method, namely by heating the ischemic portion of the intestine. Meanwhile there is evidence that a high temperature has an unfavorable effect on the state of the intestine [1] and, conversely, that its blood supply is improved by lowering the temperature [1-3]. However, the character of features in the microcirculation has not been studied under these conditions.

The aim of this investigation was to study pathophysiological mechanisms determining the state of the microcirculation in acute local ischemia of the small intestine under normo-, hyper-, and hypothermic conditions.

EXPERIMENTAL METHOD

The investigation was conducted on 72 male Wistar rats weighing from 170 to 320 g, under pentobarbital anesthesia (6 mg/100 g body weight, intramuscularly). Ischemia of a portion of the small intestine was produced by applying a ligature for 1 h to the base of a loop of intestine, exteriorized through an incision in the abdominal wall, on the light guide of a microscope. In control experiments, only eventration of the intestinal loop was carried out, without application of a ligature.

The investigation was carried out during reperfusion of the ischemic part of the intestine for 60 min after resumption of the blood flow under normo-, hyper-, and hypothermic conditions (at 38, 42, and 20°C respectively). The necessary temperature

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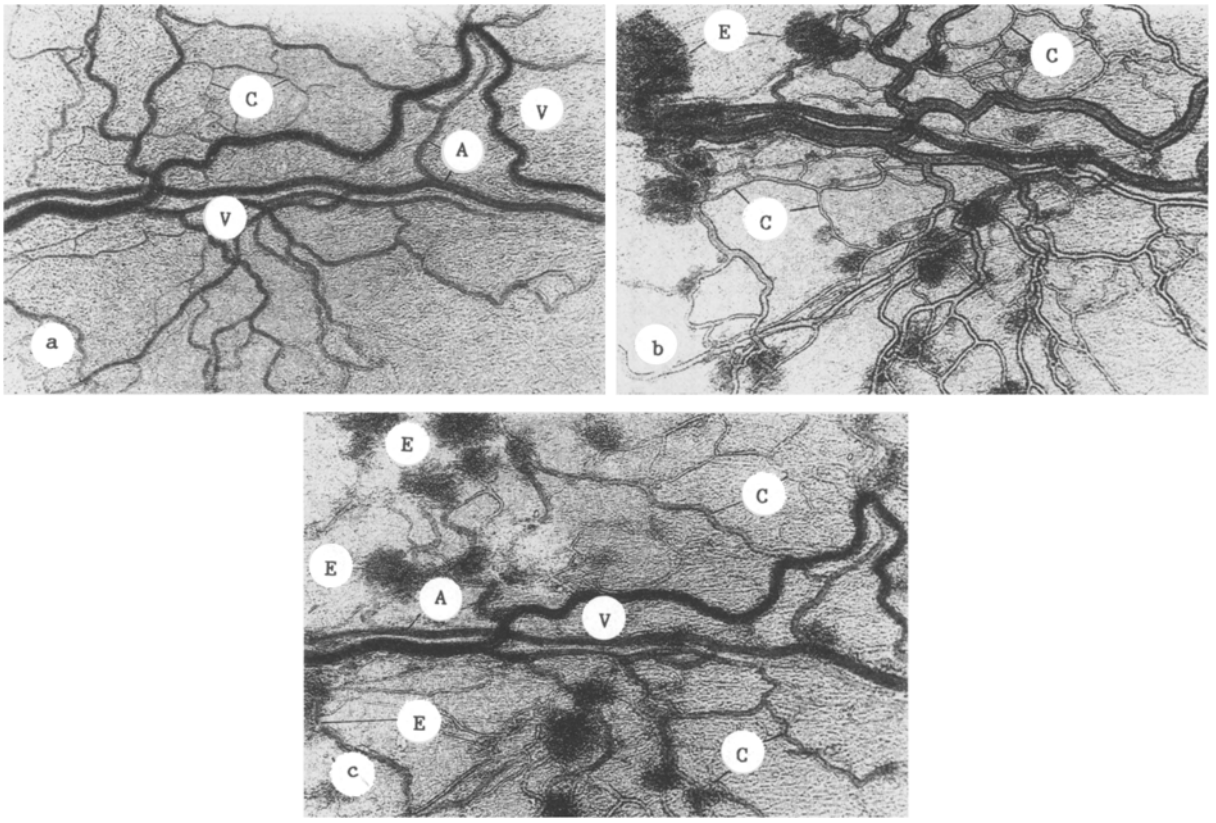

Fig. 1. Region of microcirculatory bed of the rat mesentery: a) in initial state, b) after 1 h of ischemia, c) after 60 min of reperfusion accompanied by hyperthermia. Biomicroscopy. Optical magnification 18. A) Arterioles, V) venules, C) capillaries, E) extravasation. Explanation in text.

conditions were created by applying towels, soaked in physiological saline at the appropriate temperature, to the test region of the intestine, which were changed every 2 min. The state of the microvascular bed of the mesentery and of the wall of the small intestine was studied by biomicroscopy [4] on an "Orthoplan" microscope (Ernst Leitz, West Germany), using a 6.3× objective for general observation and an SW 25/0.60 objective (saline immersion) for the measurements. The diameters of the microvessels were measured with a 16× ocular micrometer with scale division of 0.01. Pressure in the left common carotid artery was recorded by means of a P23Db transducer (Statham Instruments, USA). Samples of tissue for histological investigation were taken from the zone of ischemia and adjacent parts of the intestine, above and below the ligature. The histological sections were stained with hematoxylin and eosin.

EXPERIMENTAL RESULTS

The systemic blood pressure of the experimental animals averaged 124 ± 4 mm Hg (16.5 ± 0.5 kPa). During compression of the part of the small intestine and in the initial period of reperfusion, no significant changes of pressure were observed. A fall of pressure occurred only at the end of the reperfusion period, against a background of hyperthermia, on average to 94 ± 12 mm Hg ($p < 0.001$) and of hypothermia to 100 ± 13 mm Hg ($p < 0.05$).

After application of the ligature to the base of the intestinal loop, considerable slowing of the blood flow was observed biomicroscopically in all parts of the microvascular bed of the mesentery and intestinal wall. With an increase in the severity of ischemia, multiple foci of extravasation and microhemorrhages appeared around the microvessels, mainly the capillaries (Fig. 1). The character of disturbances of the microcirculation during ischemia and reperfusion has been investigated previously [5, 6].

During the first minutes of reperfusion under hyperthermic conditions the blood flow in the region studied was increased. Later the blood flow became slower in most vessels: toward the 60th minute of hyperthermia the blood flow was preserved mainly in the large arterioles (A) and venules (V) (Fig. 1c), but a considerable part of the distal segments of the microvascular bed was in a state of stasis. Whereas during perfusion under ordinary conditions, areas of extravasation are much

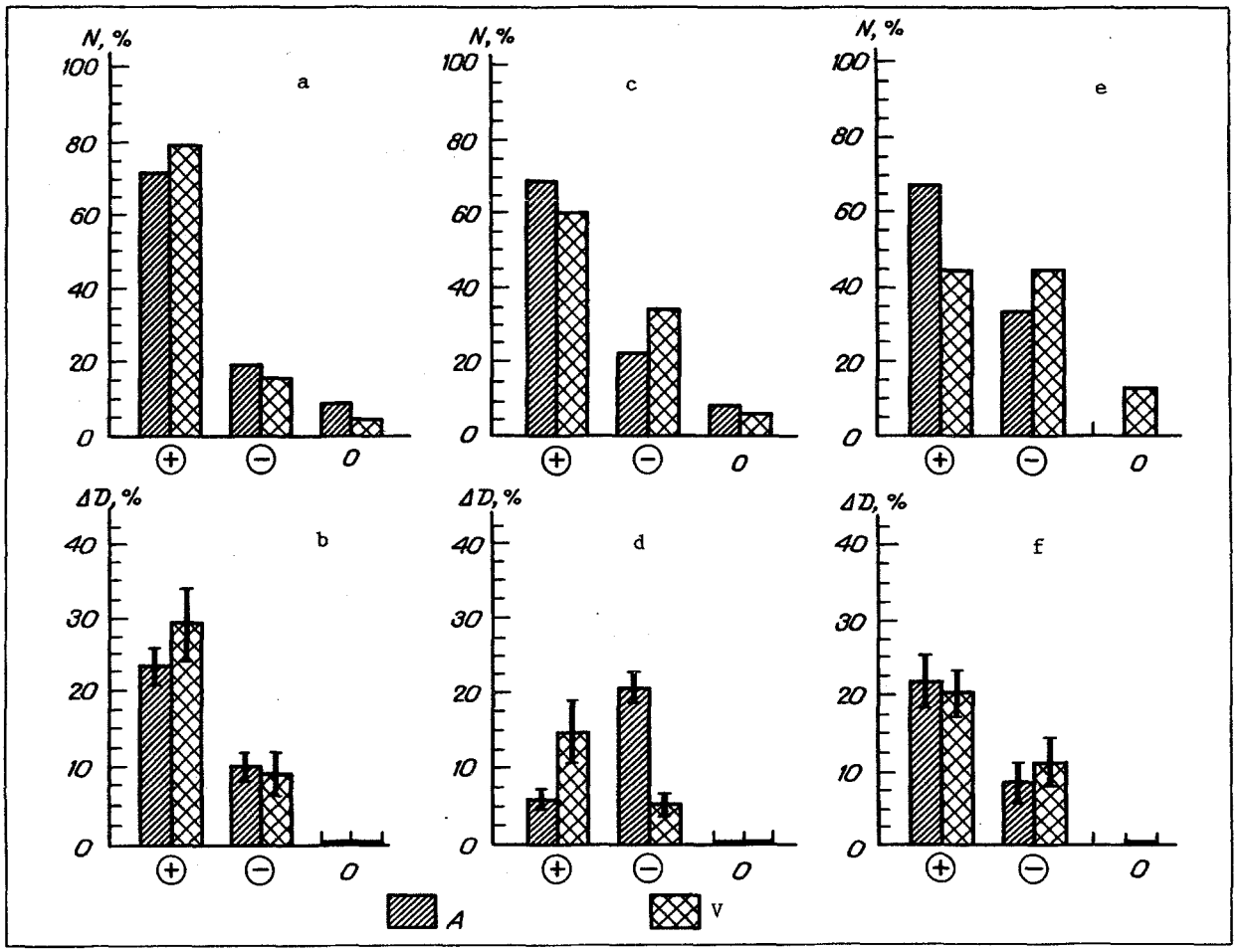

Fig. 2. Diagrams of distribution of various components of mesenteric vascular bed depending on type of reaction (a, c, e) and its intensity (b, d, f) during ischemia and also during hyper- and hypothermia after ischemia. a, b) Ischemia, c, d) ischemia + hyperthermia, e, f) ischemia + hypothermia. *N*) Percentage of vessels involved in particular type of reaction: +) dilatation, −) constriction, 0) no response. Δ*D*) relative change in diameter of vessels. A) Arterioles, V) venules.

reduced in size at this time and undergoing resorption, during hyperthermia they became denser and most of them were increased in volume. On the whole, disturbances of the microcirculation under these circumstances were much more marked than during normothermia.

Quantitative analysis of changes in the internal diameter of different segments of the microvascular bed in response to ischemia showed that most arterioles and venules responded to that state by an increase of 22-28% in their lumen (Fig. 2a, b). Meanwhile, the diameter of about 19% of arterioles and 15% of venules was reduced by 8-10%, and the diameter of 1/10 of the arterioles and 1/20 of the venules remained unchanged during ischemia, these vessels staying "neutral."

Exposure of the intestine to hyperthermia after ischemia modified the character of response of the microvessels: whereas the fraction of arterioles involved in responses of different types did not change significantly, the intensity of each type of response did change significantly (Fig. 2c, d). The degree of dilatation of the arterioles was reduced by almost two-thirds, and of the venules by half. Meanwhile the degree of constriction of the arterioles was doubled. The fraction of venules responding to ischemia by constriction was doubled, but the degree of their contraction was halved. The fraction of "neutral" vessels remained virtually unchanged.

With a fall in temperature of the intestine in the postischemic period the structure of the response of the microvessels changed significantly (Fig. 2e, f). Against the background of a virtually unchanged number of dilated arterioles, the number of venules in a dilated state was almost doubled. Meanwhile the degree of dilatation of both parts of the vascular bed was unchanged. In this case the fraction of arterioles whose lumen was reduced was significantly greater, on account of vessels which had not exhibited their response during ischemia. The character of the response of the venules was rather different: the number

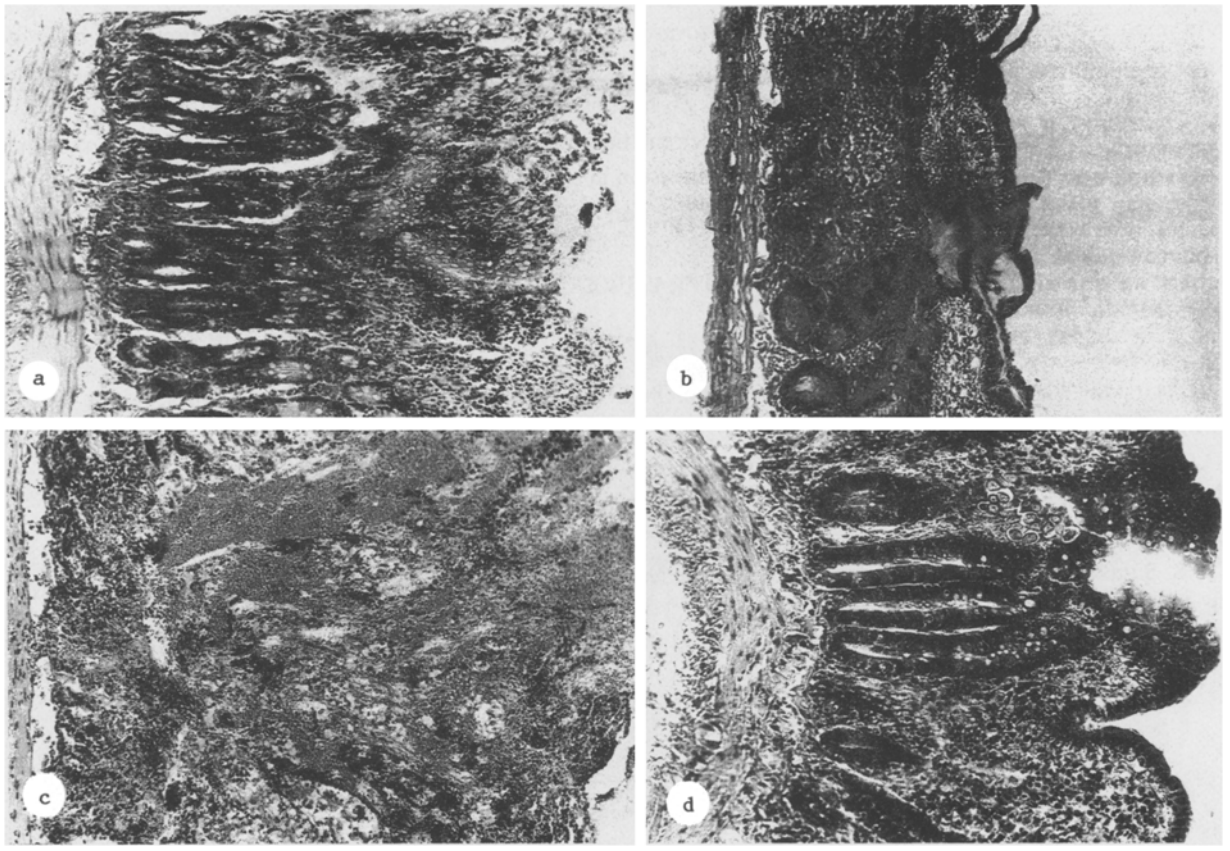

Fig. 3. Transverse section through wall of small intestine. a) After 1 h of ischemia, b) after 1 h of ischemia and reperfusion for 60 min, c) after reperfusion accompanied by hyperthermia, d) by hypothermia. Objective 16×, ocular 2.5×. Hematoxylin and eosin. Explanation in text.

of vessels taking part in the response of dilatation and constriction was virtually identical, whereas the fraction of "neutral" vessels was doubled.

The histological investigation showed that after 1 h of ischemia, the following changes were observed in the intestinal wall: edema of the stroma of the villi, small-round-cell infiltration, discrete hemorrhages and, in some areas, disturbance of the normal structure of the mucous membrane (Fig. 3a). After reperfusion for 1 h the morphological changes in the intestinal wall were appreciably intensified and, the wall itself was stretched and all its layers were reduced in thickness (Fig. 3b).

Heating the intestine after ischemia caused a sharp increase in the intensity of destructive processes in the intestinal wall: marked edema, infiltration with round cells, massive hemorrhages, against the background of a disturbed structure of the mucosal layer (Fig. 3c). The structure of the serous and muscular coats of the intestine showed no significant changes, although their microvessels were grossly dilated.

During hypothermia edema and the round-cell reaction of the villi were ill-defined and no marked changes were observed in the microvessels (Fig. 3d). On the whole, the histological picture in this case was close to that observed at the end of the ischemic period.

Destructive changes in the wall of the small intestine during ischemia lasting 1 h are thus accompanied by preservation of the base of the mucous membrane, evidence of its possible regeneration. The results of the histological investigations correlate with those of the biomicroscopic study of the microvascular bed in ischemia, hyperthermia, and hypothermia.

On the whole the results of the investigation indicate that heating tissues subjected to ischemia potentiates disturbances arising in the microvascular bed and stimulated destructive processes in the tissues, whereas lowering the temperature, optimizing the conditions for the microcirculation and reducing the intensity of metabolism, restrains the development of these processes. Since, according to recent data, a significant role in the genesis of ischemic disturbances of the microcirculation is played by platelet activating factor (PAF) [7] the action of high and low temperatures on the intestinal wall evidently also affects the metabolism of PAF of its antagonists.

An important feature of the reaction of the microvascular bed, revealed by the present investigation, is its heterogeneity. The mechanism lying at the basis of this heterogeneity have received little study, but an important step toward its manifestation may be dependence of the action of temperature factors on binding efficiency of *a*-receptors [8].

An adequate evaluation of the state of the microcirculation during hyper- and hypothermia after ischemia must take into account not only the qualitative character of the response of the microvascular bed, but also the intensity of the responses of its various components, i.e., a quantitative analysis of these reactions is needed.

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