

EXPERIMENTAL ANALYSIS OF THE HUMORAL MECHANISM OF MICROCIRCULATORY  
DISTURBANCES AFTER THERMAL AND MECHANICAL INJURY INDUCING SHOCK  
IN PARABIOTIC RATS

Yu. M. Shtykhno and I. P. Titova

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Mechanical or thermal injury to one of a pair of parabiotic rats with a crossed circulation but separate innervation was followed by the development of a state resembling shock in the other partner. Microcirculatory changes characteristic of either traumatic or burn shock developed in its mesentery under these circumstances. The results are interpreted as evidence in support of a humoral rather than a nervous mechanism of the microcirculatory disturbances in these types of shock.

KEY WORDS: parabiotic rats; shock; microcirculation; humoral mechanisms.

Parabiotic animals, animals with a crossed circulation but with separate innervation, produced by surgical intervention, have been used for about 70 years in experiments to establish or reject the role of nervous or humoral factors in the regulation of various functions, including physiological or pathological processes.

In the investigation described below this method was used to study the mechanism of microcirculatory disturbances in traumatic and burn shock.

#### EXPERIMENTAL METHOD

Experiments were carried out on 27 pairs of parabiotic rats. Artificial parabiosis was produced surgically by creating a cutaneo-musculo-vascular anastomosis by Perel'man's method [3]. For this purpose, adult Wistar rats of the same sex (predominantly males) from the same litter, and weighing about 180-220 g, were sutured together in pairs. The experiments were carried out 4-6 weeks after the operation, but only on pairs with good union of their bodies and with no signs of parabiotic intoxication. This time is long enough for a firm anastomosis to form, with exchange of fluid and cells between the united organisms both via the newly formed blood vessels and lymphatics and via the intercellular spaces of the tissues at the site of anastomosis [1, 2, 6, 7]. At the same time, this period was long enough to rule out even latent signs of an immunologic incompatibility reaction (parabiotic intoxication), which, should it arise, begins as a rule after the end of the 1st or beginning of the 2nd week after the operation of anastomosis. The state of the vascular anastomoses in these experiments was further verified morphologically at autopsy after the experiment.

All pairs of parabiotic rats were divided into three groups: 1) control (8 pairs), without preliminary trauma; 2) after thermal trauma (IV degree) by a spirit flame, equal in area to 20% of the surface of the skin covering the trunk of one of the parabiotic partners (10 pairs); 3) after mechanical sublethal trauma of the soft tissues of the thigh of one partner by Cannon's method (9 pairs). To prevent the redistribution of blood between the partners in groups 2 and 3 as a result of the difference in blood pressure, the degree of trauma inflicted was deliberately restricted to moderate, not causing deep hypotension: When observations were made on the microcirculation the arterial pressure in the two partners did not differ significantly and was not below 100 mm Hg. Meanwhile thermal denaturation of the skin (group 2) or crushing of the tissues of the hind limb (group 3) was present and, consequently, toxic products from the wound entered the bloodstream, and their possible effect on the microcirculation was the object studied in this investigation.

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Laboratory of Pathophysiology of Extremal States, Research Institute of General Pathological Physiology, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR N. A. Fedorov.) Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 86, No. 10, pp. 416-418, October, 1978. Original article submitted February 20, 1978.

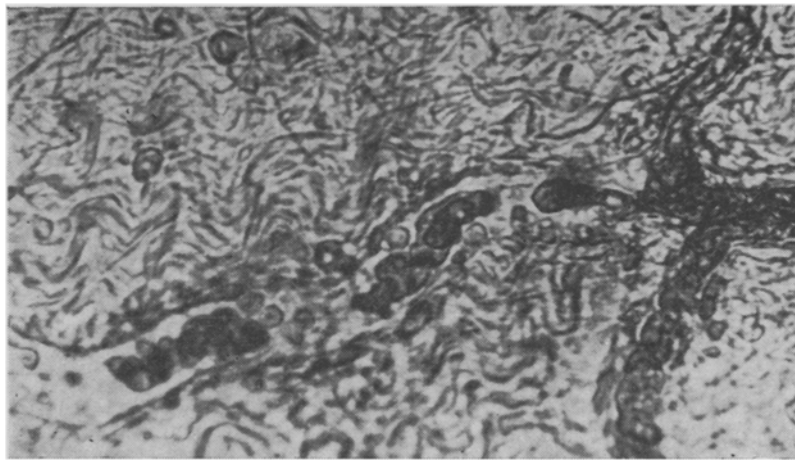


Fig. 1. Photomicrograph. Area of mesentery of second partner of parabiotic pair of rats 20 h after sublethal thermal trauma to first partner giving rise to shock. Explanation in text, 520 $\times$ .

The microcirculation was studied 18-20 h after trauma in the mesentery of the second, intact partner, under urethane anesthesia on an apparatus for intravital biomicroscopy mounted on the basis of the MBI-6 microscope. The mesentery was kept under constant temperature conditions in an oil chamber consisting of the biologically inert silicone fluid PMS-500, which served at the same time as immersion medium.

#### EXPERIMENTAL RESULTS AND DISCUSSION

Immediately after injury the traumatized animals developed a transient state resembling shock, which passed off after 10-15 min, possible evidence of the development of a comparatively stable phase of compensation or relative adaptation of the circulation. By the time of investigation of the microcirculation the clinical state of both partners was marked by symptoms of intoxication: some degree of apathy and passiveness, although less severe than in lethal shock. The clinical state of the animals of the control group was normal. The microcirculation in their mesentery likewise did not differ from normal.

In the intact partners of the parabiotic animals of groups 2 and 3 the same disturbances of the microcirculation as are characteristic of sublethal shock of corresponding duration and corresponding origin were observed. Although no reduction in the velocity of the blood flow in the venous and arterial microvessels over 100  $\mu$  in caliber could be detected visually, the velocity of the blood flow in the smaller vessels, especially the capillaries and venules, was significantly below normal and the structure of the flow was disturbed everywhere: In some such vessels the flow consisted entirely of plasma, virtually without any cells, or the blood flow was granular. A tendency toward stasis was observed. The movement of blood was pulsatile in some arterioles. The number of functioning capillaries was reduced in all fields of vision and much of the blood flow was directed through numerous arteriovenous anastomoses. Appreciable leukocytosis and pavementing of the leukocytes were observed. After burn trauma numerous extravasations and widespread intravascular aggregation of erythrocytes were observed (Fig. 1), whereas after mechanical trauma these findings are rare. This agrees fully with differences observed previously in the microcirculatory changes associated with burn and traumatic shock [4].

Consequently, after thermal trauma or mechanical trauma by Cannon's method to one partner of a pair of experimental parabiotic rats, a severe state resembling shock develops in both partners and the microcirculation in the mesentery of the second, intact partner is characterized by changes resembling those observed in the corresponding types of shock.

The results are evidence that microcirculatory disturbances after thermal and mechanical trauma are due principally not to its nervous, but to humoral factors, possibly toxic substances circulating in the blood and lymph of the injured animals. The discovery of significant intravascular aggregation of erythrocytes after burns and the absence of this phenomenon af-

ter mechanical trauma confirm the writers' previous hypothesis [5] of qualitative differences in the character of the toxemia in traumatic and burn shock, and not merely quantitative differences.

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