COMPARATIVE STUDY OF INTRAVITAL MICROCIRCULATION AND BLOOD RHEOLOGY IN RATS AFTER BURNS OF DIFFERENT DEGREES OF SEVERITY

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Experiments on rats showed that burn trauma is accompanied by disturbances of the microcirculation, hemoconcentration, and increased viscosity of the blood, which are especially marked in vessels with low pressure. Changes in the mesenteric microcirculation coincided with changes in the dynamic viscosity and composition of the blood determined in vitro. These disturbances were more marked after extensive and deep burns, accompanied by severe shock ending in death than after moderately severe burns, the consequences of which were less serious.

KEY WORDS: burns; microcirculation; blood viscosity.

Burn trauma of the skin is accompanied not only by local, but also by general disturbances of the microcirculation [2, 4, 7] and also by significant changes in the viscosity and other rheologic indices of the blood [3, 8]. The character, severity, and consequences of disturbances of the microcirculation have been shown to depend directly on the area and depth of thermal injury to the body tissues [2, 7]. It is generally accepted that disturbances of the microcirculation are closely linked with changes in blood rheology [5, 6].

The aim of this investigation was to study to what degree intravital disturbances of the microcirculation found in the rat mesentery correlate with changes in blood rheology determined in vitro after burns of different degrees of severity.

EXPERIMENTAL METHOD

Three groups of experiments were carried out on 60 Wistar rats weighing 300 ± 50 g, with 20 animals in each group: 1) animals not subjected to trauma (control); 2) 3-4 h after a fourth degree flame burn affecting 30 ± 5% of the body surface; 3) the same time after a third degree flame burn affecting 10-12% of the body surface. The degree of heating and of damage to the skin and subcutaneous tissues was monitored by means of an electrothermometer during burning, and later at autopsy. Observations on the microcirculation in the mesentery and photographic recording were carried out under urethane anesthesia on an apparatus for intravital microscopy by the method described in [2]. The dynamic viscosity (in centipoise, cP) at shear velocities of 491, 310, 114, 63, and 25 sec^{-1} was determined on a Koupli viscosimeter, improved by the writers [1], and the hematocrit index (in per cent) was determined by centrifugation for 15 min at a speed of 3000 rpm in blood samples taken at the same times from the portal vein. The hemoglobin concentration also was determined (in g/liter) by Sahli's method.

EXPERIMENTAL RESULTS AND DISCUSSION

After a fourth degree burn affecting 30 ± 5% of the body surface (group 2) all the animals developed severe shock with 100% mortality in the course of 3 days (LD_{100}). Severe disturbances of the microcirculation were observed in the mesentery 3-4 h after trauma: a decrease in the velocity of blood flow in the microvessels or even its complete arrest in some areas of the vascular network, a decrease in the number of functioning capillaries, and direction of a considerable part of the blood flow, where it still existed, along very numerous open arteriovenous anastomoses, bypassing the true capillaries. Even visually hemoconcentration

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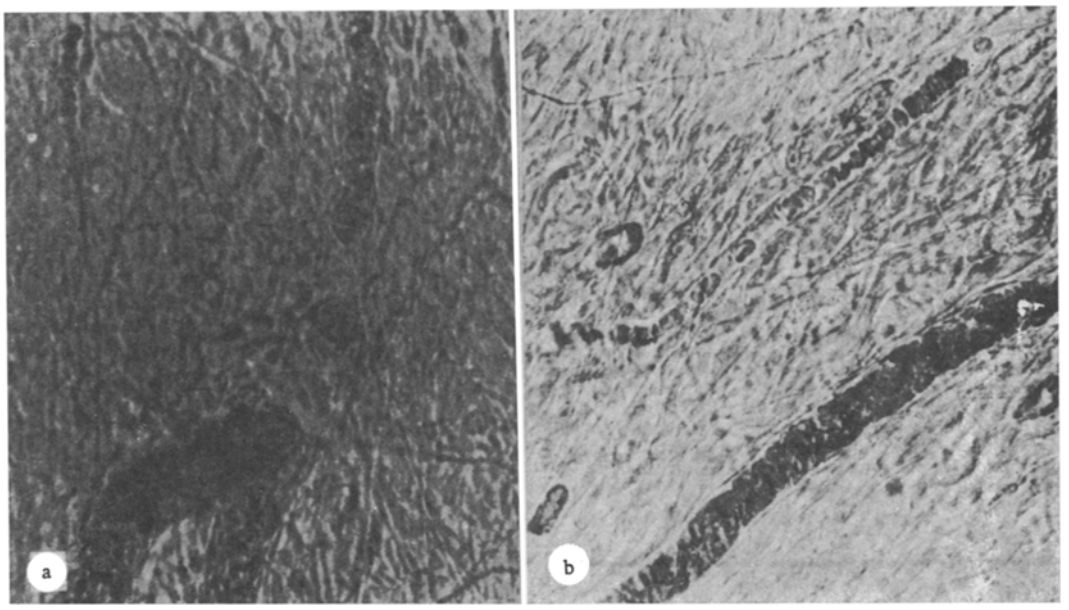

Fig. 1. Photomicrograph of blood vessels in the rat mesentery 4 h after extensive and deep (a) and less severe (b) flame burns of the skin. Explanation in text, 520×.

TABLE 1. Changes in Blood Rheology in Rats 3-4 h after Burns of Different Degrees of Severity (M ± m)

Group of animals	Hematocrit, %	Hemoglobin, g/liter	Viscosity, cP				
			$u = 491\ sec^{-1}$	$u = 310\ sec^{-1}$	$u = 144\ sec^{-1}$	$u = 63\ sec^{-1}$	$u = 15\ sec^{-1}$
1-(Control)	46,4±0,5	149±3,0	2,5±0,05	2,80±0,04	2,94±0,05	3,51±0,06	3,94±0,06
2-	59,8±1,69	190,6±8,09	4,50±0,19	4,74±0,20	5,13±0,18	5,88±0,21	7,56±0,21
3-	52,3±1,58	165,3±4,38	3,29±0,15	3,36±0,16	3,55±0,14	4,01±0,54	4,36±0,61

Legend. All differences between control and experimental groups and also between experimental groups 2 and 3 are statistically significant: $P < 0.001$ for viscosity and $P < 0.01$ for hematocrit and hemoglobin.

was noted in the arterioles, anastomoses, and collector venules: The impression of a slowly spreading thick porridge was created, whereas in the distal microvessels of smaller caliber the flow consisted of plasma alone, without any cells (Fig. 1a).

The state of the animals after a third degree burn affecting 10-12% of the body surface (group 3) was characterized by milder and, in many cases, by comparatively brief shock without a fatal issue. The microcirculation in the animals of this group also was disturbed, but less severely than in the rats of group 2. Besides a decrease in the number of functioning capillaries and dilatation of the network of arteriovenous bypass anastomoses, hemoconcentration was observed in the afferent arteries, anastomoses, and collector venules, and the flow in many terminal microvessels consisted of plasma alone without blood cells, although this fragmentation of the blood flow here was less marked than in group 2; sometimes unstable aggregates of red blood cells resembling rouleaux could be seen (Fig. 1b).

As the data in Table 1 show, the blood viscosity after burns was significantly increased at all shear velocities, and the deeper and more extensive the burn the greater the increase. Changes in viscosity were more marked at slower shear velocities. From this it can be concluded that the greatest increase in dynamic viscosity of the blood after burns is observed in vessels with low pressure. The hematocrit index and hemoglobin concentration changed in the same direction, thus confirming the considerable hemoconcentration observed on examination of the microcirculation 3 h after burning, and again the more extensive and deeper the burn, the more marked the hemoconcentration. This is evidently one of the principal causes of the increase in blood viscosity and, consequently, of the decrease in the velocity of the blood flow in the microvessels also, especially in capillaries and venules. These same phenomena – hemoconcentration and a decrease in the velocity of the blood flow – also were found on visual observation of the microcirculation in the mesentery, a region draining into the portal vein.

The results are evidence that burn trauma is accompanied by disturbances of the microcirculation, hemoconcentration, and increased viscosity of the blood, which are especially marked in vessels with low pressure. Changes in the mesenteric microcirculation coincided with changes in the dynamic viscosity of the blood and hematocrit index determined in vitro. These disturbances were more marked after extensive and deep burns with a fatal issue than after moderately severe burns, the consequences of which were less serious. This investigation confirms the important role of changes in the blood rheology and disturbances of the microcirculation in the early period of burns.

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PERMEABILITY OF TISSUE–BLOOD BARRIERS OF THE SMALL INTESTINE DURING PERFUSION WITH CERTAIN PRESERVATIVE SOLUTIONS

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The effect of some preservative solutions on changes in permeability of tissue–blood barriers of isolated loops of small intestine was studied in laboratory albino rats during perfusion of their vessels with 0.85% sodium chloride solution, with Ringer–Locke, Hanks', and Collins-2 solutions, and with the Soviet preparations Gemodez and Aminopeptid. The volume of fluid flowing from the vessels, penetration of perfusion fluid into the lumen of the intestine, and its elimination through the serous membrane were determined. It was concluded that the least disturbance to the tissue–blood barriers of the small intestine is observed during perfusion of its vessels with Collins-2 solution. This method is recommended as a test for comparing the properties of preservative solutions.

KEY WORDS: small intestine; tissue–blood barriers; perfusion; preservative solutions.

Of the many methods of keeping organs and tissues viable in vitro the most promising at this stage seems to be their preservation in cold liquid media. In this connection many solutions balanced with the extracellular or intracellular fluids and containing electrolytes, carbohydrates, amino acids, and antibiotics, have been studied [1, 6, 8]. However, no general criterion for comparison of these solutions could be found in the accessible literature.

It has been shown [2, 3, 7, 9, 10] that during perfusion of the vessels of the small intestine with various solutions the latter penetrate through the vascular wall and tissue–blood barriers into the lumen of the intestine and emerge on its serous membrane. The writers have used this phenomenon to compare the properties of preservative solutions used in experimental and clinical transplantology.

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