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CHANGES IN THE PORTAL HEMODYNAMICS IN BURN SHOCK

G. A. Bykov

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The anatomical features distinguishing the portal vascular system suggest that it plays the role of a pathological blood depot in stress states and, in particular, in severe burn trauma [1, 2]. However, no reference could be found in the literature to measurements of the blood volume in the portal vessels after burns.

This paper gives the results of measurement of the hepatic blood flow, the blood volume in the portal vessels, their tone, and the portocaval resistance in 15 dogs and eight rabbits in a state of burn shock.

EXPERIMENTAL METHOD

Burns of the IIIB degree affecting 20% of the body surface were inflicted by means of special heating elements. The animals were anesthetized with thiopental (50 mg/kg body weight). The total hepatic blood flow of the dogs was measured with the aid of colloidal ^{198}Au by the method of Restrepo et al. [7], the portal blood volume was measured by a slightly modified Bradley's method [4], and the cardiac output and circulating blood volume (CBV) were determined with the aid of the dye T-1824 [5]. To measure the pressure and to take blood samples from the aorta and hepatic veins, catheters were introduced through the femoral vessels into the right atrium, the hepatic vein, and the abdominal aorta under the control of a televisor of an image converter (Fig. 1). The catheter was introduced into the portal vein through one branch of the splenic vein, for which purpose the medial pole of the spleen was exteriorized through an incision in the abdominal wall. After introduction of the catheter the abdominal wound was closed in layers without drainage. Pressure curves were recorded by "Mingograph-81" electromanometers. The results are given in Table 1.

In rabbits the CBV, blood volume in the portal vessels, in the thorax, and in the region of the burns was determined by a method of regional radiometry based on the distribution of ^{51}Cr-labeled erythrocytes. Radiometry was carried out with three collimated sensors of the K-302 apparatus. The first sensor recorded the count from the head and chest, the second from the abdominal vessels, the third from the buttocks and lower limbs (the region of the burns). The sensitivity of the sensors was corrected for a two-dimensional phantom. Labeled erythrocytes were injected into the rabbit's auricular vein. Blood samples for determination of CBV were taken from the right atrium through the catheter introduced via the jugular vein. The first sample of labeled erythrocytes was injected before trauma, and CBV was then determined and the count obtained from each of the three collimated regions of the animal's body. These data were used to calculate regional blood volumes in the vessles of the thorax, abdomen, and region of the burns (Table 2).

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TABLE 1. Changes in Indices of Portal Hemodynamics in Dogs after Burns of the IIIB Degree Covering 20% of the Body Surface

Index	Time after trauma, min	n	Limits of variations	M ± m	P_1
Mean intraportal pressure, mm Hg	Initial	12	6,9—17,1	12,83±1,50	
	30	12	8,5—18,3	13,95±1,48	0,026
	180	8	10,5—19,5	16,30±2,15	0,008
Mean portal pressure gradient, mm Hg	Initial	15	3,0—15,5	8,36±1,34	
	30	14	4,0—16,8	8,94±1,48	0,134
	180	10	8,0—16,2	11,62±1,41	0,001
Total hepatic blood flow, ml/min/kg body weight	Initial	14	20,5—41,3	32,6±2,90	
	30	14	14,1—45,3	24,3±3,44	0,001
	180	9	10,4—40,6	22,3±5,90	0,261
Resistance of hepatic vessels, dynes • sec • cm^{-5}	Initial	14	737—2558	1691±225	
	30	14	1451—3710	2620±319	0,001
	180	9	1379—6416	3619±1127	0,102
Circulating blood volume in portal vessels, ml/kg	Initial	14	15,8—42,4	25,8±3,05	
	30	13	12,8—24,9	19,0±1,75	0,042
	180	9	8,2—25,9	17,9±3,41	0,047
Modulus of bulk elasticity of portal vessels, dynes • cm^{-5}	Initial	14	39,5—71,9	51,4±3,87	
	30	12	40,9—105,0	67,8±9,95	0,031
	180	9	60,6—164,0	115,5±20,45	0,017

TABLE 2. Blood Volume (in ml/kg) in Vessels of Thorax, Abdomen, and Burned Tissues of Rabbits after IIIB Degree Burns Covering 20% of Body Surface

Test object	Time of investigation	n	Limits of variations	M ± m	P_1
Vessels of head and thorax	Initial	8	28,1—43,6	35,8±2,1	
	60 min after trauma	8	18,9—43,8	32,9±2,2	0,952
Abdominal vessels	Initial	8	17,2—24,8	19,9±0,97	
	60 min after trauma	8	9,4—21,0	15,0±1,2	0,012
Region of burned tissues	Initial	8	7,9—26,3	13,2±2,1	
	60 min after trauma	8	1,8—11,4	7,5±1,4	0,007

EXPERIMENTAL RESULTS

Before trauma the blood volume in the dogs' portal vessels was 25.8 ± 3 ml/kg, or 27% of CBV. The pressure in the portal veins varied from 6.9 to 17.1 mm Hg and the total hepatic blood flow, as the average for the group, was 32.6 ± 3 ml/min/kg body weight. These values coincide with those obtained by other workers [4, 6, 7]. The blood volume in the dogs' portal vessels 30 min after burning was reduced by 26.4%, and after 180 min by 30.6%.

In the rabbits before trauma the mean value of CBV for the group was 68.9 ml/kg. The blood volume in the abdominal vessels was 19.9 ml/kg, or 28.9% of CBV for the whole body. In the course of 1 h of observation after burns there was virtually no change in the number of erythrocytes injected before trauma as recorded by all three sensors. A second portion of labeled erythrocytes was then injected. The value of CBV calculated on the basis of the second injection showed a decrease for the whole body to 55.4 ml/kg, and for the abdominal vessels to 15 ml/kg, or by 24.6%.

Direct measurements by two basically different methods thus showed that CBV in the abdominal vessels was reduced after severe burn trauma. No redistribution of blood between the different regions of the vascular system took place under these circumstances. It can only be suggested that the decrease in CBV was due to exclusion of some of the vessels from the circulation. This conclusion is confirmed by the exclusion of many areas of the mesenteric microcirculation from the general circulation observed in burned rats as a result of stasis of blood due to erythrocyte aggregation [3].

The pressure in the portal vessels 30 min after burn trauma was increased statistically significantly by 8.7% of its initial level, and after 180 min by 27%. The portocaval pressure gradient was increased by the same degree. The total hepatic blood flow after burns was reduced by 41%. The increase in the portocaval gradient accompanied by a decrease in the hepatic blood flow is evidence of an increase in the resistance of the hepatic vascular system in the portion between the portal and hepatic veins.

To assess the tone of the portal vessels a modulus of bulk elasticity was calculated: the ratio of the pressure in the portal vessels to the blood volume in them. Before trauma, the modulus of bulk elasticity of the portal vessels averaged 52 dynes · cm^{-5}. It increased 30 min after burns by 32%, and 180 min after burns

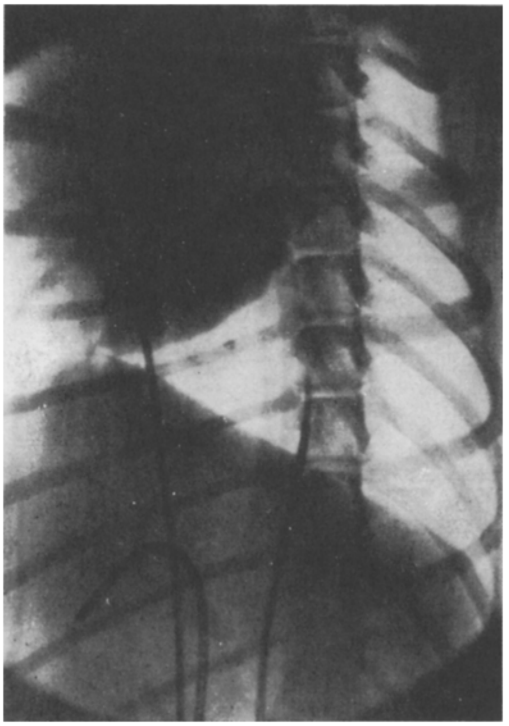

Fig. 1. Roentgenogram of dog's thorax and abdomen. Catheters inserted into hepatic vein, right atrium, and aorta can be seen.

by 125%. This increase in tone of the portal veins after burns prevents the accumulation of blood in the abdominal vessels.

The suggestion that blood is stored in the vessels of the portal system as a result of a fall in tone of the portal veins was thus not confirmed by these experiments. The changes in the portal hemodynamics after burns were the same as those in other parts of the circulation.

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