CORRELATION BETWEEN DISTURBANCES OF THE ENTEROHEPATIC HEMODYNAMICS AND ABSORPTION FUNCTION AFTER BLOOD LOSS

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Previous investigations into the possibility of correcting posthemorrhagic hypovolemia by infusion of an electrolyte-monomer solution into the small intestine showed that blood loss amounting to 30 ml/kg, at the rate of 0.7-1 ml/min/kg (30-45 min), during the first 30-45 min of the posthemorrhagic period, has no inhibitory effect on the absorptive function. As a result, absorption of the solution results in rapid and stable restoration of the plasma deficit [3]. In the process of absorption, nutrients from the enteral medium enter the portal blood flow.

The aim of this investigation was to study correlation between disturbances of the enterohepatic hemodynamics and absorption function after blood loss in order to obtain information on the mechanisms regulating this correlation.

EXPERIMENTAL METHOD

The first series of experiments was carried out on 11 dogs into which a catheter had been inserted previously into the portal vein. At the beginning of the experiment, under premedication (ketamine 2.0, relanium 2.0, diphenhydramine 2.0; all doses per 10 kg body weight) catheter transducers for impedansometry were introduced through the femoral vessels into the aorta and inferior vena cava. Blood loss to a volume of 30 ml/kg was carried out in one stage through an arterial catheter at the rate of 0.7 ml/min/kg (on average, for 40 min). At successive stages of the experiment the circulating blood volume (CBV), cardiac ejection, and volume velocity of the blood flow in the liver were determined by the impedance method [4]. The arterial, central venous, and portal pressures were recorded. In the 2nd series of experiments noradrenalin (NA) in a dose of 1 μg/kg was injected intravenously into 14 dogs. To study the hemodynamics in the hepatic artery and portal vein, the dogs were anesthetized and electromagnetic transducers and also catheters were implanted in the aorta, inferior vena cava, and portal vein. The volume velocity of the blood flow in the hepatic artery and portal vein, and the pressure in the aorta, inferior vena cava, and portal vein, also were recorded. The resistance of the arterial and portal vascular bed of the liver and also the resistance of vessels of the gastrointestinal tract (GIT) were calculated. The total hepatic blood flow and the percentage content of arterial blood in the total hepatic blood flow also were calculated. Absorptive function was tested on three conscious dogs in 63 experiments by perfusing a segment of intestine isolated from the general digestive tract only during the experiment [3]. An electrolyte-monomer solution of definite composition [3] was used for perfusion. The results were subjected to statistical analysis.

EXPERIMENTAL RESULTS

As will be clear from Table 1, blood loss with a volume of 30 ml/kg caused disturbance of the central hemodynamics and the hemodynamics of the liver. It was found that with an increase in volume of blood loss there was a gradual fall of the mean arterial, central venous, and portal pressures, and also in CBV and the volume velocity of the hepatic blood flow. Parameters of cardiac ejection reacted to blood loss by a considerable decrease in the stroke volume and (as a result of a compensatory increase in heart rate) a less marked fall of cardiac output (Table 1). If parameters characterizing the state of the central hemodynamics and the hemodynamics of the liver are compared, the fact will be noted that as a result

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TABLE 1. State of the Central Hemodynamics and Hepatic Blood Flow after Blood Loss in a Volume of 30 ml/kg

Conditions	Mean arterial pressure, mm Hg	Central venous pressure, mm water	Heart rate, beats/min	Stroke volume, mg/kg	Cardiac output, ml/kg/min	Circulating blood volume, ml/kg	Specific peripheral resistance CUR	Vol. veloc. of hepatic blood flow, ml/min/kg	Pressure in portal vein, mm Hg
Initial data	102±5,4	67±11,2	118±5,4	1,47±0,11	176±7,1	79±2,04	579±18	43,5±2,1	100±12,2
After blood loss 30 ml/kg	87±4,1	56±9,0	142±6,3*	0,97±0,13*	134±5,2*	56±1,51*	649±21	28,1±1,5*	51±5,1*
±Δ %	−15 %	−16 %	+20 %	−34 %	−24 %	−29 %	+11 %	−35 %	−49 %

Legend. Asterisk indicates significance of differences from initial data ($p < 0.05$). CUR) Conventional units of resistance.

TABLE 2. Changes in Basic Parameters of Hepatic Circulation Following Injection of Noradrenalin (1 μg/kg) into Femoral Vein (n = 14)

Conditions	Pressure in portal vein, mm Hg	Volume velocity of blood flow in portal vein, ml/min/kg	Vascular resistance of portal vein in the liver, IEC	Vascular resistance in GIT, CUR	Pressure in hepatic artery, mm Hg	Volume velocity of blood flow in hepatic artery, ml/min/kg	Vascular resistance of renal artery, CUR	Volume velocity of hepatic blood flow, ml/min/kg	Fraction of arterial blood in total hepatic blood flow, %
Initial data	108,8±6,5	29,8±2,03	0,27±0,05	3,0±0,40	98,0±6,54	10,2±0,41	9,7±1,32	40,1±3,86	25,0±4,78
After intravenous injection of noradrenalin, 1 μg/kg	81,05±5,1* −28 %	12,5±2,02* −58 %	0,47±0,07* +75 %	10,8±2,25* +260 %	141,0±12,1* +44 %	8,7±0,51 −15 %	16,1±3,22* +66 %	21,3±3,69* −47 %	41,0±7,05* +63 %

Legend. As to Table 1.

of blood loss the reduction of arterial pressure, CBV, and cardiac ejection was less marked than the decrease in volume velocity of the hepatic blood flow and pressure in the portal vein (Table 1).

The results of the study of the absorptive function of the small intestine in these experiments fully confirmed those of previous experiments [3] and showed that during the first 30 min after blood loss at the rate of 30 ml/kg the rate of absorption of the electrolyte–monomer solution had only a slight tendency to decrease, but remained at a sufficiently high level throughout (compare with data in Table 3).

These investigations showed that in the immediate posthemorrhagic period blood loss with a volume of 30 ml/kg causes combined disturbances of the central hemodynamics and the hemodynamics of the liver, but has virtually no effect on the absorptive function. To elucidate the mechanisms regulating correlation between absorptive activity and the enterohepatic hemodynamics, and the role of the sympathoadrenal system in their development [6, 10, 13], we carried out the next series of experiments.

In these experiments dogs were given an intravenous injection of noradrenalin, the principal mediator of the peripheral portion of the sympathetic nervous system (Table 2).

As Table 2 shows, introduction of NA in a dose of 1 μg/kg into the blood stream was accompanied by an increase in resistance of the entire vascular bed of the enterohepatic circulation, which reached a maximum 30-45 sec after injection. Spasm of vessels of the GIT was most marked (Table 2). At the same time or after a short latent period the resistance of the vessels of the arterial and portal systems of the liver increased (but by a lesser degree).

The experiments showed that the change of vascular tone caused limitation of the blood flow along the portal vein and hepatic artery. However, the degree of the decrease in the arterial and venous blood flow was unequal. Whereas after injection of NA the portal blood flow decreased on average by 58%, the decrease in the blood flow along the hepatic artery was minimal – on average by 15%.

Thus in the period of the minimal blood supply to the liver the relative contribution of arterial blood to the total hepatic blood flow increased (Table 2).

TABLE 3. Effect of Blood Loss (30 ml/kg during 40 min) or Intravenous Injection of Noradrenalin (1 μg/kg) on Rate of Absorption of Electrolyte–Monomer Solution (ml/kg/min)

Initial values	After blood loss	After injection of noradrenalin at the rate of	
		1 μg/kg/1 min	1 μg/kg/2 min
0,568±0,024 n=33	0,540±0,037 n=11	0,483±0,031 n=11	0,536±0,036 n=11

Investigation of the absorptive function of the small intestine showed that the rate of absorption depends on the rate of injection of NA. If injected in the course of 1 min, the rate of absorption of the solution had a tendency to become slower (on average by 15%). However, if NA was infused for the duration of 2 min the rate of absorption was the same as initially (Table 3).

Comparison of the results obtained in experiments with blood loss and in those with intravenous injection of NA revealed, first, close interaction between the state of tone of the arteries and veins of GIT and the liver, and also between the central blood flow and the blood flow in the liver. The investigations also showed that in the case of both blood loss and of intravenous injection of NA, changes in the hemodynamics of the liver correlated positively with changes in absorptive function, evidence of their identical humoral nature, so that it was possible to analyze the results of the investigation in the general data bank.

Analysis of the experimental data showed that blood loss causes combined disturbances of the central hemodynamics and of the hemodynamics of the liver. It can be postulated that the decrease in the hepatic volume blood flow observed in the experiments was due to a considerable increase in vascular resistance in GIT due to the more rapid release of NA into the blood stream [6-9]. In turn, as a result of spasm of these vessels the blood flow was redistributed from the abdominal organs into the central blood flow [1, 5, 10]. These adaptive reactions, taken together, evidently lead to the milder changes in parameters of the central hemodynamics compared with changes in the hepatic hemodynamics, observed in our experiments with blood loss (Table 1).

The study of the mechanisms of reduction of the hepatic volume blood flow showed that disturbances arise chiefly in the portal basin. As a result of the sharp increase in resistance of the vessels of GIT and a smaller increase in resistance of the portal vessels, the blood flow and the pressure in the portal vein fall significantly. Meanwhile, the arterial blood supply of the liver shows little change.

Such a small decrease in the blood flow along the hepatic artery is evidently due to the fact that in response to injection of NA not only does the resistance of the hepatic arteries increase, but there is also an appropriate increase of pressure in the hepatic artery.

Despite the sudden spasm of the intestinal vessels observed in these experiments the rate of absorption of the solution did not differ significantly from initially either after blood loss or after injection of NA, although there was a more or less marked tendency for it to slow. This may perhaps be explained by the results of investigations [1, 11, 12] which showed that during adrenergic nervous impulses autoregulation of the mesenteric blood flow takes place, so that the blood flow in the villi is maintained at the initial level and the rate of absorption is independent of activity of the sympathetic nervous system. Meanwhile, the lowering of the hydrostatic pressure in the portal vein, observed in some experiments [1], probably has a positive effect on the rate of absorption of fluid.

On the whole the investigations showed that neurohumoral regulation of the blood flow in the enterohepatic basin and of the absorptive function of the small intestine is realized in extremal situations, associated with release of NA into the blood stream, in such a way that reduction of the total hepatic blood flow and of the blood flow in the intestine takes place mainly through limitation of the portal blood flow, but also on account of a decrease in the blood flow in the muscular layer and in the zone of the small intestinal mucosa containing the crypts [1, 11, 12]. The arterial blood supply to the villi of the intestinal epithelium and to the liver is maintained under these conditions. After blood loss this regulation of the blood flow creates the resistance of the small intestine and liver to circulatory hypoxia [2] and maintains their functional activity. Taken as whole, these adaptive mechanisms not only ensure redistribution of the blood flow into the

central blood flow, but they also organize the rapid absorption of the liquid fraction of the chyme, thereby taking part in autoregulation of the circulating blood volume when that is deficient.

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ROLE OF LIMBIC STRUCTURES IN THE MECHANISMS OF POST-TRAUMATIC EPILEPSY

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The epileptic syndrome is a very widespread aftereffect of brain trauma (BT) [6, 7]. Meanwhile the neurophysiological mechanisms of post-traumatic epilepsy have not yet been adequately studied. It was shown previously that an epileptic syndrome is formed through the appearance of an epileptic system, whose determinant structure is located differently in focal and generalized forms of the epileptic syndrome [3, 4]. It is not yet clear whether the formation of post-traumatic epilepsy likewise is connected with activity of an epileptic system, or what brain structures can play the role of pathological determinant in this form of epilepsy. We know that hyperactive determinant structures differ from dependent components of the epileptic system and other brain formations in their high level of excitability and their ability to respond first to relatively weak provoking stimuli. For their detection, the usual method is to increase brain excitability very slightly through

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