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Effect of Sodium Hypochlorite and UV Irradiation of the Blood on Fluid and Electrolyte Balance, Metabolism of Lipids and Proteins, and State of Cell Plasma Membranes during Experimental Bile Peritonitis

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We compared the normalizing effects of various methods of hemocorrection on homeostasis in animals with bile peritonitis. Combined treatment with hypochlorite and UV irradiation produced a potent membrane-stabilizing effect and increased adaptability of erythropoiesis.

Key Words: *bile peritonitis; sodium hypochlorite; UV irradiation of the blood; homeostasis*

Intensive care in the postoperation period is aimed at compensation of vital functions [1]. Published data show that uncompensated homeostasis disorders (cardiovascular and respiratory failure) are the main cause of patient death in the absence of serious surgical error [3]. These disorders inevitably result from disturbances in fluid and electrolyte balance and protein metabolism, pathological changes in plasma membranes, and intoxication associated with abnormalities in lipid metabolism. Much attention is given to the methods of efferent therapy correcting these pathogenetic stages of bile peritonitis. Here we studied the effect of sodium hypochlorite (NaClO) and UV irradiation of the blood on parameters of homeostasis during bile peritonitis (BP).

MATERIALS AND METHODS

Experiments were performed on 42 male dogs (16±4 kg) with experimental BP. The animals were divided into 4 groups. Group 1 animals were subjected to sanation of the abdominal cavity with furacilin (1:5000) 24 h after the incidence of experimental BP. Group 2 animals (n=13) intravenously received 0.04% NaClO immediately and 12 h after surgery (1/10 circulating blood volume). In group 3 animals (n=14) 0.9% NaCl was intravenously infused immediately and 12 h after surgery (1/10 circulating blood volume) and UV irradiation of the blood was performed 24 h after surgery (1.5-2.0 ml/kg). Group 4 animals (n=15) received 2 intravenous injections of 0.04% NaClO and were exposed to UV irradiation of the blood.

Plasma content of K^+, Na^+, and Cl^- was measured on an Easy Lyte Plus K/Na/Cl automatic analyzer. Erythrocyte count, hematocrit, and mean erythrocyte volume (MEV) were estimated on a Medonic 620 analyzer. The concentrations of urea, cholesterol, and β-lipoproteins and activities of alanine transaminase (ALT), aspartate transaminase (AST), creatine phosphokinase, and alkaline phosphatase were assayed on a Cobas Myra analyzer. Osmolarity was calculated by the equation: $2\times Na^+ + K^+ +$glucose+urea [2]. The measurements were performed in intact animals, before sanation of the abdominal cavity, and 1, 2, 3, 7, 10, 15, 20, and 30 days after surgery.

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The significance of differences was evaluated by means of dispersion analysis.

RESULTS

The development of BP was accompanied by pronounced changes in fluid and electrolyte balance (Table 1). K^+ concentration in animals of all groups did not differ from that in intact dogs. Hyponatremia ($p<0.01$) and hypochloremia ($p<0.001$) were observed before surgery and in the early postoperation period. The development of hypochloremia is associated with hyperthermia during inflammation and respiratory alkalosis. Hyponatremia is probably caused by impaired cell membrane permeability. This assumption is supported by the increase in activity of specific blood enzymes. Activities of ALT, AST, creatine phosphokinase, and alkaline phosphatase increased by 58 ($p<0.01$), 166 ($p<0.001$), 180 ($p<0.001$), and 264% ($p<0.001$), respectively, 24 h after BP modeling. Most parameters returned to normal by the 7th day. The only exception was alkaline phosphatase, whose activity in group 4 dogs returned to normal only on day 20 after treatment (Table 2).

Parameters of electrolyte and osmotic homeostasis most rapidly returned to normal in group 3 animals on day 2 after treatment. Therefore, isolated use of methods of hemocorrection does not produce stabilizing effects on individual cells membranes, while combined treatment with NaClO and UV has a strong membrane-stabilizing effect.

Abdominal fluid sequestration (200-300 ml) was found during sanation of the abdominal cavity 24 h after BP modeling. Redistribution of the fluid into the

TABLE 1. Fluid and Electrolyte Balance in Animals with 24-h BP in the Dynamics of Treatment ($M\pm m$)

Group, days		Hematocrit, %	Erythrocyte count, 10^{12} cells/liter	MEV, fl	Na^+, mol/liter	Cl^-, mol/liter	Osmolarity, mosm/liter
Intact animals		39.9±1.1	6.2±0.2	64.1±0.9	147.0±0.8	107.8±0.5	306.8±1.9
1		51.7±1.2***	8.1±0.2***	64.0±0.8	141.7±1.3**	101.3±1.0***	297.8±3.3*
2	1	45.1±1.7*	6.6±0.2	68.0±2.5	140.4±1.2***	99.8±0.8***	297.9±1.9**
	2	39.7±2.2	5.9±0.2	67.2±2.2	141.0±1.5**	96.4±1.1***	295.2±3.6**
	3	38.2±3.1	5.7±0.4	66.6±2.6	142.0±1.1***	99.2±2.0***	296.0±1.7***
	7	31.9±1.9***	4.8±0.3***	66.3±2.7	141.9±1.5**	108.6±1.3	295.0±3.1**
	10	34.6±2.8	5.1±0.4**	62.5±4.3	145.0±1.2	109.7±1.3	301.4±2.6
	15	38.2±2.0	5.5±0.4	70.0±4.1	144.3±2.7	109.1±0.9	300.7±8.4
	20	36.7±1.8	5.3±0.4	69.8±2.7	141.9±2.5	108.0±0.8	295.9±4.5*
	30	33.4±2.0**	5.0±0.4**	68.3±3.0	144.1±1.2	107.2±1.9	300.8±2.5
3	1	41.8±1.9	6.1±0.2	68.2±2.0	144.8±1.3	104.1±1.2**	301.2±2.2
	2	38.9±1.9	5.5±0.2*	69.4±2.5	147.1±1.2	106.8±1.0	304.8±2.6
	3	38.7±2.4	5.7±0.2*	68.5±4.0	146.4±1.1	104.5±1.6	304.5±2.0
	7	31.7±3.4*	4.6±0.5**	69.4±2.0*	149.7±1.4	108.9±1.3	312.2±2.9
	10	34.8±2.3	4.8±0.3***	72.9±3.9*	147.9±1.1	106.4±2.2	308.7±3.2
	15	32.2±2.6*	4.5±0.4***	72.4±1.9***	146.8±0.8	106.7±1.7	305.7±1.0
	20	35.4±3.2	4.7±0.4**	75.3±1.3***	149.7±1.5	110.3±1.3	315.4±3.2*
	30	31.6±3.3*	4.3±0.4***	73.4±1.6***	147.4±1.3	109.0±1.1	306.4±2.7
4	1	45.1±1.7*	6.6±0.2	68.0±2.5	140.4±1.2**	99.8±0.8***	297.9±1.9**
	2	41.1±2.6	6.1±0.4	68.3±1.6*	142.1±1.1***	99.3±2.2***	298.4±1.9**
	3	40.2±1.5	5.6±0.3	72.2±1.8***	141.1±1.8***	99.0±2.6**	294.8±3.9**
	7	39.8±2.6	5.5±0.4	72.9±1.8***	144.4±1.9**	106.1±1.6	301.1±4.0
	10	41.3±2.5	5.2±0.2*	80.1±2.6***	147.7±2.5	111.0±2.2	306.2±6.0
	15	35.2±1.7*	4.7±0.2***	75.6±0.6***	145.3±1.3	110.3±1.7	304.7±2.5
	20	34.4±2.1*	4.6±0.4***	75.0±2.0***	145.3±0.7	110.3±1.2	304.2±1.6
	30	35.4±4.0	4.9±0.6***	72.7±2.2**	147.4±0.8	110.5±1.4	307.2±1.0

Note. Here and in Table 2: *$p<0.05$, **$p<0.01$, and ***$p<0.001$ compared to intact animals.

third water space leads to hemoconcentration, but on days 1-2 after surgery it was changed by hemodilution. It is known that moderate hemodilution is associated with relative anemia, decreased blood viscosity, and improved tissue perfusion. In group 4 animals, anemia developed in a later period. It could be related to stimulation of erythropoiesis upon combined treatment with NaClO and UV irradiation of the blood. MEV was measured to test this hypothesis. The mean size of young erythrocytes was higher compared to old erythrocytes. Moreover, young cells have a greater value of MEV during stimulation of erythropoiesis.

The study of MEV is important for the diagnosis and prediction of the course of blood disorders and other diseases [4,6]. Increased MEV serves as a criterion of good compensatory capacity of erythropoiesis [2,5]. Our study showed that MEV significantly increased in animals exposed to UV irradiation of the blood, but remained unchanged in group 2 dogs (compared to intact animals). Stimulation of erythropoiesis was most pronounced in group 4 animals. These data suggest that NaClO potentiates the stimulatory effect of UV irradiation on the release of young erythrocytes from depots.

Urea concentration characterizes putrefaction in the intestinal tract and peristaltic activity of the intestine. Urea concentration in group 3 dogs and NaClO-treated animals returned to normal on days 1 and 2 after surgery, respectively (Table 2). Creatinine concentration in animals of various groups remained practically unchanged.

Cholesterol concentration reflecting the intensity of lipolysis rapidly returned to normal in group 2 and 4 animals receiving NaClO (day 7). In group 3 dogs this parameter returned to normal only by the 10th day. β-Lipoprotein concentration in animals of various groups was higher than in intact dogs.

TABLE 2. Protein and Lipid Metabolism in Animals with 24-h BP in the Dynamics of Treatment (*M*±*m*)

Group, days		Urea, mmol/liter	ALT, U/liter	Creatine phosphokinase, U/liter	Alkaline phosphatase, U/liter	Cholesterol, mol/liter	β-Lipoproteins, U/liter
Intact animals		4.7±0.4	45±5	288±29	74±6***	3.7±0.2	13.8±1.3
1		8.0±0.8***	120±15***	804±83***	284±22***	4.4±0.2*	35.5±3.3***
2	1	7.7±0.9**	173±25***	5697±1109***	383±31***	4.7±0.3**	29.0±2.2***
	2	4.6±0.7	150±24***	1762±369***	328±20***	4.6±0.3*	37.2±3.3***
	3	5.3±0.9	130±17***	922±210**	380±29***	5.4±0.3***	41.0±2.5***
	7	3.9±0.5	57±10	192±27*	208±19***	4.2±0.3	36.4±4.2***
	10	3.7±0.7	43±6	225±22	194±16***	4.8±0.5	33.0±2.5***
	15	3.4±0.8	31±6	195±48	214±30***	4.2±0.3	32.7±5.4**
	20	3.8±0.8	44±8	192±42	200±38**	4.4±0.4	28.4±5.2*
	30	3.7±0.5	35±6	184±20**	205±37**	4.0±0.4	24,9±3,5**
3	1	5.1±0.4	71±7***	2680±483***	313±25***	4.5±0.2**	30.8±2.7***
	2	3.5±0.4*	75±9***	803±110***	277±28***	5.2±0.4**	36.5±2.7***
	3	4.7±0.6	79±116***	655±131***	275±41***	5.7±0.7**	36.8±6.1**
	7	5.1±0.5	49±7***	243±29*	193±27***	4.6±0.3*	38.0±3.7***
	10	5.0±0.6	44±8	197±47	114±18*	3.9±0.1	27.6±2.3***
	15	4.3±0.8	32±4	201±41	123±19*	4.0±0.4	23.0±3.1*
	20	5.7±0.7	31±3	140±21***	124±18*	4.0±0.2	21.2±1.8**
	30	3.8±0.6	33±4	223±50	178±24***	3.9±0.4	23.2±4.2*
4	1	4.7±0.4**	173±25***	5697±1109***	74±6***	4.7±0.3**	29±2.2***
	2	8.0±0.8	126±10***	1884±371***	284±22***	5.9±0.4***	40.5±4.8***
	3	7.7±0.9	103±8***	791±133***	383±31**	5.3±0.6*	42.8±2.0***
	7	6.3±1.2	64±9***	332±63***	529±87**	4.2±0.3	43.7±3.6***
	10	6.4±0.9	59±9	244±31	444±112**	4.5±0.4	36.8±2.4***
	15	5.0±0.4	44±11	248±63	221±46*	4.9±0.6	36.7±2.9***
	20	4.1±0.5	58±10	232±44	243±56	4.4±0.2*	30.9±3.2***
	30	4.9±0.7	29±6	126±11***	182±46	3.7±0.2	25.7±3.4**

The mortality rate in group 2, 3, and 4 animals was 23, 31, and 13%, respectively, which attested to high effectiveness of combined treatment.

Thus, indexes of water and electrolyte balance and urea concentration most rapidly return to normal in animals exposed to UV irradiation of the blood. It should be emphasized that UV irradiation increases MEV, which attests to stimulation of erythropoiesis. Combined treatment with NaClO and UV irradiation of the blood contributes to rapid and more significant increase in MEV. Activity of specific enzymes in animals of various groups returned to normal in the same period after treatment, except alkaline phosphatase characterized by a lower recovery rate. Therefore, this enzyme can be used as a marker of prolonged nonspecific hyperenzymemia during acute abdominal inflammation. Alkaline phosphatase activity returned to normal only in animals of the main group, which suggests that combined treatment with NaClO and UV irradiation produces a strong membrane-stabilizing effect. The intensity of lipolysis estimated by cholesterol concentration most rapidly decreases in NaClO-treated animals. However, the methods of hemocorrection used in our study do not completely normalize β-lipoprotein metabolism. Therefore, combined treatment with NaClO and UV irradiation of the blood is a pathogenetically substantiated approach in postoperation therapy of BP. This method suggests adequate evaluation and correction of electrolyte balance.

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