Morphofunctional Assessment of Intestinal Wound Repair in Different Age

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Anastomoses were formed with a single-row continuous suture in dogs of different age. The course of intestinal wound repair was the least favorable in the youngest dogs, which was apparently due to greater disorders of regional blood flow, high activity of free-radical processes, and pronounced tissue hypoxia at the site of anastomosis, in comparison with the older dogs.

Key Words: *small intestine; regional blood flow; free-radical process; tissue hypoxia; redox potential*

Intestinal injuries often require the repair of biological intactness of the organ [2,3,8]. The course and outcome of reparative regeneration of the anastomosis are determined by the type and extent of the injury and by age [1,4,9]. Studies of the mechanisms responsible for local homeostasis will help disclose the regularities in the course of repair processes at different ages.

MATERIALS AND METHODS

Forty-two experiments were carried out on 20 young (1-6 months) and 15 adult (over 8 months) dogs of both sexes weighing 1-20 kg. Medical laparotomy was carried out under intravenous sodium thiopental narcosis (0.04-0.045 g/kg) after treating the operation field with iodonate and ethanol. The small intestine was retracted into the wound and crossed. Anastomoses were formed with a single continuous suture through all layers of the intestinal wall by Capron threads of different diameters (8/0-3/0), depending on the age of animals.

Immediately after suturing of the wound defect, hemocirculation parameters (by the capillary filter), plasma protein loss, and blood viscosity were recorded. Changes in small intestinal mesenteric vessels adjacent to the anastomosis were examined by biomicroscopy. The disorders of tissue homeostasis were assessed after 1, 3, and 5 days (7 animals per term) by evaluating (in wet tissue at the site of anastomosis) the activity of lipid peroxidation (from accumulation of malonic dialdehyde, MDA) [5], catalase activity [6], blood content of tissues, bioenergetic potential (from the redox potential, RP), and oxygen supply (by oxygen diffusion coefficient, ODC). Lactate and succinate dehydrogenases and acid and alkaline phosphatases were measured in unfixed sections of intestinal wall [7].

RESULTS

Assessment of hemocirculation directly after the formation of anastomosis showed its moderate disorders in young animals. Capillary infiltration increased by 278.85% ($p<0.05$). Blood viscosity and plasma protein loss were virtually the same as initially. Microscopic examination revealed moderately reduced blood flow in all venules, stasis in multiple venules and individual capillaries, and multiple perivascular hemorrhages. The number of functioning capillaries decreased by 70-75%.

Repeated opening of the abdominal cavity 1 day after the operation showed appreciable changes in

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TABLE 1. Changes in Tissue Homeostasis at the Site of Anastomosis in Young Dogs ($M\pm m$, $n=7$)

Parameter		Time of analysis, day		
		1	3	5
MDA, nmol/g tissue	control	1.37±0.26	1.33±0.23	1.37±0.12
	experiment	4.17±0.45**	4.01±0.51**	3.94±0.46**
Catalase, mg H_2O_2/min/g tissue	control	3.74±0.33	3.52±0.14	3.74±0.13
	experiment	1.55±0.45**	2.09±0.3**	2.47±0.36*
Blood content, μl/g tissue	control	221.99±25.4	209.42±34.46	193.4±22.32
	experiment	1701.54±217.41***	1425.12±116.27***	882.08±60.65***
Redox potential, mB	control	-50.69±1.27	-50.46±1.55	-52.87±2.65
	experiment	-57.54±2.19*	-56.01±3.74	-56.72±3.68
ODC, cm^2/c	control	$(3.09\pm0.28)\times10^{-3}$	$(2.3\pm0.37)\times10^{-3}$	$(2.89\pm0.25)\times10^{-3}$
	experiment	$(9.08\pm0.34)\times10^{-4}$***	$(1.17\pm0.21)\times10^{-3}$*	$(2.18\pm0.54)\times10$

Note. Here and in Table 2: *$p<0.05$, **$p<0.01$, ***$p<0.001$ *vs.* the control.

TABLE 2. Changes in Tissue Homeostasis at the Site of Anastomosis in Adult Dogs ($M\pm m$, $n=7$)

Parameter		Time of analysis, day		
		1	3	5
MDA, nmol/g tissue	control	1.33±0.36	1.39±0.62	1.38±0.12
	experiment	3.98±0.14***	3.75±0.67*	3.17±0.56*
Catalase, mg H_2O_2/min/g tissue	control	3.59±0.51	3.42±0.33	3.6±0.22
	experiment	1.83±0.44*	2.16±0.16*	2.45±0.39*
Blood content, μl/g tissue	control	427.38±43.56	435.22±38.81	404.84±54.65
	experiment	2211.21±270.81***	1901.18±272.56**	1314.28±91.63***
Redox potential, mB	control	-49.86±2.94	-50.57±3.36	-50.71±2.83
	experiment	-53.29±0.82	-51.71±2.12	-51.14±1.41
ODC, cm^2/c	control	$(3.17\pm0.72)*10^{-2}$	$(2.53\pm0.69)*10^{-2}$	$(3.25\pm0.77)*10^{-2}$
	experiment	$(1.94\pm0.66)*10^{-2}$	$(1.7\pm0.17)*10^{-2}$	$(2.95\pm0.61)*10^{-2}$

tissue homeostasis (Table 1). The activity of lipid peroxidation and blood content in tissues increased, while catalase activity, RP, and ODC decreased. This indicates pronounced destructive processes in tissues at the site of suturing. The histochemical picture of activities of succinate and lactate dehydrogenases and acid and alkaline phosphatases indicated that aerobic respiration of cells was replaced by anaerobic, and pronounced tissue hypoxia developed.

The time course of changes in the above-mentioned parameters in young animals at different periods after the intervention demonstrated their drastic deviation from the norm during a long period. Only RP and ODC remained virtually the same as initially for 5 days after the operation. Pronounced pathophysiological changes at the site of anastomosis were apparently responsible for delayed reparative regeneration of the anastomosis, associated with numerous postoperative complications (incompetent sutures in 8 cases).

Studies of regional blood flow in adult animals immediately after the formation of the anastomosis showed its lesser disorders in comparison with young animals. Capillary infiltration increased moderately (by 182.27%, $p<0.01$). Other hemocirculation parameters were comparable to the control. Microscopic study of the small intestinal mesenteric vessels adjacent to the anastomosis revealed moderately decelerated blood flow in small venules, stasis only in few venules, and solitary perivascular hemorrhages. The number of functioning capillaries decreased by 30-50%.

Examination of tissue homeokinesis in anastomozed zone of the small intestine 24 h after the operation showed a pronounced increase in the level

of malonic dialdehyde and in the blood content of tissues (Table 2). Catalytic activity dropped by 49.03% ($p<0.05$). RP and ODC were the same as initially. Oxygen deficiency was negligible, as evidenced by moderate activities of the enzymes in unfixed sections of the intestinal wall.

Subsequent recovery of tissue homeostasis was more rapid, unlike in the younger group. This may be the cause of a more favorable course of intestinal wound healing with lower incidence of postoperative complications (incompetent sutures in 3 dogs).

Disorders of regional blood flow after formation of anastomoses were more severe in young animals than in adult. Greater circulatory shifts in the younger group resulted in a greater increase in the activities of free-radical processes and development of tissue hypoxia, which inevitably led to imbalance in tissue homeostasis. The disturbances in the environment of sutured compartments of the organ deteriorated the conditions of repair of biological intactness of the intestine. This, no doubt, delayed intestinal wound repair and was responsible for a higher incidence of postoperative complications, such as incompetent anastomosis sutures in the younger dogs.

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