Regulatory Mechanisms in Biosystems

ISSN 2519-8521 (Print)
ISSN 2520-2588 (Online)
Regul. Mech. Biosyst.

Effect of autologous platelet-rich plasma on gastric wall regeneration after experimental gastrotomy in rabbits

D. O. Kovalenko*, M. O. Malyuk*, V. V. Klymchuk*, O. V. Onyshchenko*, V. V. Honchar*, V. V. Tkachenko*, I. M. Gorkava*

**National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine*

Article info

Received 02.01.2026
Received in revised form 01.02.2026
Accepted 26.02.2026

National University of Life and Environmental Sciences of Ukraine, Kyiv, 03041, Ukraine.
E-mail: dima.kovalenko.zoolux@gmail.com

Kovalenko, D. O., Malyuk, M. O., Klymchuk, V. V., Onyshchenko, O. V., Honchar, V. V., Tkachenko, V. V., & Gorkava, I. M. (2026). Effect of autologous platelet-rich plasma on gastric wall regeneration after experimental gastrotomy in rabbits. Regulatory Mechanisms in Biosystems, 17(2), e26026. doi:10.15421/0226026

The aim of the study was to determine the effect of autologous platelet-rich plasma on the processes of regeneration of the gastric wall in rabbits after experimental gastrotomy. The study was conducted on 62 Chinchilla breed rabbits, which were divided into a control group and an experimental group. Animals of the experimental group underwent infiltration of the gastric wall suture with autologous platelet-rich plasma, whereas animals of the control group received standard therapy. Morphological changes in gastric tissues were evaluated histologically on the 1st, 3rd, 7th, 10th, 14th, and 21st days after surgery. It was established that the use of autologous platelet-rich plasma contributed to a more intensive contraction of the gastric muscular layer at the early stages of healing, which ensured faster wound closure and a reduction in the effect of gastric juice on the tissues. Animals of the experimental group exhibited a less pronounced inflammatory reaction, improved blood supply, and active proliferation of smooth muscle tissue cells. As early as the 7th day, the structure of the muscular and serosal layers in the area of surgical intervention was similar to that of intact tissues. Complete regeneration of all layers of the gastric wall in animals of the experimental group was observed on the 10th–14th day, whereas in the control group this process was completed only on the 21st day. The obtained results indicate that the use of autologous platelet-rich plasma significantly accelerates the regenerative processes of the gastric wall after gastrotomy and may be an effective method for optimizing postoperative healing in veterinary surgery.

Keywords: platelet-rich plasma; gastric wall regeneration; experimental gastrotomy; rabbits; histological studies; smooth muscle tissue regeneration.

Introduction

The use of blood components is a relevant area of modern veterinary medicine, particularly in the context of stimulating regenerative processes in the postoperative period. Considerable attention of researchers is focused on autologous platelet-rich plasma, which, due to the high concentration of biologically active substances, is capable of modulating tissue healing processes. It has been shown that the use of platelet-rich plasma in combination with autologous mesenchymal stem cells of adipose origin provides a positive clinical effect in the treatment of laminitis in horses, which confirms its significant regenerative potential (Malyuk et al., 2023; Malyuk et al., 2024).

Activation of reparative processes in body tissues is a complex multifactorial phenomenon that is realized with the participation of various cell populations and signaling molecules. In this regard, during recent years numerous studies have been conducted using different types of cells and biological agents capable of accelerating the restoration of damaged tissues in animals of various species (Labunets et al., 2022). A special role in the regulation of healing processes is played by platelets, which, after activation in the area of injury, interact with components of the extracellular matrix and release growth factors and cytokines, in particular platelet-derived growth factor (PDGF) and transforming growth factor beta (TGF-β), which ensure cell proliferation, angiogenesis, and tissue remodeling (Diegelmann et al., 2004).

It has been proven that platelet-rich plasma has a positive effect on the healing of soft tissues precisely due to platelet degranulation and the release of a complex of growth factors. Owing to this, it is widely used in the treatment of injuries of tendons, ligaments, muscles, cartilage tissue, as well as in the early stages of osteoarthritis (Cole et al., 2010). In addition, the effectiveness of recombinant platelet-derived growth factor (rhPDGF-BB) in the therapy of chronic ulcerative lesions has been established, which confirms the expediency of using platelet-derived factors to stimulate reparative processes. An advantage of the use of autologous platelet-rich plasma is its biological safety, determined by its autologous nature, as well as the possibility of delivering a physiologically balanced complex of growth factors and cytokines directly to the site of injury. At the same time, it has been established that the individual effects of certain growth factors studied under *in vitro* conditions do not always fully reflect their action *in vivo*, since the realization of regenerative potential requires the synergistic interaction of several signaling molecules (Mishra et al., 2009; Cole et al., 2010).

Despite a significant number of studies devoted to the use of platelet-rich plasma in pathologies of the musculoskeletal system, the issue of its effect on regenerative processes in the tissues of the digestive tract, in particular the gastric wall, remains insufficiently studied. Considering the prevalence of surgical interventions on the organs of the digestive system in animals (trichobezoar disease, foreign bodies, inflammatory diseases, neoplasms), the search for effective methods to optimize postoperative healing is relevant.

In this regard, the aim of the present study was to determine the effect of autologous platelet-rich plasma on the processes of regeneration of the gastric wall in rabbits after experimental gastrotomy.

Materials and methods

The animals were housed in pairs in boxes with free access to food and water; treatment with Advocate against ecto- and endoparasites was performed, and vaccination was carried out in accordance with the requirements for the prevention of infectious processes. Experiments on animals were conducted in compliance with the requirements of the "General Ethical Principles for Conducting Experiments on Animals," approved by the I National Congress on Bioethics (Law of Ukraine, 2006), and the provisions of the "European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes" (European Convention, 1986), as well as the Law of Ukraine "On the Protection of Animals from Cruelty" (Bulletin of the Verkhovna Rada, 2010, 2020). The animals were approved for use in the study according to the protocol issued by the

Bioethics Commission of the National University of Life and Environmental Sciences of Ukraine (27.10.2020, Protocol No. 80-3).

The study was carried out during 2020–2024 at the Department of Surgery and Pathophysiology named after Academician I. O. Povazhenko, Faculty of Veterinary Medicine, National University of Life and Environmental Sciences of Ukraine. In particular, the preparation of autologous platelet-rich plasma was performed at the Educational and Research Laboratory "Animal Blood Bank," while surgical interventions on the stomach of animals were carried out at the Educational and Research Laboratory "Electric Welding of Biological Tissues" of the Department of Surgery and Pathophysiology named after Academician I. O. Povazhenko. Histological examinations were conducted at the Department of Anatomy, Histology, and Pathomorphology of Animals named after Academician V. H. Kasianenko, Faculty of Veterinary Medicine, National University of Life and Environmental Sciences of Ukraine.

Laboratory animals (Chinchilla breed rabbits) were used in the experiments, in a total number of 62 individuals (males, 8 months of age, with a body weight of 3.0–3.5 kg). To form two experimental groups, rabbits of the same age group, body weight, and sex were selected. All animals underwent quarantine measures, vaccination, and treatments against ecto- and endoparasites in advance in order to prevent the influence of infectious and parasitic factors on the health status of the rabbits. Surgical intervention was performed using an upper midline laparotomy, with visualization of the stomach, fixation, and gastrotomy carried out in the area of the greater curvature. After gastrotomy, the incision site was closed with a Schmieden suture, and the abdominal wall was closed with an interrupted suture.

To ensure total intravenous anesthesia, Zoletil (Virbac, France) was used at a dose of 3 mg/kg body weight and Medison (Brovafarm, Ukraine) at a dose of 0.5 mg/kg body weight, administered as a bolus intramuscularly. After administration of the drugs, a catheter was placed in the lateral ear vein for further monitoring and maintenance of anesthesia. For this purpose, propofol (Lipuro, B. Braun, Germany) was used at a dose of 6 mg/kg body weight, and anesthesia was maintained by a constant-rate infusion of the hypnotic at 1 mg/kg/min. For analgesia of soft tissues, epidural anesthesia was applied by administration of a 2% lidocaine solution (Darnytsia, Ukraine) at a dose of 2–4 mg/kg body weight.

Platelet-rich plasma was obtained using a two-step blood centrifugation method. During the first centrifugation, centrifugal force of 160 G was applied for 7 minutes, and the layer of platelet-rich plasma and leukocytes was collected. The suspension was then centrifuged again at 500 G for 10 minutes. The supernatant was removed, leaving 1 mL of platelet-rich plasma at the bottom of the tube.

The subject of the study was samples of the gastric wall of Chinchilla breed rabbits, which were obtained by surgical intervention using the upper midline laparotomy method followed by gastrotomy, with subsequent fixation of the collected biomaterial in a 10% formaldehyde solution and further preparation of histological sections.

To study the effect of autologous platelet-rich plasma on the wound healing process, the rabbits were divided into two groups. Rabbits of the control group (n = 31) received a classical therapeutic treatment regimen: antibiotic therapy with Enroxil at a dose of 5 mg/kg body weight once daily for 7 days; the prokinetic drug metoclopramide at a dose of 1 mg/kg body weight every 12 hours for 3 days; and for analgesia, the animals received butorphanol at a dose of 0.1 mg/kg body weight every 6 hours for 7 days. Rabbits of the experimental group (n = 31) received infiltration of the gastric wall suture at the site of gastrotomy with autologous platelet-rich plasma, as well as the classical treatment regimen, which included antibiotic therapy with Enroxil at a dose of 5 mg/kg body weight once daily for 7 days; administration of the prokinetic agent metoclopramide at a dose of 1 mg/kg body weight every 12 hours for 3 days; and for analgesia, the animals received butorphanol at a dose of 0.1 mg/kg body weight every 6 hours for 7 days.

Animals were withdrawn from the experiment in groups of five after sampling of material for histological examination by performing euthanasia via intravenous administration of sodium thiopental at a dose of 1 g per animal.

Results

It was established that in rabbits of the control group on the 1st day after defect creation, the site of the experimentally created wound was closed due to contraction of the muscular layer of the gastric wall. In the area of the created wound, the muscular layer during this observation period formed numerous folds, as a result of which it became significantly thickened. Near the outer surface of the gastric wall, small partially destroyed fragments of the muscular layer were detected (Fig. 1a).

The muscular layer of the stomach, externally gathered into folds in the area of the experimentally created wound, was locally covered by a markedly thickened serous membrane. At the same time, the mesothelium on the surface of the serous membrane was absent. Instead, the subserous layer was markedly thickened due to edema, hemorrhages, and infiltration by a large number of inflammatory cells (Fig. 1b). Inflammatory cells in the subserous layer were represented by a large number of eosinophils, segmented neutrophils, and monocytes, as well as single lymphocytes. In addition, destruction and lysis of fibroblasts and lysis of bundles of collagen fibers were recorded in this area (Fig. 1c). Changes in the outer layer of the muscular coat at the site of the experimentally created wound on the 1st day were uneven. In some areas, pronounced infiltration by inflammatory cells was recorded, whereas in other areas only slight edema of this layer and granular degeneration of smooth muscle cells were detected, and infiltration by inflammatory cells was absent. In the areas of inflammatory cell infiltration, granular degeneration of smooth muscle cells, as well as disintegration and lysis of smooth muscle cells, were established (Fig. 1d). Among the inflammatory cells, a large number of lymphocytes were detected.

Changes in the middle and inner layers of the muscular coat at the site of the experimentally created wound on the 1st day were generally similar to those observed in its outer layer. However, in some areas, foci of muscle tissue necrosis were detected. Closer to the submucosa, between the folds of the muscular coat, during this observation period partially and completely necrotized fragments of the muscular and mucosal layers, as well as partially necrotized and partially lysed fragments of the submucosa, were identified (Fig. 1e). Near the site of the experimentally created wound on day 1 in rabbits of the control group, a large number of relatively large hemorrhages in the muscular layer were recorded (Fig. 1f). The serous membrane was unchanged.

In the submucosa at the site of the experimentally created wound on the 1st day, connective tissue elements (fibroblasts and bundles of collagen fibers) were almost completely lysed. Only remnants of thin bundles of collagen fibers and single fibroblasts at various stages of lysis were detected. In this part of the gastric wall, numerous large hemorrhages and infiltration by a large number of inflammatory cells were also recorded. Among the inflammatory cells, monocytes and segmented neutrophils predominated, among which single eosinophils and lymphocytes were detected (Fig. 2a).

Near the site of the experimentally created wound, the submucosa of the gastric wall contained numerous large hemorrhages and was infiltrated by the same inflammatory cells as directly at the site of the experimentally created wound. However, the connective tissue of the submucosa adjacent to the site of the experimentally created wound was noticeably better preserved – relatively large fragments composed of fibroblasts and bundles of collagen fibers were detected in this area (Figs. 1e, 2b).

At the lateral margins of the experimentally created wound during this observation period, large hemorrhages were detected in the mucosal layer, and the mucosa itself at the edges of the defect was destroyed and necrotized (Fig. 2c).

Beyond the zone of destruction and necrosis, edema and hemorrhages were recorded in the mucosal layer (Fig. 2c, 2d). Foveolar cells of the neck region of many fundic glands of the stomach were destroyed. In the upper regions of the fundic glands, foci of destruction of all cell types were also observed. In the deeper parts of the fundic glands, granular degeneration and destruction of chief and parietal cells were detected (Fig. 2d). Some of the chief and parietal cells were desquamated into the lumen of the glands (Fig. 2e). In iso-

lated epithelial cells of the gastric pits, chromatin margination was observed, which, according to current concepts, is a precursor of cell death.

In some areas, loosening and partial lysis of the basement membrane of the epithelium of the gastric pits were also observed. In such areas, a pronounced subepithelial edema was detected (Fig. 2f).

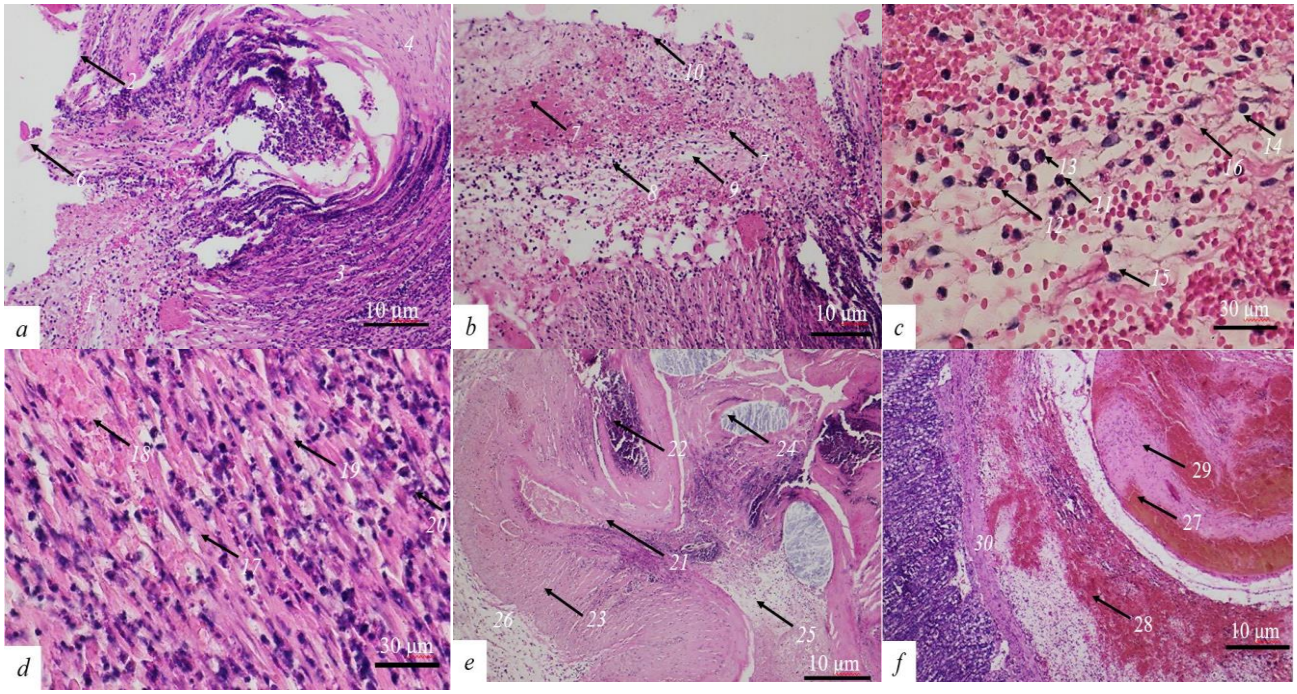

Fig. 1. Histological changes of the gastric wall of rabbits of the control group on the 1st day after gastrotomy (Carazzi's hematoxylin and eosin): *a* – outer part of the fold of the muscular layer at the site of the experimentally created wound; *b* – serous membrane of the stomach in the area of the experimentally created wound; *c* – cellular composition of the inflammatory infiltrate of the serous membrane; *d* – outer layer of the muscular coat infiltrated with inflammatory cells; *e* – fold of the muscular layer with necrotized fragments of the mucosal layer and the submucosa; *f* – fragment of the fold of the gastric wall adjacent to the site of the experimentally created wound; *1* – thickened serous membrane; *2* – outer layer of the muscular coat without serous covering; *3* – infiltration by inflammatory cells; *4* – edema and granular degeneration of smooth muscle cells; *5* – area of destruction of the muscular coat; *6* – fragment of the muscular coat outside the gastric wall; *7* – hemorrhage; *8* – cellular infiltration; *9* – edema; *10* – absence of mesothelium; *11* – eosinophil; *12* – segmented neutrophil; *13* – monocyte; *14* – lymphocyte; *15* – lysis of fibroblast; *16* – lysis of bundles of collagen fibers; *17* – granular degeneration of smooth muscle cells; *18* – disintegration of smooth muscle cells; *19* – lysis of smooth muscle cells; *20* – inflammatory cells; *21* – fold of the muscular layer; *22* – infiltration of the muscular layer; *23* – edema of the muscular layer; *24* – necrotized fragment of the mucosal layer; *25* – partially necrotized and lysed fragment of the submucosa; *26* – submucosa; *27* – hemorrhages in the muscular layer; *28* – hemorrhage in the submucosa; *29* – muscularis mucosae; *30* – mucosal layer

On the 3rd day after defect creation in rabbits of the control group, the site of the experimentally created wound was still closed by the muscular layer, which, however, was already covered by an unchanged serosal layer (Fig. 3a).

During this observation period, the serosal layer had already acquired its characteristic microscopic structure. In the muscular layer, which formed much smaller folds than on the 1st day, small isolated hemorrhages and accumulations of inflammatory cells were still observed; however, at this stage of observation, most of these cells were at various stages of destruction, which indicated the completion of the inflammatory process in the muscular layer of the gastric wall (Fig. 3b). Near the defect site, edema of the muscular layer and the presence of isolated foci of destroyed smooth muscle cells were still preserved. However, pronounced proliferation of smooth muscle cells was already recorded, which documented the processes of intensive restoration of the muscular layer of the gastric wall at the site of the experimentally created wound (Fig. 3c).

At the site of the created wound, the submucosal layer, the muscularis mucosae, and the mucosal layer itself were absent (Fig. 3d). Adjacent to the damaged area, hemorrhages and accumulations of inflammatory cells were still observed in the submucosal layer. However, at this stage of observation, proliferation of fibroblasts was already detected in the submucosal layer, which indicated the initiation of regenerative processes (Fig. 3e). At the same time, fragments of necrotized mucosal layer were detected in the submucosal layer near the defect site of the gastric wall (Fig. 3f), which indicated incomplete cleansing of the experimentally created wound on the 3rd day.

Microscopic changes in the muscularis mucosae and in the gastric pits adjacent to the site of the experimentally created wound were similar to those observed at the previous observation period.

On the 7th day in rabbits of the control group, restoration of the submucosal layer was already observed at the site of the experimentally created wound. However, the defect still extended to the muscularis mucosae and the mucosal layer. At the same time, formation of the submucosal layer was already taking place, but edema was detected in the mucosal layer adjacent to the defect (Fig. 4a).

The muscular layer directly beneath the submucosal layer was still edematous. Hemorrhages and significant accumulations of inflammatory cells were recorded in the submucosal layer. Along with this, newly formed bundles of collagen fibers were detected; however, they still had markedly variable thickness and orientation and were arranged in a disorganized and uneven manner (Fig. 4b).

On the 10th day, in rabbits of the control group, the muscular layer, submucosal layer, and muscularis mucosae at the site of the experimentally created wound were already completely restored. However, the muscularis mucosae at the defect site was hypertrophied and directly at the site of the created wound formed two layers, which indicated a hyperergic (excessive) regenerative response (Fig. 4c).

Directly at the site of the created wound, a relatively deep defect was still observed in the mucosal layer; however, above the muscularis mucosae, intensive formation of the mucosal layer was noted (Fig. 4c), which was characterized by pronounced proliferation of all types of epithelial cells of the gastric pits (Fig. 4d). On the 14th day, the muscularis mucosae at the site of the experimentally created wound remained unevenly thickened. The newly formed mucosal

layer had not yet formed clearly defined gastric pits, contained cavities, and necrotized tissue was detected on its surface. At the sides of the defect site, hemorrhages were detected; however, proliferation of foveolar cells and the initial stages of formation of the necks of fundic glands were already recorded (Fig. 4d, 4e). Only on the 21st day was complete restoration of all layers of the gastric wall recorded at the site of the experimentally created wound (Fig. 4f).

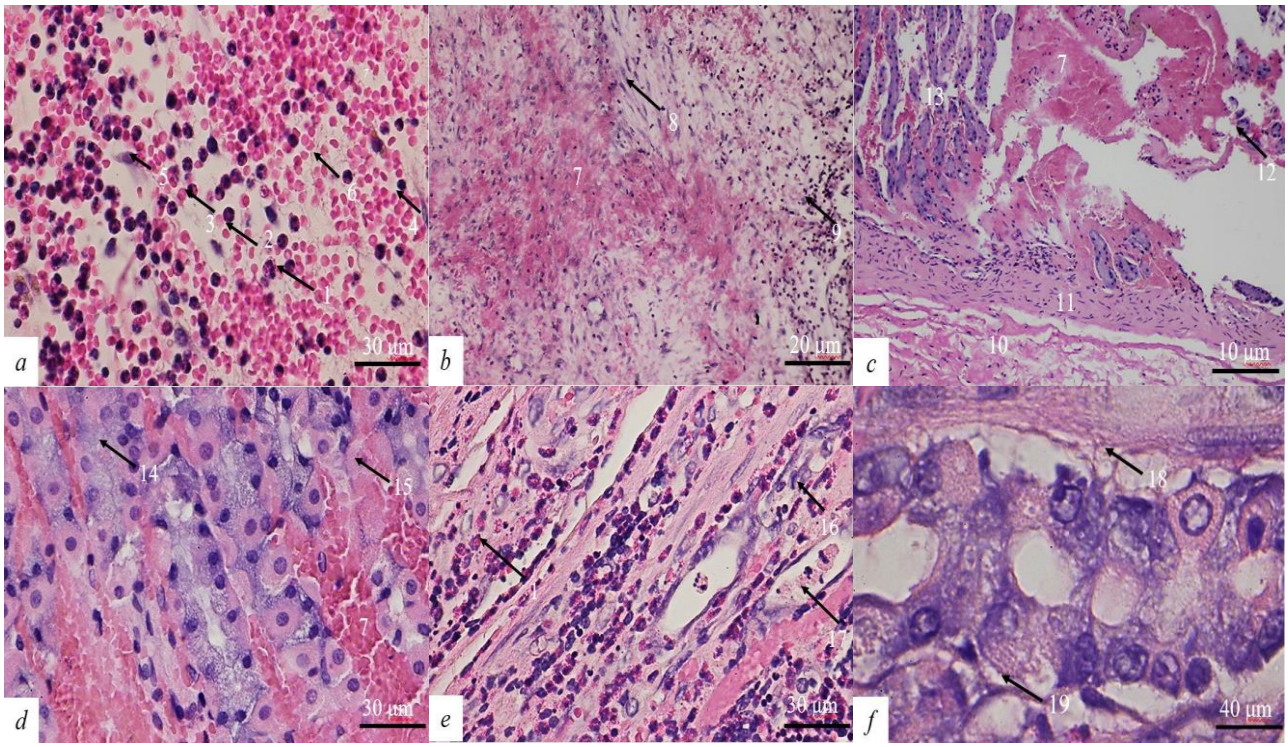

Fig. 2. Histological changes in the gastric tissues of a rabbit from the control group on the 1st day after gastrotomy (Carazzi's hematoxylin and eosin): *a* – submucosal layer of the gastric wall at the site of the experimentally created wound; *b* – submucosal layer of the gastric wall adjacent to the site of the experimentally created wound; *c* – mucosal layer of the gastric wall adjacent to the site of the experimentally created wound; *d* – mucosal layer with signs of dystrophic changes in the cells of the gastric pits; *e* – middle part of the fundic gland of the stomach adjacent to the site of the experimentally created wound; *f* – mucosal layer with disruption of the integrity of the basement membrane; *1* – eosinophil; *2* – segmented neutrophil; *3* – monocyte; *4* – lymphocyte; *5* – destruction of a fibroblast; *6* – almost completely lysed bundles of collagen fibers; *7* – hemorrhage; *8* – inflammatory cells; *9* – fibroblasts and bundles of collagen fibers; *10* – submucosal layer; *11* – granular degeneration of the muscularis mucosae; *12* – destroyed fragments of the mucosal layer; *13* – edema and partial destruction of the mucosal layer; *14* – granular degeneration of chief cells of the gastric pit; *15* – granular degeneration of parietal cells; *16* – destruction of chief cells; *17* – destruction of a parietal cell; *18* – loosening and partial lysis of the basement membrane; *19* – subepithelial edema

It was established that in rabbits of the experimental group, on the 1st day, the site of the experimentally created wound was closed due to contraction of the muscular layer of the gastric wall, as a result of which the muscular layer formed numerous folds during this period of observation (Fig. 5a).

However, in contrast to rabbits of the control group, no changes were detected on the part of the serosal layer of the gastric wall. In the muscular layer, unlike animals of the control group, no disintegration and lysis of smooth muscle cells or foci of muscle tissue necrosis were observed. In addition, no fragments of other layers of the gastric wall were detected between the folds of the muscular layer. In our opinion, this indicates that in animals treated with autologous platelet-rich plasma, more rapid and intensive contraction of the muscular layer occurred, resulting in faster closure of the experimentally created wound. This is also confirmed by the less pronounced inflammatory response in this layer and the absence of eosinophils among inflammatory cells, which indicates the absence of a significant effect of gastric juice on the muscular layer.

It should also be emphasized that during the application of autologous platelet-rich plasma, in contrast to rabbits of the control group, dilated blood vessels filled with blood were detected in the muscular layer in the area of the experimentally created wound during this observation period (Fig. 5b). This allows the conclusion that autologous platelet-rich plasma stimulates blood supply at the site of the gastric wall defect. In addition, unlike rabbits of the control group, hemorrhages in the muscular layer near the experimentally created wound on the 1st day were not recorded in animals of the experimental group. The folds of the muscular layer tightly entered the experimentally created defect of the mucosal layer. It should be emphasized that the size of the mucosal defect in rabbits of the experimental group (Fig. 5b, 5c) was noticeably smaller than in rabbits of the control group. This fact, together with the observation that fragments of necrotized and partially lysed mucosal tissue during the application of autologous platelet-rich plasma were detected only in the upper parts of the experimentally created defect, also confirms more rapid and intensive contraction of the muscular layer with correspondingly faster closure of the experimentally created wound in animals of the experimental group.

Near the experimentally modeled wound on the 1st day, small foci of lysis of the submucosal layer were recorded (Fig. 5b), which, in our opinion, was caused by the action of gastric juice. In the incompletely lysed submucosal layer, lysis of many fibroblasts and some bundles of collagen fibers was observed, as well as small focal infiltrates of inflammatory cells, predominantly monocytes (Fig. 5d). The mucosal layer at the site of the experimentally created wound was absent on the 1st day (Fig. 5b). Near the experimentally created wound on the 1st day, large hemorrhages and necrosis and destruction of the mucosal layer were recorded, as was observed in animals of the control group.

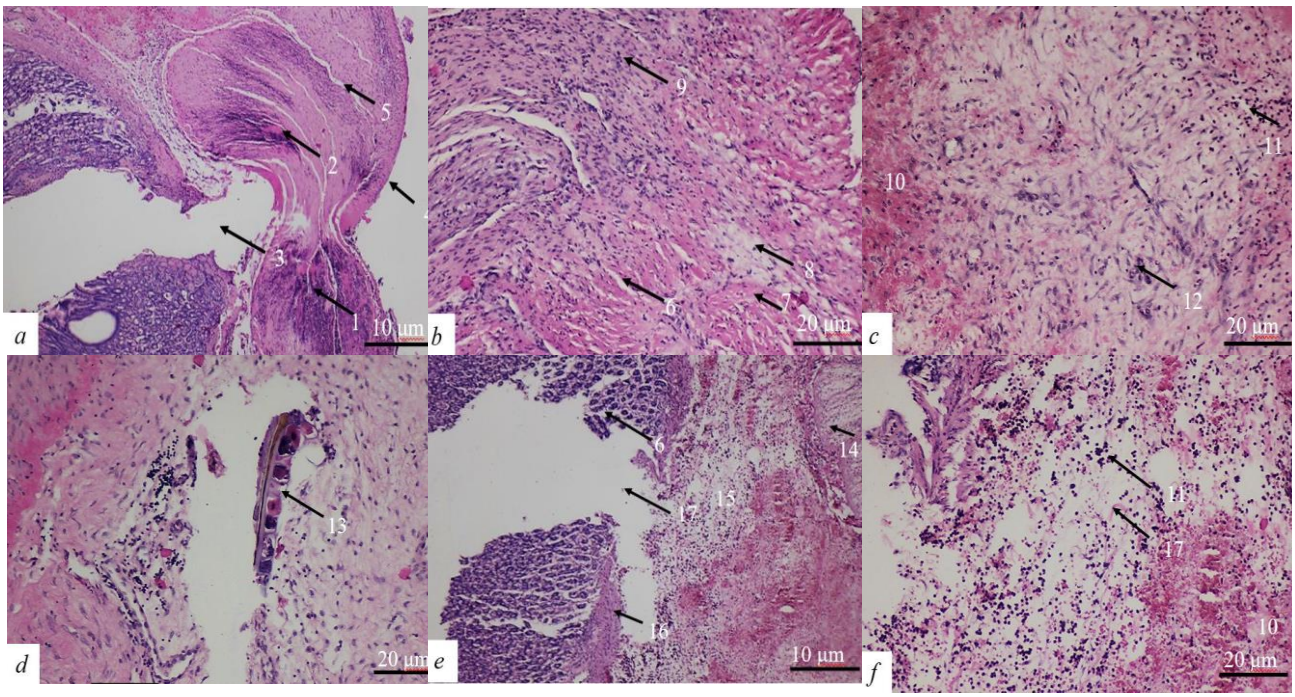

Fig. 3. Histological examination of gastric tissues of animals from the control group on the 3rd and 7th days (Carazzi's hematoxylin and eosin): *a* – gastric wall at the site of the experimentally created wound on the 3rd day with formation of the defect zone and reduction of the folds of the muscular layer; *b* – muscular layer with signs of edema, granular dystrophy, and foci of destruction of smooth muscle cells; *c* – submucosal layer adjacent to the defect site with hemorrhages, cellular infiltration, and proliferation of fibroblasts; *d* – submucosal layer with fragments of necrotized gastric pits; *e* – gastric wall on the 7th day with a defect extending to the submucosal layer and edema of the mucosal layer; *f* – submucosal layer in the zone of the experimentally created wound with hemorrhages, cellular infiltration, and newly formed bundles of collagen fibers; *1* – inflammatory cells in the muscular layer; *2* – hemorrhage in the muscular layer; *3* – defect zone of the gastric wall extending to the muscular layer; *4* – unchanged serosal layer; *5* – reduction of the muscular layer fold; *6* – edema; *7* – granular dystrophy of smooth muscle cells; *8* – focus of destroyed smooth muscle cells; *9* – proliferation of smooth muscle cells; *10* – hemorrhage; *11* – inflammatory cells; *12* – proliferation of fibroblasts; *13* – fragment of a necrotized gastric pit (indicated by an arrow); *14* – muscular layer; *15* – submucosal layer; *16* – muscularis mucosae; *17* – defect zone of the gastric wall extending to the submucosal layer; *18* – newly formed bundle of collagen fibers

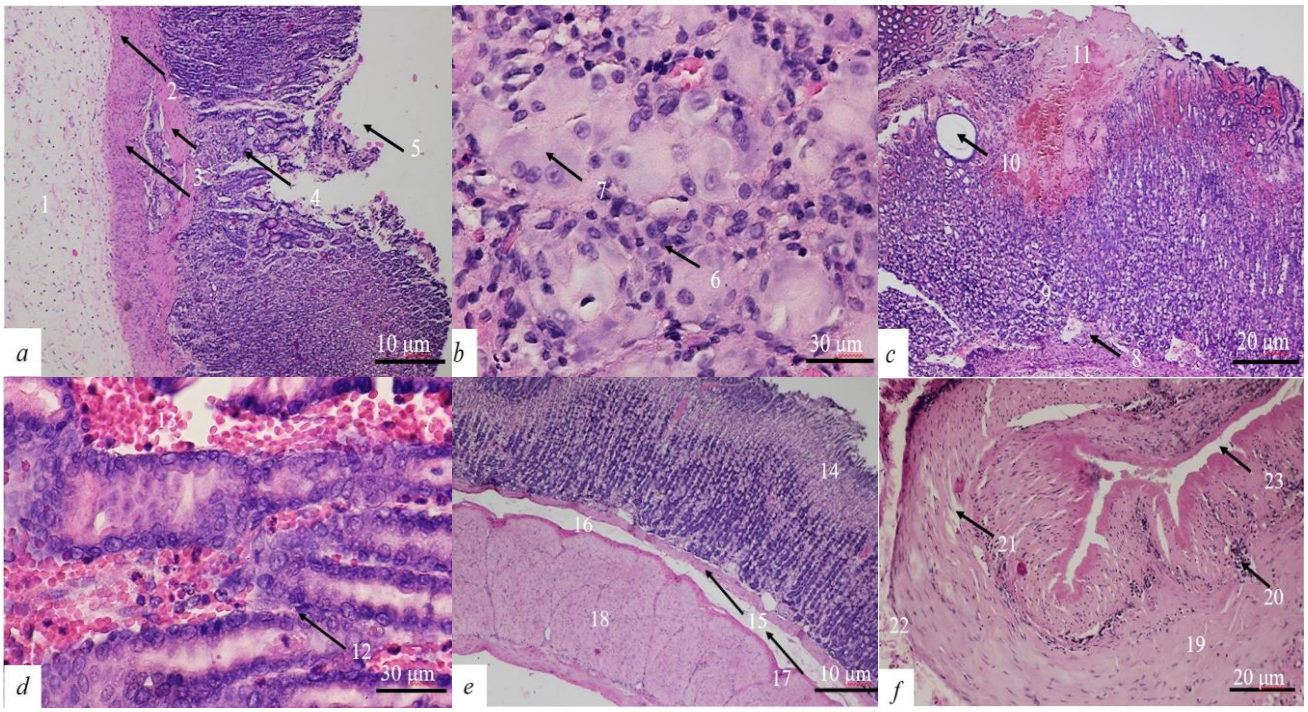

Fig. 4. Histological changes of the gastric tissues of rabbits of the control group on the 10th, 14th, and 21st days after gastrotomy (Carazzi's hematoxylin and eosin): *a* – gastric wall at the site of the experimentally created wound on the 10th day; *b* – formation of the gastric mucosal layer in the area of the experimentally created wound on the 10th day; *c* – gastric wall at the defect site on the 14th day; *d* – upper region of the gastric mucosa adjacent to the defect site on the 14th day; *e* – gastric wall at the site of the experimentally created wound on the 21st day; *f* – fold of the gastric muscular layer at the site of the experimentally created wound with the application of platelet mass on the 1st day; *1* – unchanged submucosal layer; *2* – hypertrophied muscularis mucosae; *3* – duplicated muscularis mucosae; *4* – defect zone of the gastric wall; *5* – newly formed

mucosal layer at the defect site; *6* – proliferation of chief and accessory cells; *7* – proliferation of parietal cells; *8* – unevenly thickened muscularis mucosae; *9* – newly formed mucosal layer; *10* – cavity within the newly formed mucosal layer; *11* – hemorrhage; *12* – proliferation of foveolar cells; *13* – fresh hemorrhage; *14* – mucosal layer; *15* – muscularis mucosae; *16* – submucosal layer; *17* – bundles of collagen fibers; *18* – muscular layer; *19* – granular dystrophy of smooth muscle cells; *20* – infiltration of the muscular layer by inflammatory cells; *21* – edema of the muscular layer; *22* – submucosal layer; *23* – lumen of the abdominal cavity between folds of the gastric wall

Instead, edema of the stroma of the gastric pits, microhemorrhages, and granular dystrophy of epithelial cells of all types were detected (Fig. 5e). In addition, small fragments of necrotized mucosal tissue were recorded in the gastric mucosa near the experimentally created wound. Near such fragments, destruction of the apices of gastric pits and hemorrhages into the mucosal layer were observed (Fig. 5f). At some distance from the wound, slight destruction of the apices of gastric glands and hemorrhages were also recorded, mainly in the upper region of the gastric glands (Fig. 6a).

Thus, when autologous platelet-rich plasma was applied, the microscopic changes observed near the site of the experimentally created wound on the 1st day differed from those in animals of the control group at the same observation period. It should be noted that in animals of the experimental group, massive destruction of epithelial cells, desquamation of chief and parietal cells into the lumen of the fundic glands, as well as loosening and partial lysis of the basal membrane of the epithelium of gastric pits were not recorded at the site of the modeled gastric defect.

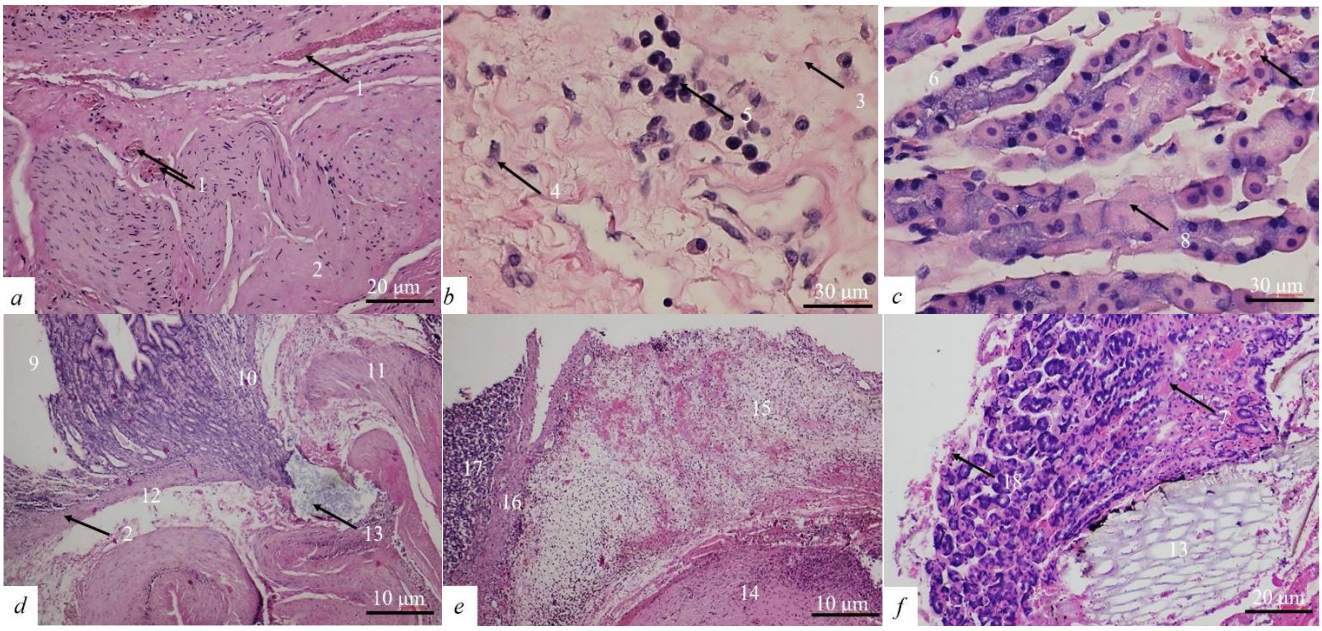

Fig. 5. Histological changes in gastric tissues of rabbits of the experimental group on the 1st day after gastrotomy following the application of autologous platelet-rich plasma (Carazzi's hematoxylin and eosin): *a* – fold of the muscular layer of the stomach at the site of the experimentally created wound with signs of granular dystrophy of smooth muscle cells and hemorrhage; *b* – submucosal layer adjacent to the site of the experimentally created wound with lysis of collagen fibers and fibroblasts and accumulation of monocytes; *c* – mucosal layer immediately adjacent to the site of the experimentally created wound with edema of the stroma of gastric pits, hemorrhages, and granular dystrophy of epithelial cells; *d* – gastric wall at the site of the experimentally created wound with a defect of the mucosal and submucosal layers, granular dystrophy of smooth muscle cells, and foci of tissue lysis; *e* – gastric wall at the site of the experimentally created wound with visualization of the fold of the muscular layer, submucosal layer, and mucosal layer; *f* – mucosal layer adjacent to the site of the experimentally created wound with destruction of the apices of gastric pits, hemorrhages, and necrotized fragments of the mucosal layer; *1* – dilated blood vessels filled with blood; *2* – granular dystrophy of smooth muscle cells; *3* – lysis of collagen fiber bundles; *4* – lysis of a fibroblast; *5* – accumulation of monocytes; *7* – hemorrhage; *8* – granular dystrophy of epithelial cells of all types; *9* – gastric lumen; *10* – mucosal layer; *11* – fold of the muscular layer covered by the submucosal layer within the defect of the mucosal and submucosal layers; *12* – focus of lysis of the submucosal layer; *13* – fragment of necrotized and partially lysed mucosal layer; *14* – fold of the muscular layer; *15* – submucosal layer; *16* – muscularis mucosae; *17* – mucosal layer; *18* – destruction of the apices of gastric pits

On the 3rd day after the application of autologous platelet-rich plasma, the folds of the muscular layer in the area of the experimentally created wound, as in animals of the control group, were noticeably smaller. In the muscular layer, small foci of hemorrhage and necrosis of smooth muscle cells were still detected, and a significant proportion of these muscle cells were in a state of granular dystrophy. However, as in animals of the control group, foci of regeneration of smooth muscle tissue were observed in the muscular layer at this observation period (Fig. 6b). However, in contrast to animals of the control group, such regeneration was markedly more intense and was characterized by the formation of a large number of still immature smooth muscle cells against the background of pronounced hyperemia, which indicated restoration and a significant enhancement of blood circulation in this layer of the gastric wall (Fig. 6c).

The defect at the site of the experimentally created wound in rabbits of the experimental group was less deep than in animals of the control group: at the site of the experimentally created wound at this observation period, the submucosal layer and the muscularis mucosae had already been formed, and the initial stages of regeneration of the mucosal layer were recorded (Fig. 6d). However, the submucosal layer had not yet acquired a normal structure and was represented by thick, irregularly arranged bundles of collagen fibers and contained numerous foci of fibroblast proliferation (Fig. 6e).

The muscularis mucosae in the area of the defect still had uneven thickness (Fig. 6d), and its smooth muscle cells were in a state of granular dystrophy. In some areas, hemorrhages were detected beneath the muscularis mucosae (Fig. 6f).

In the area of the gastric wall defect, the initial stages of mucosal layer formation were also recorded in the form of intensive proliferation of cambial cells of the mucosal layer and the onset of gastric pit formation (Fig. 6d, 7a).

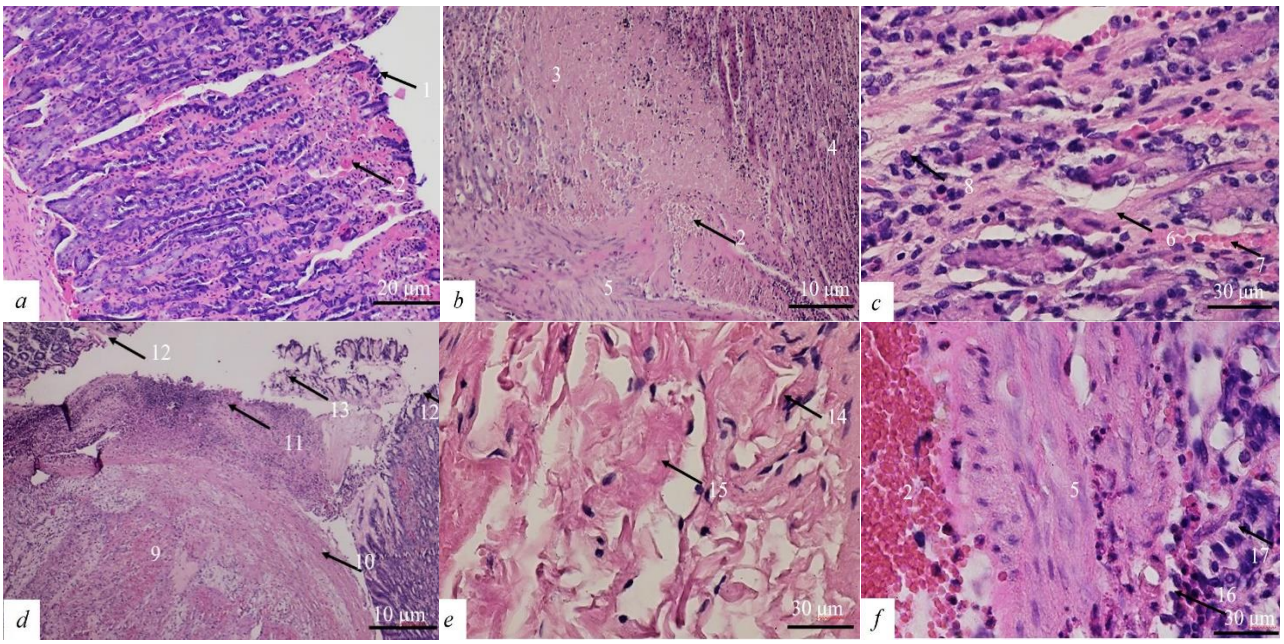

Fig. 6. Histological changes in gastric tissues of rabbits of the experimental group on the 3rd day after gastrotomy with the application of autologous platelet-rich plasma (Carazzi's hematoxylin and eosin): *a* – gastric mucosa adjacent to the site of the experimentally created wound with signs of destruction of the apices of gastric pits and hemorrhages; *b* – muscular layer at the site of the experimentally created wound with foci of necrosis, granular dystrophy, and regeneration of smooth muscle cells; *c* – muscular layer in the zone of the experimentally created wound with newly formed muscle fibers and intensive proliferation of smooth muscle cells; *d* – site of the experimentally created wound with formation of the submucosal layer, muscularis mucosae, and initial stages of mucosal regeneration; *e* – submucosal layer in the zone of the experimentally created wound with fibroblast proliferation and irregularly arranged bundles of collagen fibers; *f* – muscularis mucosae at the site of the experimentally created wound with signs of granular dystrophy, hemorrhages, and formation of gastric pits; *1* – destruction of the apices of gastric pits; *2* – hemorrhage; *3* – necrotized smooth muscle cells; *4* – regeneration of the muscular layer; *5* – granular dystrophy of smooth muscle cells; *6* – newly formed muscle fiber; *7* – blood capillary; *8* – intensive proliferation of smooth muscle cells; *9* – submucosal layer; *10* – muscularis mucosae; *11* – onset of mucosal formation; *12* – mucosal layer adjacent to the site of the defect; *13* – fragment of necrotized mucosal layer; *14* – fibroblast proliferation; *15* – thick, irregularly arranged bundles of collagen fibers; *16* – proliferation of cambial cells of the mucosal layer; *17* – formation of a gastric pit

Near the site of the defect, later stages of mucosal regeneration were observed, which were characterized not only by intensive proliferation of cambial cells of the mucosal layer but also by the formation of gastric pits that already formed a sufficiently thick mucosa. However, at this observation time these newly formed gastric pits were still covered with undifferentiated epithelium (Fig. 7a). Thus, in rabbits of the experimental group treated with autologous platelet-rich plasma, the microscopic changes on day 3 also differed from those in rabbits of the control group at the same observation time. Cessation of the inflammatory process in all layers, more intensive regeneration of the damaged gastric wall, as well as restoration and intensification of blood circulation in the muscular layer were recorded.

On day 7, in animals of the experimental group, in the area of the experimentally created wound, the microscopic structure of the serous and muscular layers of the gastric wall did not differ from that of intact animals, which indicates their complete restoration. The muscularis mucosae was also already formed; however, in the area of the defect it was unevenly thickened (Fig. 7a). At the site of the defect, directly beneath and above the muscularis mucosae, numerous hypertrophied lymphoid nodules were detected at this observation time (Fig. 7b), indicating significant activation of the immune system in the stomach. The mucosal layer was already fairly well formed, although not completely. Areas of defect surrounded by newly formed mucosa were detected. However, in this newly formed mucosa, small gaps between gastric pits were occasionally observed (Fig. 7b). In the mucosal layer itself, intensive proliferation of chief and accessory cells was recorded (Fig. 7c), as well as intensive proliferation of foveolar cells, which was accompanied by the formation of the necks of fundic glands. Unlike animals of the control group, in animals of the experimental group the muscular layer and the submucosal layer at this observation time were fully formed and, in their microscopic structure, did not differ from the corresponding layers of the gastric wall of intact rabbits.

On day 10, in animals of the experimental group, in the area of the experimentally created wound, the microscopic structure of the muscular layer, submucosal layer, and muscularis mucosae of the gastric wall did not differ from that of intact animals, which indicates their complete restoration.

Unlike rabbits of the control group, in rabbits of the experimental group the mucosal defect was no longer detected, and at the site of the experimentally created wound only a slight thinning of the mucosal layer and the presence of necrotized tissues on its surface were recorded; however, directly beneath them the necks of fundic glands were already formed (Fig. 7d). The epithelium of the body of the fundic glands at this observation time in the area of the experimentally created wound did not differ in structure from that of intact animals. Fully formed parietal, accessory, and chief cells were clearly differentiated here (Fig. 7e).

Discussion

The histological studies conducted indicate that the use of autologous platelet-rich plasma provides faster closure of the experimentally modeled gastric wall wound due to more intensive and earlier contraction of the muscular layer. This leads to a reduction in the duration and intensity of the action of gastric juice on the serosal and muscular layers; as a result, an inflammatory reaction does not develop in the serosal layer, and in the muscular layer it is of significantly lower intensity. Importantly, an allergic component of the inflammatory reaction was not detected in the animals of the experimental group.

It was established that the use of autologous platelet-rich plasma stimulates blood supply in the area of the gastric wall defect, creating favorable conditions for the activation of reparative processes and acceleration of tissue regeneration. Enhancement of local microcirculation and angiogenesis when using PRP is associated with the release of platelet-derived growth factors, in particular PDGF, VEGF, and

TGF-β, which play a key role in cellular proliferation and the formation of the regenerative matrix (Marx, 2004; Andia & Abate, 2013; Xu et al., 2020). Complete regeneration of all layers of the gastric wall in animals of the experimental group was recorded on day 14, whereas in rabbits of the control group similar morphological signs of recovery were observed only on day 21.

In general, autologous platelet-rich plasma demonstrates significant potential in regenerative medicine. At the same time, the complexity of tissue repair processes determines the limited effectiveness of traditional transplantation methods, which makes regenerative medicine and tissue engineering promising alternative therapeutic approaches (Papadimitriou et al., 2020).

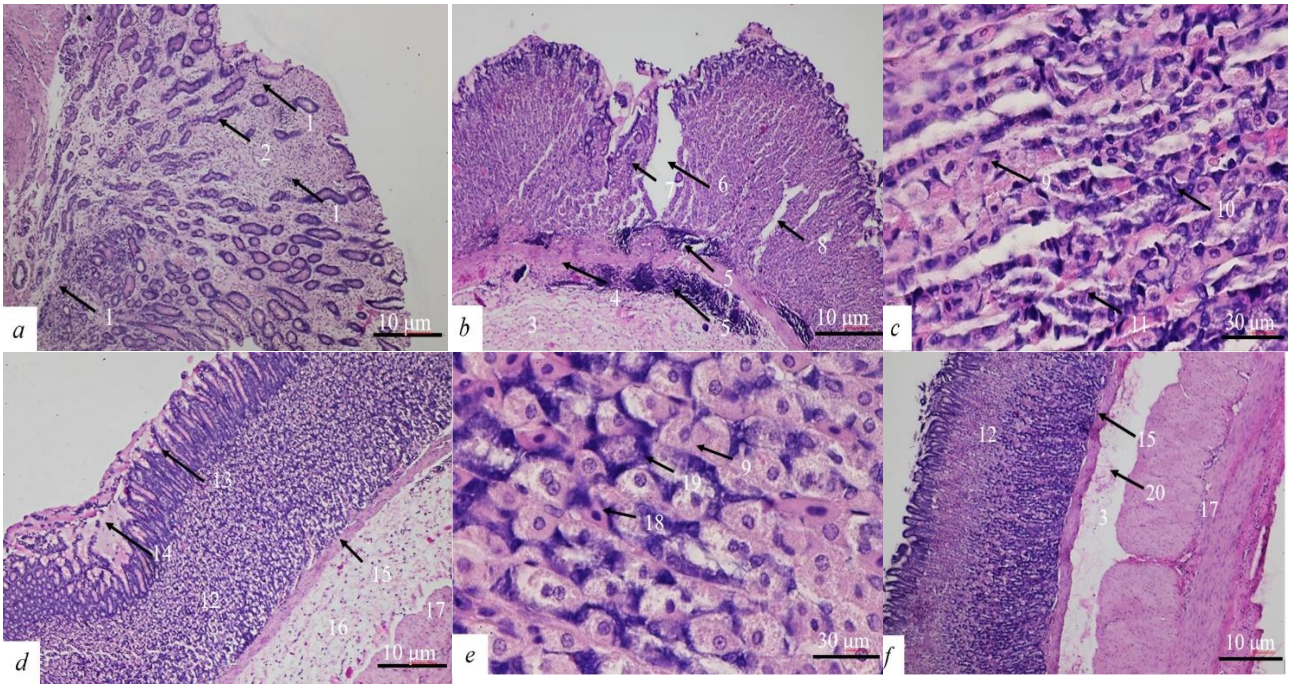

Fig. 7. Histological changes in the gastric tissues of rabbits of the experimental group on days 3–14 after gastrotomy with the use of autologous platelet-rich plasma (Carazzi's hematoxylin and eosin): *a* – gastric mucosa adjacent to the site of the experimentally created wound on day 3, with proliferation of cambial cells and formation of newly formed gastric pits; *b* – gastric wall at the site of the experimentally created wound on day 7, with a fully formed submucosal layer, unevenly thickened muscularis mucosae, and hypertrophied lymphoid nodules; *c* – middle part of the gastric mucosa in the area of the experimentally created wound on day 7, with intensive proliferation of chief, parietal, and accessory cells; *d* – gastric wall at the site of the experimentally created wound on day 10, with a fully formed muscular layer, submucosal layer, and muscularis mucosae, and remnants of necrotized mucosal tissue; *e* – middle part of the gastric mucosa at the site of the experimentally created wound on day 10, with fully differentiated cells of the fundic glands; *f* – gastric wall at the site of the experimentally created wound on day 14, with completely restored histological structure; *1* – proliferation of cambial cells of the mucosa; *2* – newly formed gastric pit covered with undifferentiated epithelium; *3* – submucosal layer (unchanged); *4* – unevenly thickened muscularis mucosae; *5* – hypertrophied lymphoid nodules; *6* – site of the mucosal defect; *7* – newly formed gastric pits; *8* – space between gastric pits; *9* – parietal cell; *10* – proliferation of chief cells; *11* – proliferation of accessory cells; *12* – mucosa; *13* – neck of the fundic gland; *14* – necrotized mucosa; *15* – muscularis mucosae; *16* – submucosal layer; *17* – muscular layer; *18* – accessory cell; *19* – chief cells; *20* – bundles of collagen fibers

Platelet-rich plasma (PRP) contains a wide range of bioactive molecules and cytokines that participate in the modulation of inflammation and the stimulation of cell migration and proliferation. Experimental studies in goat and sheep models have demonstrated the ability of PRP to accelerate tissue healing, reduce inflammatory reactions, and improve the quality of the formed regenerate, confirming its translational potential in veterinary medicine (Sharun et al., 2024; Gallo et al., 2020).

A systematic review by Geropoulos et al. (2021), which included 18 experimental studies with a total sample of 712 animals, showed the absence of postoperative complications after the use of platelet-rich plasma. This is consistent with data on the safety and biocompatibility of autologous platelet concentrates, which are actively implemented in veterinary practice to stimulate regenerative processes in the postoperative period (Everett et al., 2021; Malyuk et al., 2024).

Despite numerous positive results, the use of PRP has a number of limitations. The main problem remains the lack of standardized protocols for its preparation and administration, including centrifugation parameters, platelet concentration, and activation methods, which complicates the comparison of results between different studies (Magalon et al., 2020; Smith et al., 2022). Therefore, further experimental studies should be aimed at optimizing PRP application schemes, taking into account the type of tissue and the nature of the injury.

In veterinary medicine, PRP is also widely used in the treatment of wounds, orthopedic pathologies, and degenerative changes, demonstrating a positive effect on the overall condition of animals and the rate of recovery (Wang et al., 2022). Similar effects have also been described in human dentistry and orthopedics, where the use of PRP and PRF promotes regeneration of bone and soft tissues and shortens healing times (Zanirati et al., 2021; Petrosyan et al., 2022; Egierska et al., 2023; Giammarinaro et al., 2025; Mastrogiacomo et al., 2025). Thus, the results of the conducted experiment confirm that autologous platelet-rich plasma activates regenerative processes in the gastric wall, reduces the intensity of the inflammatory reaction, and significantly shortens healing times after surgical injury. This substantiates the feasibility of further studies aimed at standardizing protocols and expanding the clinical application of PRP in veterinary surgery.

Conclusion

Based on the results of the histological study, it was established that the use of autologous platelet-rich plasma promotes the acceleration of regenerative processes in the gastric wall of rabbits after gastrotomy. At the early stages of healing, active contraction of the muscular layer of the stomach was observed, which ensured faster closure of the wound defect and reduced the negative effect of gastric juice on

the damaged tissues. This was accompanied by a less pronounced inflammatory reaction.

In rabbits of the experimental group, on the 3rd day after gastrotomy, intensive regeneration of smooth muscle tissue was observed, which was combined with improved blood supply in the area of injury. The influence of platelet-derived growth factors contributed to the activation of cellular proliferation, the formation of new structures of the gastric mucosa, and the restoration of gastric glands. As early as the 7th day, the structure of the muscular and serosal layers in the area of surgical intervention was similar to that of intact tissues, indicating their functional recovery.

On days 10–14, rabbits of the experimental group demonstrated complete regeneration of all layers of the gastric wall, whereas in animals of the control group the healing process continued until day 21. The obtained results confirm that the use of autologous platelet-rich plasma ensures an intensive course of regenerative processes and promotes restoration of the gastric wall tissues without the development of complications.

The authors declare the absence of any conflict of interest.

References

Andia, I., & Abate, M. (2013). Platelet-rich plasma: underlying biology and clinical correlates. Regenerative Medicine, 8(5), 645–658.

Cole, B. J., Seroyer, S. T., Filardo, G., Bajaj, S., & Fortier, L. A. (2010). Platelet-rich plasma: Where are we now and where are we going? Sports Health, 2(3), 203–210.

Diegelmann, R. F., & Evans, M. C. (2004). Wound healing: An overview of acute, fibrotic and delayed healing. Frontiers in Bioscience, 9, 283–289.

Egierska, D., Perszke, M., Mazur, M., & Duś-Ilnicka, I. (2023). Platelet-rich plasma and platelet-rich fibrin in oral surgery: A narrative review. Dental and Medical Problems, 60(1), 177–186.

Everett, E., Smith, J. K., Williams, R. A., Brown, M. T., Johnson, L. M., & Harris, D. L. (2021). Safety and biological effects of autologous platelet-rich plasma. Regenerative Therapy, 18, 205–213.

Gallo, J., Raska, M., Mrazek, F., Petrek, M., & Kolar, M. (2020). Platelet-rich plasma enhances fibroblast proliferation and collagen synthesis. Journal of Tissue Engineering and Regenerative Medicine, 14(9), 1290–1302.

Geropoulos, G., Psarras, K., Giannis, D., Martzivanou, E. C., Papaioannou, M., Kakos, C. D., Pavlidis, E. T., Symeonidis, N., Koliakos, G., & Pavlidis, T. E. (2021). Platelet-rich plasma effectiveness in bowel anastomoses: A systematic review. World Journal of Gastrointestinal Surgery, 13(12), 1736–1753.

Giammarinaro, E., Baldini, N., Covani, U., Menini, M., Pesce, P., & Marconcini, S. (2025). Does platelet-rich fibrin enhance the outcomes of peri-implant soft tissues? A systematic review. BMC Oral Health, 25(1), 615.

Labunets, I., Utko, N., Panteleymonova, T., Kyryk, V., Kharkevych, Y., & Rodnichenko, A. (2022). Age features of the effects of adipose-derived multipotent mesenchymal stromal cells from mice in experimental parkinsonism and changes in the effect of cells from aging donors using exogenous melatonin. International Neurological Journal, 18(4), 5–12.

Lacci, K. M., & Dardik, A. (2010). Platelet-rich plasma: Support for its use in wound healing. The Yale Journal of Biology and Medicine, 83(1), 1–9.

Magalon, J., Bausset, O., Serratrice, N., Giraudo, L., Aboudou, H., Veran, J., Magalon, G., Sabatier, F., & Dignat-George, F. (2020). Platelet-rich plasma classification and standardization. Transfusion, 60(4), 826–835.

Malyuk, M. O., Brusko, E. P., Hnapovska, Y. O., Tkachenko, V. V., Tarnavskyi, D. V., & Tkachenko, T. A. (2023). Influence of autological growth factors on activation of regenerative processes of the superficial digital flexor tendon of horses. Regulatory Mechanisms in Biosystems, 14(2), 284–289.

Malyuk, M. O., Klymchuk, V. V., Kharkevych, Y. O., Honchar, V. V., Tarnavskyi, D. V., Dovbnia, Y. Y., Holopura, S. I., & Tkachenko, V. V. (2024). Effectiveness of blood transfusion to cats suffering flea infestation. Regulatory Mechanisms in Biosystems, 15(2), 207–211.

Mishra, A., Woodall Jr., J., & Vieira, A. (2009). Treatment of tendon and muscle using platelet-rich plasma. Clinics in Sports Medicine, 28(1), 113–125.

Papadimitriou, L., Manganas, P., Ranella, A., & Stratakis, E. (2020). Biofabrication for neural tissue engineering applications. Materials Today Bio, 6, 100043.

Sevchenko, S., Rublenko, M., & Bonkovskyi, O. (2019). Technologies for producing platelet masses for regenerative medicine. Scientific Bulletin of Veterinary Medicine, 2, 105–117.

Sharara, F. I., Lelea, L. L., Rahman, S., Klebanoff, J. S., & Moawad, G. N. (2021). A narrative review of platelet-rich plasma (PRP) in reproductive medicine. Journal of Assisted Reproduction and Genetics, 38(5), 1003–1012.

Sharun, K., Banu, S. A., Dhama, K., & Amarpal (2024). Platelet-rich plasma in experimental animal models. Veterinary Research Communications, 48, 321–334.

Sharun, K., Banu, S. A., El-Husseiny, H. M., Abualigah, L., Pawde, A. M., Dhama, K., & Amarpal (2024). Exploring the applications of platelet-rich plasma in tissue engineering and regenerative medicine: Evidence from goat and sheep experimental research. Connective Tissue Research, 65(5), 364–382.

Xu, Z., Yin, W., Zhang, Y., Qi, X., & Chen, Y. (2020). Platelet-rich plasma promotes angiogenesis and tissue regeneration. Stem Cell Research and Therapy, 11, 331.

Zhang, J., Yuan, T., Wang, J., Wang, Y., & Sun, K. (2019). Platelet-rich plasma promotes healing of gastrointestinal injury. Biomedicine and Pharmacotherapy, 109, 1310–1317.

Zhu, Y., Yuan, M., Meng, H. Y., Wang, A. Y., Guo, Q., Wang, Y., & Peng, J. (2021). Anti-inflammatory effects of platelet-rich plasma in tissue repair. International Journal of Molecular Sciences, 22(6), 3121.