DOI 10.29254/2077-4214-2022-4-167-296-301
UDC 616.34–089.8:615.46

Kobeniak M. M., Pronina O. M.

MORPHOFUNCTIONAL CHARACTERISTICS OF THE CRYPTS STRUCTURAL COMPONENTS OF THE CECUM PERIVULNAR AREA BY USING DESMOSIN SURGICAL THREAD

Poltava State Medical University (Poltava, Ukraine)
Kobeniak1987@gmail.com

As a result of the research, it was established that the crypts of the cecum after the incision and suturing with synthetic monofilament surgical thread desmosin dynamically changed its morphometric indicators according to the observation period. It was found that the elements of the hemomicrocirculatory bad were visualized in the mucosa and submucosa: arterioles, capillaries, and venules, which in turn provided blood circulation and blood exchange of the wall of the cecum as a whole. The structure of the cecal crypts of animals of the control group included various cell associations: columnar cells with a brush border, goblet cells, single endocrinocytes, columnar epitheliocytes without a brush border, and Paneth cells. Lieberkhun's glands histotopographically passed through the entire surface of the mucous membrane, their openings opened into the lumen of the cecum, and their lower parts reached the lamina propria. Thus, the implementation of alteration processes in the perivulnar region of rabbits' caecum begins on the 3rd day of the experimental study and is determined in the deep layers of the mucous membrane with the involvement of all its structural components. Due to destructive changes in columnar epitheliocytes with a brush border in the crypts of the perivulnar area, digestion and absorption processes are disrupted and possibly stopped from the 3rd to the 7th day of the experimental study. The recovery of the pool of these cellular elements begins from the 14th day of the experiment, and the control indicators reach up to the 30th day. The restoration of the cellular composition of Lieberkün's glands in the perivulnar region occurred due to the few differentiated cells, which tended to increase their average number from 3 to 21 days of the experiment. Recovery of the average number of these cells compared with control indicators occurred on the 30th day of observation.

Key words: *cecum, crypt, Lieberkün's glands, desmosin.*

Connection of the publication with planned research works.

The scientific work was carried out within the scientific topic “Experimental and morphological justification of the effect of new surgical suture materials, implants and covering surfaces on various organs when used in experiments and clinical practice,” state registration number 0118U004459.

Introduction.

Nowadays, surgical interventions in surgical practice require not only high professionalism but also the use of high-quality materials, including surgical suture material. The correct choice of surgical suture material is the key to the successful and rapid healing of wounds during surgical operations on the large intestine [1, 2]. However, focusing only on the technical convenience of the suture material, such as strength, smoothness, and elasticity, the surgeon forgets about the effect of the surgical suture material on the sutured tissues, the degree of expression of inflammation in the wound, the toxic effect of the suture material on the body, and the severity of the postoperative scar [3, 4, 5].

During the development of surgery, the process of improving surgical suture material did not stand still. Despite the variety of connecting tissues, the suture material is the most common method nowadays and occupies 95% of all types of tissue joining [6, 7, 8, 9]. Studying the effect of surgical suture material on the structural components of the cecum in the perivulnar area, and in our case, it is desmosine, will provide the surgeon with an alternative choice of suture material for connecting tissues and obtaining the desired result [10, 11].

The aim of the study.

Determination of the structural components of the crypts of the cecum in the perivulnar area when using surgical desmosin thread.

Object and research methods.

The experiment involved ten sexually mature outbred domestic rabbits (of different sexes) aged 8-10 months and weighing (2.6±0.2) kg. The study was conducted in compliance with the principles of bioethics following the provisions of the European Convention on the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (Strasbourg, 1986), Council of Europe Directive 2010/63/EU, Law of Ukraine № 3447-IV «On protection of animals from cruelty.» By decision of the commission on bioethical issues of the Poltava State Medical University. Histological, morphometric, and statistical research methods were used in work.

Operative interventions were performed in the operating room at the Department of Anatomy with Clinical Anatomy and Operative Surgery of the Poltava State Medical University.

Before surgery, the animals were sedated by intramuscular injection of a lytic mixture (0.2 ml of 1% Sol. Dimedroli, 0.1 ml of 0.1% Sol. Atropinii Sulfates and 0.1 ml of 10% Sol. Nalbufini). 5.5-5.7 ml of 4% Ubistesiniforte was used for local anesthesia. Treatment of the operative field was carried out according to Grosech – Filonchikov. An upper-middle-lower-middle laparotomy was performed. Then, the cecum was removed into the wound.

Biopsies of the cecum were removed and embedded in paraffin according to generally accepted methods to determine the main morphological parameters. Thin sections with a thickness of 4-5 µm were made from paraffin blocks, stained with hematoxylin and eosin, Mayer’s hematoxylin. Next, the histological sections were studied with the help of a light microscope with a digital microphoto nozzle of the Olympus C 3040–ADU company with programs adapted for the research data (Olympus DP – Soft, license № VJ285302, VT310403, 1AV4U13B26802) and Viorex 3 (serial number 5604). Morphometric studies

were carried out using the visual analysis system of histological preparations. Images of histological preparations were displayed on a computer monitor from a microscope using a Visiion CCD Camera. Morphometric studies were carried out using VideoTest-5.0, KAARA Image Base, and Microsoft Excel programs on a personal computer.

Morphometrically, the metric indicators of the cecum wall were determined, the morphometric characteristics of the elements of the hemomicrocirculatory bad were determined following the guidelines [12], and the morphometric changes of Lieberkün's glands were determined. The average depth of the crypts, the average total width of the bottom of the crypts, the total width of the crypt openings, the total lumen width of the bottom of the crypts, the total width of the lumen of the crypt openings, the average number of columnar epitheliocytes with a brush border, the average number of goblet cells, the average number of enteroendocrine cells, the average number of poorly differentiated cells were measured in the perivulnar area.

Research results and their discussion.

On the histological preparations of the caecum wall of animals of the control group, it was determined that it was made of the mucosa, submucosa, muscle, and serous membranes. The mucous membrane included cylindrical epitheliocytes arranged in one layer on its own plate. Under the lamina propria, the mucous membrane's muscular lamina was visualized, including smooth myositis, which were located in two layers: the inner circular and the outer longitudinal. A large number of crypts and the absence of villi were determined in the composition of the mucous membrane. In the mucosa and submucosa, the elements of the hemomicrocirculatory bad were visualized: arterioles, capillaries, and venules, which in turn provided blood circulation and blood exchange of the wall of the cecum as a whole. The submucosa consisted of loose fibrous connective tissue in the thickness of which clusters of lymphocytes at different stages of differentiation were determined and provided, together with similar associations of the mucous membrane, an essential link in the formation of immune protection of the alimentary canal.

The structure of the cecal crypts of the control group animals included various cell associations: columnar cells with a brush border, goblet cells, single endocrinocytes, columnar epitheliocytes without brush border, and Paneth cells. Lieberkhun's glands histotopographically passed through the entire surface of the mucous membrane, their openings opened into the lumen of the cecum, and their lower parts reached the lamina propria **(fig. 1).**

When suturing the wound defect with Desmosin surgical thread, specific changes in the structural organization of the cecal wall were determined in the periulnar area. Thus, on the 3rd day of the experimental study, morphometric changes in the location of the crypts and their morphometric indicators were clearly determined: crypt depth (CD), the total width of the crypt bottom (TWCB), the total width of the crypt opening (TWCO), the total width of the crypt bottom lumen (TWCBL) and total lumen width of the crypt opening (TLWCO). It was determined that during this term of the experimental study, all the above indicators increased, at $p<0.05$, compared with the control group. Thus, the average CD index increased by 1.1 times; the average indicator of TWCB increased by 1.4 times; the average indicator of TWCO increased by 1.1 times; the average indicator of TWCBL increased by 1.3 times; the average indicator of TLWCO also increased by 1.3 times. Such obtained data indicate that, on the 3rd day of the experimental study, the alterative processes cover the deep layers of the mucous membrane of the cecum, which are in direct contact with the area of the wound defect sutured with Desmosin surgical thread.

Later, on the 7th day of observation, the morphometric values of Lieberkhun's glands continued to increase, at $p<0.05$, in comparison with both the control indicators and the indicators of the previous observation group. Thus, the average CD index increased by 1.12 times; the average indicator of TWCB increased by 1.44 times; the average indicator of TWCO increased by 1.22 times; the average indicator of TWCBL increased by 1.35 times; the average indicator of TLWCO increased by 1.42 times. Such morphometric changes indicate that more superficial sections of the crypts and the mucous membrane were also involved in implementing the neutralization of the alteration processes.

After suturing the wound defect with Desmosin surgical thread on the 14th day of the experimental study, it was determined that the above-mentioned morphometric indicators tended to decrease compared to the previous observation period but were significantly different at $p<0.05$ with similar indicators of the control group of animals. On the 21st day of observation, it was determined that only the average value of TLWCO has a statistically significant difference compared to control indicators. On the 30th day of the experimental study, all the above-mentioned morphometric parameters of the crypts did not statistically significantly different from the control values. Data on the morphometric changes of Lieberkün's glands of the mucous membrane of rabbits' caecum in the experimental study's dynamics are presented in **figure 2**.

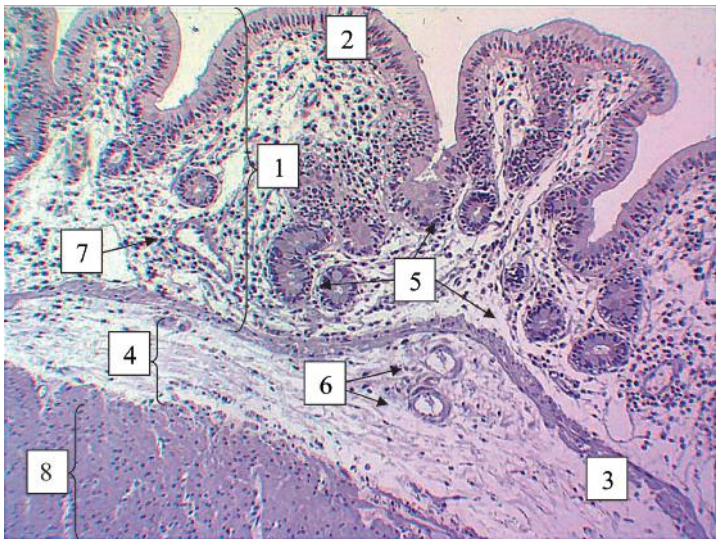

Figure 1 – Structural organization of the cecum wall of the control group rabbits. Staining: Mayer's hematoxylin. Magnification: eyepiece 10, objective 40. Designation: 1 – mucous membrane; 2 – epithelial layer; 3 – own plate of the mucous membrane; 4 – submucosa; 5 – crypts; 6 – arterioles; 7 – venules; 8 – muscular layer.

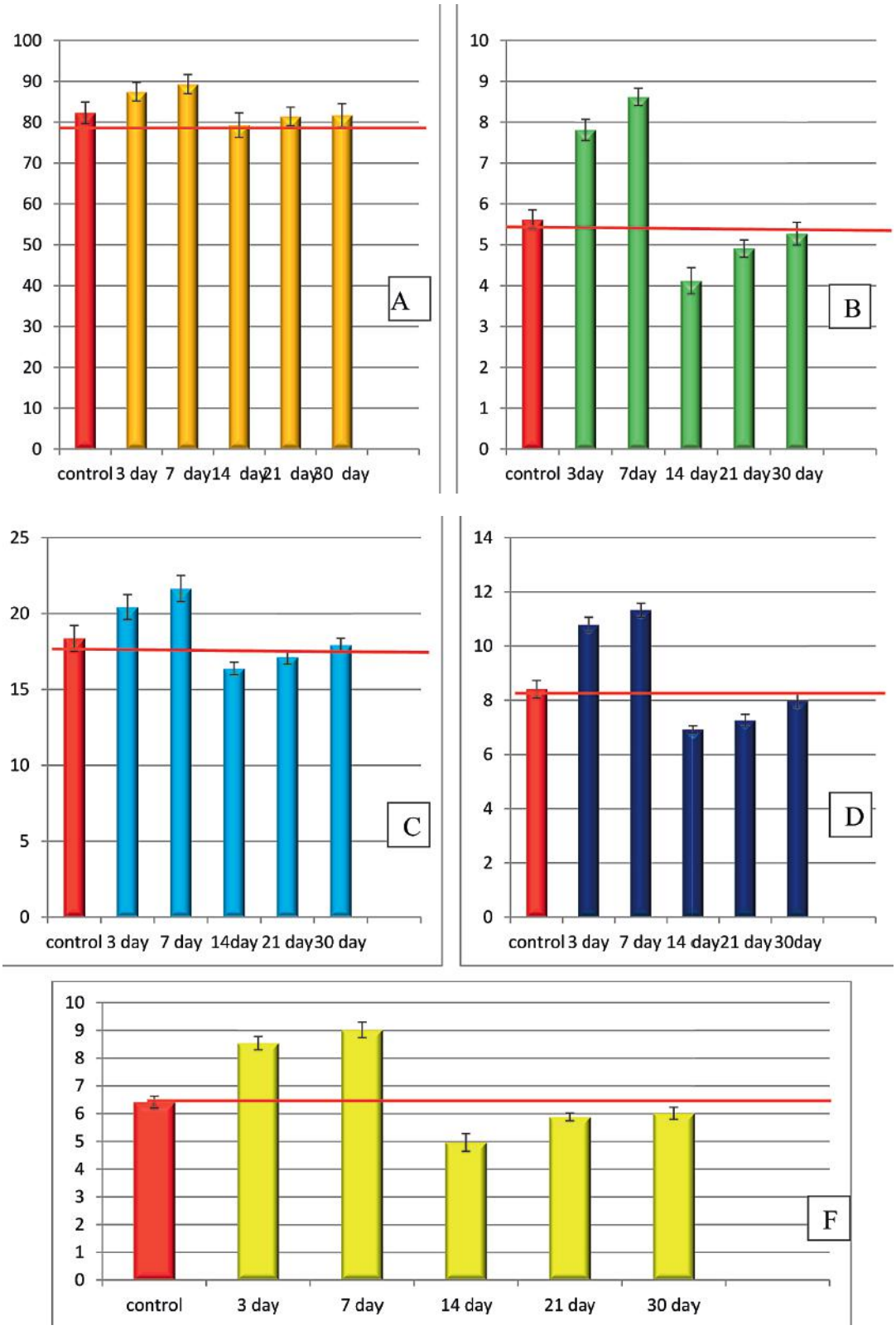

Figure 2 – Morphometric changes of Lieberkhun's glands of the mucous membrane of rabbits caecum in the dynamics of the experimental study: A – crypt depth; B – the total width of the bottom of the crypt; C – the total width of the crypt openings; D – the total lumen width of the bottom of the crypts; F – the total width of the lumen of the crypt opening.

In parallel with the morphometric changes in the indicators of Liberkhun's glands, we also determined the structural changes and changes in their cell populations. At the light-optical level, it was determined that on the 3rd day of the experimental study, certain changes in their cell populations occurred in Lieberkhun's glands, which were directly adjacent to the perivulnar area. In comparison with the control parameters, the average number of columnar epitheliocytes with a brush border (CEBB) sharply and significantly decreased by 4.1 times, and accordingly, areas of desolation were determined in the crypts themselves. In contrast to the above-described

cellular structures that were part of the crypts, the average number of goblet cells (GC), on the contrary, increased by 1.73 times, which indicates the strengthening of the mucus formation process and the creation of an additional protective layer of the epithelial layer of the mucous membrane of the cecum in the perivulnar area.

In parallel with the strengthening of mucus formation processes, we establish and strengthen the local endocrine load, which is evidenced by a 2.21-fold increase in the average number of enteroendocrine cells in the crypts of the perivulnar area. A slight increase of 1.22 times in the composition of the crypts of the perivulnar area of poorly differentiated cells that had signs of basophilia was also determined, and in our opinion, differentiation and restoration of the cellular composition of Lieberkün's glands will take place in the future at the expense of these cells **(fig. 3).**

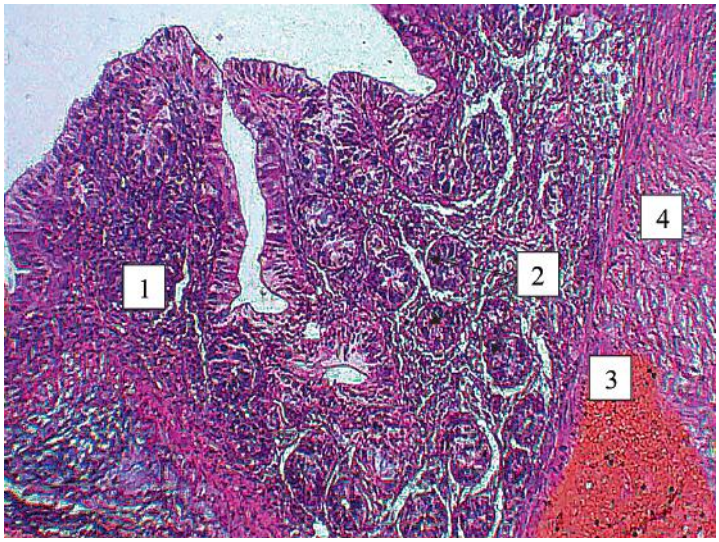

Figure 3 – Perivulnar section of the cecal wall of rabbits using Desmosin surgical thread. Staining: hematoxylin and eosin. Magnification: eyepiece 10, objective 40. Designation: 1 – mucous membrane; 2 – crypts; 3 – an area with implanted Desmosin surgical thread; 4 – an area of connective tissue scar formation.

On the 7th day of the experimental study, the average number of CEBB compared to the previous observation group began to increase slightly, but compared to the control group; it was 3.7 times smaller. The average number of GC continued the upward trend and, compared to the control indicators, was already increased by 2.05 times, and compared to the previous observation period by 1.2 times, thus intensifying the processes of mucus formation. The average number of enteroendocrine cells also increased similarly to GC by 2.66 and 1.2 times, respectively. The average number of poorly differentiated cells also tended to increase, and compared to the control group, it increased by 1.48 times and compared to the previous observation period by 1.19 times. In period 3, 14 to 21 days of observation, the average number of CEBB began to increase,

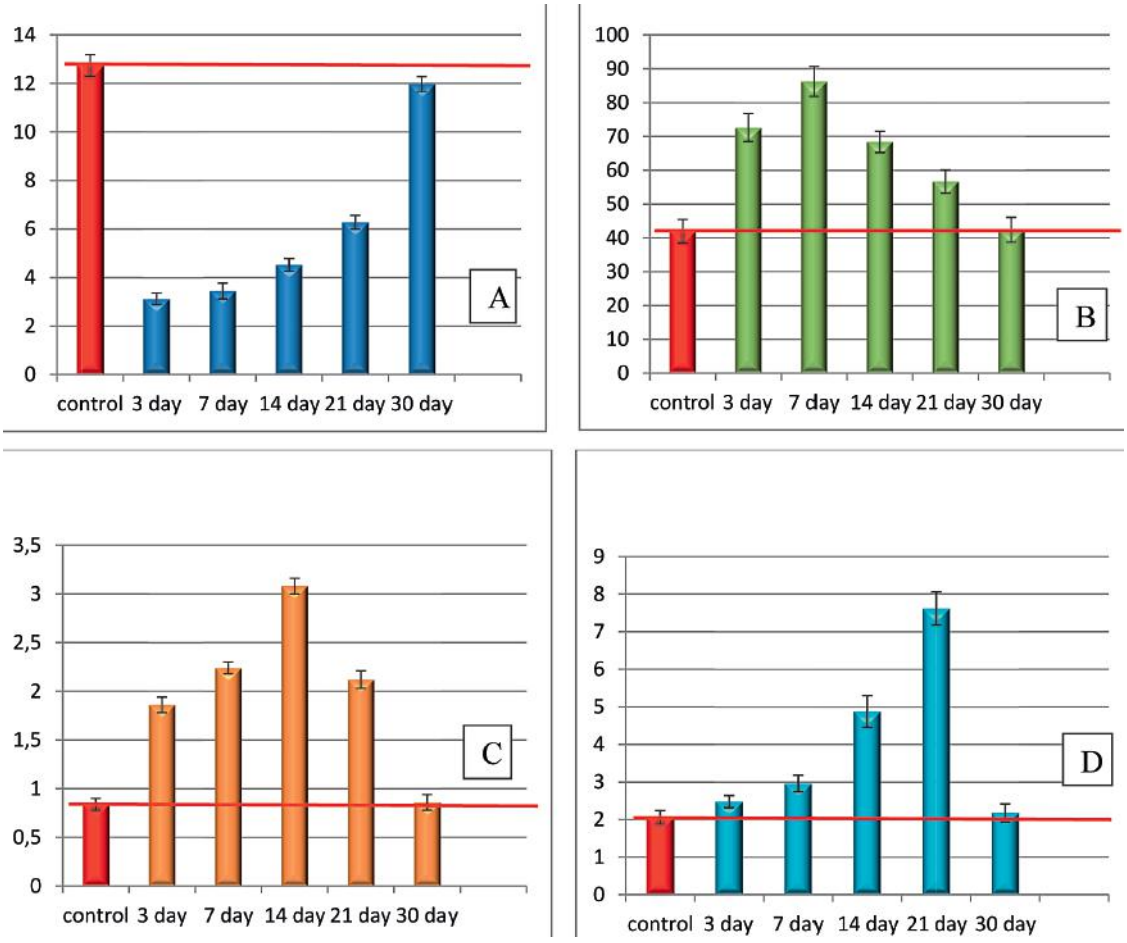

Figure 4 – Changes in the average indicators of the cellular composition of the perivulnar area crypts when using Desmosin surgical thread: A – the average number of columnar epitheliocytes with a brush border; B – the average number of goblet cells; C – the average number of enteroendocrine cells; D – the average number of poorly differentiated cells.

and control indicators reached the 30th day of the experimental study. On the contrary, the average number of GC and enteroendocrine cells started to decrease during this period, and control indicators also reached day 30. The average number of poorly differentiated cells during this period continued the trend of increasing its number in the composition of the crypts and indicators of the control group acquired on the 30th day of the experimental study **(fig. 4).**

Conclusions.

The implementation of alteration processes in the perivulnar region of rabbits' caecum begins on the 3rd day of the experimental study. It is determined in the deep layers of the mucous membrane with the involvement of all its structural components.

Connection to the regenerative and compensatory processes of the surface layers of the mucous membrane of rabbits cecum in the area of the wound defect sutured with Desmosin surgical thread occurs from the 7th day of observation, in which the structural components of Lieberkhun's glands are involved.

Due to destructive changes in the columnar epitheliocytes with a brush border in the crypts of the perivulnar area, digestion and absorption processes are disrupted and possibly stopped from the 3rd to the 7th day of the experimental study. The recovery of the pool of these cellular elements begins from the 14th day of the experiment, and the control indicators reach up to the 30th day.

Restoration of the cellular composition of Lieberkün's glands in the perivulnar area occurred due to poorly differentiated cells, which tended to increase their average number from 3 to 21 days of the experiment. Recovery of the average number of these cells compared with control indicators occurred on the 30th day of observation.

Prospects for further research.

It is promising to determine the morphological changes of the cecum perivulnar area when using desmosin surgical thread on electron-microscopic preparations.

References

1. Pronina OM, Kobenyak M.M. Makroskopichna kharakterystyka stanu pislyaoperatsiynoho rubtsya tovstoho kyshechnyka pry eksperymental'nomu vykorystanni desmosynu. Materialy 2-yi Vseukrayinskoyi naukovo-praktychnoyi konferentsiyi z mizhnarodnoyu uchastyu Teoriya ta praktyka suchasnoyi morfolohiyi. 2018 Zhovten 10-12; Dnipro; 2018. s. 15-17. [in Ukrainian].
2. Wallace SJ, Mioton LM, Havey RM, Muriuki MG, Ko JH. Biomechanical Properties of a Novel Mesh Suture in a Cadaveric Flexor Tendon Repair Model. J Hand Surg Am. 2019;44(3):208-215. DOI: 10.1016/j.jhsa.2018.11. 016.
3. Onesti MG, Nestsi N, Carella S, Scuderi N. Effectiveness of antimicrobialcoated suturesfor the prevention of surgical site infection:a review of the literature. European Review for Medical and Pharmacological Sciences. 2018;22:5729-5739.
4. Pronina OM, Yeroshenko HA, Dal'nichenko SI, Polovyk OYU. Ul'trastruktura tkanyn sechovoho mikhura sobak v ranni stroky pislya eksperymental'noyi tsystotomy z vykorystannyam khirurhichnoyi nytky biofil ta yoho modyfikatsiyi etoniyem. Svit medytsyny ta biolohiyi. 2012;1(32):147-150. [in Ukrainian].
5. Bilash SM, Pronina OM, Sydorenko MI. Suchasnyy pohlyad na morfolohiyu tonkoho kyshechnyka pry riznykh patolohichnykh stanakh ta vybori optymal'noho shovnoho materialu pry operatyvnykh vtruchannyakh na n'omu. Visnyk problem biolohiyi i medytsyny. 2019;1(1):20-24. [in Ukrainian].
6. Berger G, Eviatar E, Kogan T, Landsberg R. The normal uncinate process: histology and clinical relevance. Eur Arch Otorhinolaryngol. 2013;270(3):959-964.
7. Verma P, Verma KG, Khosa R, Kumar S, Basavaraju S, Patwardhan N. Combined use of frontal sinus and nasal septum patterns as an aid in forensics: a digital radiographic study. N Am J Med Sci. 2015;7(2):47-52.
8. Pogorielov M, Kalinkevich O, Deineka V, Garbuzova V, Solodovnik A, Kalinkevich A, et al. Haemostatic chitosan coated gauze: in vitro interaction with human blood and in-vivo effectiveness. Biomaterials research. 2015;19(1):22. DOI: 10.1186/s40824-015-0044-0/.
9. Pronina OM, Kobenyak MM. Porivnyal'na kharakterystyka morfolohichnykh zmin tovstoho kyshechnyka pry eksperymental'nomu vykorystanni kethutu z svynyachoyi syrovyny i kethutu modyfikovanoho L-arhininom dlya ushyvannya yoho ran. Materialy naukovo-praktychnoyi konferentsiyi z mizhnarodnoyu uchastyu Teoriya ta praktyka suchasnoyi morfolohiyi, prysvyachenoyi 100 richchyu Dnipropetrovskoyi shkoly morfolohiv; 2016 Zhovten 5-7; Dnipro; 2016. s. 127-129. [in Ukrainian].
10. Pronina OM, Kobenyak MM. Vplyv khirurhichnykh nytok modyfikovanykh L-arhininom na morfometrychni pokaznyky v tkanynakh operovanoho tovstoho kyshechnyka kroliv v ranni terminy. Zbirnyk materialiv naukovo–praktychnoyi konferentsiyi Prykladni aspekty morfolohiyi; 2016 Zhovten 20-21; Ternopil. Ternopil: DVNZ Ternopilskyy derzhavnyy medychnyy universytet im.I.YA.Horbachevskoho MOZ Ukrayiny; 2016. s. 127-129. [in Ukrainian].
11. Gauzit R, Pean Y, Barth X, Mistretta F, Lalaude O, Top Study Team. Epidemiology, management, and prognosis of secondary nonpostoperative peritonitis. French prospective observational multicenter study. Surg Infect. 2009;10(2):119-27.
12. Pronina OM, Koptev MM, Bilash SM, Yeroshenko GA. Response of hemomicrocirculatory bed of internal organs on various external factors exposure based on the morphological research data. Svit medytsyny ta biolohiyi. 2018;1(63):153-7. DOI: 10.26.724/2079-8334-2018-1-63-153-157.

МОРФОФУНКЦІОНАЛЬНА ХАРАКТЕРИСТИКА СТРУКТУРНИХ КОМПОНЕНТІВ КРИПТ ПЕРИВУЛЬНАРНОЇ ДІЛЯНКИ СЛІПОЇ КИШКИ ПРИ ВИКОРИСТАННІ ХІРУРГІЧНОЇ НИТКИ ДЕСМОСІН

Кобеняк М. М., Проніна О. М.

Резюме. В роботі охарактеризовані морфологічні зміни структурних компонентів крипт сліпої кишки в перивульнарній ділянці при зшиванні ранового дефекту хірургічною ниткою десмосін.

Визначено, що сліпа кишка кролів як і у людини складається з чотирьох оболонок: слизової, підслизової, м'язової і серозної. До складу слизової оболонки входили циліндричні епітеліоцити, які були розташовані в один шар на власній пластинці. Під власною пластинкою візуалізувалась м'язова пластинка слизової оболонки до складу якої входили гладкі міозити, які розташовувались у два шари: внутрішнього циркулярного і зовнішнього поздовжнього. У складі слизової оболонки визначалась велика кількість крипт і відсутність ворсинок. В слизовій і підслизовій оболонках чітко візуалізувались елементи гемомікроциркуляторного русла: артеріоли, капіляри і венули, які в свою чергу забезпечували кровообіг та кровообмін стінки сліпої кишки в цілому. До структури крипт сліпої кишки тварин контрольної групи входили різні клітинні асоціації: стовпчасті клітини з облямівкою, келихоподібні клітини, поодинокі ендокриноцити, стовпчасті епітеліоцити без облямівки та клітини Панета. Самі залози Ліберкюна гістотопографічно проходили через усю поверхню слизової оболонки їх гирла відкривались у просвіт сліпої кишки, а нижні їх частини сягали власної пластинки.

Таким чином встановлено, що реалізація альтераційних процесів у перивульнарній ділянці сліпої кишки кролів розпочинається з 3 доби експериментального дослідження і визначається в глибинних шарах слизової оболонки із залученням усіх її структурних компонентів.

Підключення в регенеративно-компенсаторні процеси поверхневих шарів слизової оболонки сліпої кишки кролів в ділянці ранового дефекту зшитого хірургічною ниткою Десмосін відбувається з 7 доби спостереження, у які залучені структурні компоненти залоз Ліберкюна.

За рахунок деструктивних змін стовпчастих епітеліоцитів з облямівкою у складі крипт перивульнарної ділянки порушуються, а можливо і припиняються процеси травлення і всмоктування з 3 по 7 добу експериментального дослідження. Відновлення пулу цих клітинних елементів починається з 14 доби експерименту, а показників контролю сягає до 30 доби.

Відновлення клітинного складу залоз Ліберкюна у перивульнарній ділянці відбувалось за рахунок мало диференційованих клітин, які мали тенденцію до збільшення своєї середньої кількості 3 по 21 добу експерименту. Відновлення середньої кількості цих клітин у порівнянні з контрольними показниками відбувалось на 30 добу спостереження.

Ключові слова: сліпа кишка, крипта, залози Ліберкюна, десмосін.

MORPHOFUNCTIONAL CHARACTERISTICS OF THE CRYPTS STRUCTURAL COMPONENTS OF THE CECUM PERIVULNAR AREA BY USING DESMOSIN SURGICAL THREAD

Kobeniak M. M., Pronina O. M.

Abstract. The paper describes the morphological changes in the structural components of the caecal crypts in the periulnar region while suturing the wound defect with desmosin surgical thread.

It was determined that rabbits' cecum, like humans, consists of four membranes: mucous, submucosa, muscular and serous. The mucous membrane included cylindrical epitheliocytes arranged in one layer on its own plate. Under the lamina propria, the mucous membrane's muscular lamina was visualized, including smooth myositis, which were located in two layers: the inner circular and the outer longitudinal. A large number of crypts and the absence of villi were determined in the composition of the mucous membrane. In the mucosa and submucosa, the elements of the hemomicrocirculatory channel were visualized: arterioles, capillaries, and venules, which in turn provided blood circulation and blood exchange of the wall of the cecum as a whole. The structure of the cecal crypts of animals of the control group included various cell associations: columnar cells with a brush border, goblet cells, single endocrinocytes, columnar epitheliocytes without a brush border, and Paneth cells. Lieberkhun's glands histotopographically passed through the entire mucous membrane surface, their openings opened into the lumen of the cecum, and their lower parts reached the lamina propria.

Thus, it was established that the implementation of alteration processes in the perivulnar region of rabbits' cecum begins on the 3rd day of the experimental study and is determined in the deep layers of the mucous membrane with the involvement of all its structural components.

Connection to the regenerative and compensatory processes of the surface layers of the mucous membrane f rabbits cecum in the area of the wound defect sutured with Desmosin surgical thread occurs from the 7th day of observation, in which the structural components of Lieberkün's glands are involved.

Due to destructive changes in columnar epitheliocytes with a brush border in the crypts of the perivulnar area, digestion and absorption processes are disrupted and possibly stopped from the 3rd to the 7th day of the experimental study. The recovery of the pool of these cellular elements begins from the 14th day of the experiment, and the control indicators reach up to the 30th day.

The restoration of the cellular composition of Lieberkün's glands in the perivulnar region occurred due to the poorly differentiated cells, which tended to increase their average number from 3 to 21 days of the experiment. Recovery of the average number of these cells compared with control indicators occurred on the 30th day of observation.

Key words: cecum, crypt, Lieberkün's glands, Vicryl.

ORCID and contributionship:
Kobeniak M. M.: 0000-0002-7989-5534 ABCDEF
Pronina O. M.: 0000-0002-8242-6798 ABCEF

Conflict of interest:
The Authors declare no conflict of interest.

Corresponding author
Kobeniak Mykola Mykolayovych
Poltava State Medical University
Ukraine, 36024, Poltava, 23 Shevchenko str.
Tel.: 0957260208
E-mail: Kobeniak1987@gmail.com

A – Work concept and design, **B** – Data collection and analysis, **C** – Responsibility for statistical analysis, **D** – Writing the article, **E** – Critical review, **F** – Final approval of the article.

Received 19.06.2022
Accepted 14.11.2022