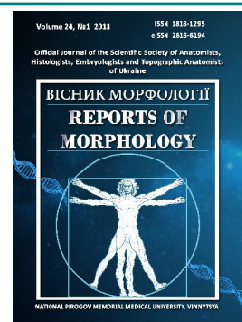




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Morphometric analysis remodeling vessels hemomicrocirculatory bed of jejunum at resections of liver

Hnatjuk M.S., Tatarchuk L.V.

I. Horbachevsky Ternopil State Medical University, Department of Operative Surgery and Topographic Anatomy, Ternopil, Ukraine

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CORRESPONDING AUTHOR

e-mail: hnatjuk@tdmu.edu.ua
Hnatjuk M.S.

Liver resection is widely used in modern surgical departments. Removal of large volumes of the liver leads to postresection portal hypertension, which is complicated by bleeding from varicose veins of the esophagus, stomach, rectum, ascites, splenomegaly with secondary hypersplenism, parenchymal jaundice and portosystemic encephalopathy. The widespread prevalence of this pathology, high mortality from its complications indicates that it is an important medical and social problem. The aim of the study is quantitative morphological study of the features of remodeling the vessels of the hemomicrocirculatory bed of the jejunum at resection of different volumes of the liver. The studies were conducted on 45 sexually mature male rats, which were divided into 3 groups. The first group consisted of 15 intact virtually animals, 2-15 rats after resection of the left lateral part - 31.5% of the parenchyma of the liver, 3-15 animals after resection of the right and left lateral parts of the liver (58.1%). Euthanasia of experimental animals was carried out by bloodletting in conditions of thiopental anesthesia 1 month after the beginning of the experiment. The hemomicrocirculatory bed of the jejunum was studied by injection of its vessels into the carcass-gelatinous mixture, which was injected through the abdominal aorta. From the jejunum, lightened and histologic preparates were prepared and morphometrically studied the vessels of the microhemocirculatory bed. Quantitative indicators were processed statistically, the difference between the comparative values was determined by the Student's criterion. It was established that the severity of structural transformation of the vessels of the microhemocirculatory bed of the jejunum depends on the volume of the removed parenchyma of the liver. The analysis of the obtained results revealed that one month after resection of 31.5% of liver parenchyma, the morphometric parameters of the vessels of the haemomicrocirculatory bed of the jejunum were insignificantly altered. It was determined that resection of 58.1% of liver parenchyma caused postresection portal hypertension and marked remodeling of blood vessels of the hemomicrocirculatory bed of the jejunum, which was characterized by narrowing of arterioles by 23.4%, precapillary arterioles by 22.8%, hemocapillaries by 22.9%, decrease in the density of microvessels - by 22.4%, the expansion of the capillary venules - by 35.5% and venules - by 28.7%, venous plethora, hypoxia, dystrophy, necrobiosis of cells and tissues, infiltrative processes and sclerosis. Resection of 58.1% of liver parenchyma leads to postresection portal hypertension, pronounced narrowing of lumen of the vessels of the adnexa and exchange units hemomicrocirculatory bed, expansion of the postcapillary venules and venules, venous plethora, hypoxia, dystrophy and necrobiosis of cells and tissues, infiltrative and sclerotic processes in wall of the jejunum.

Keywords: jejunum, remodeling, hemomicrocirculatory bed, resection of liver.

Introduction

Liver resection is often performed today in modern surgical clinics [11, 14, 17, 26]. The indicated operation is performed in benign and malignant tumors, metastases, liver injuries, intrahepatic cholangiolithiasis, alveolar echinococcosis,

cholangiocarcinoma, liver transplantation [5, 9, 15, 16, 20]. Often, the removal of large amounts of liver remains the only method that allows you to rely on the healing of a patient with a malignant tumor, or significantly extend his

life [10, 12, 19, 21, 23]. Resection of large volumes of the liver can lead to various post-resection complications: bleeding from varicose veins of the esophagus, stomach, rectum, ascites, splenomegaly, secondary enlargement of the spleen, parenchymal jaundice, porto-systemic encephalopathy, liver failure, portal hypertension [7, 10, 22, 24, 26, 27]. Post-resection portal hypertension leads to structural rearrangement the organs of the basilar portal hepatic vein, as well as the remodeling of their structures [2, 7, 13, 22, 25]. Jejunum refers to the organs, venous drainage from which go through the portal hepatic vein, where hemodynamic disorders are complicated by various morphological changes in the vessels and structures of the specified organ [15, 18, 25]. It should be noted that the features of remodeling of the structures of the intestine in post-resection portal hypertension are not well understood [25].

The aim of the study is quantitative morphological study of the features of remodeling of the vessels of the hemomicrocirculatory bad of the jejunum at resection of different volumes of the liver.

Materials and methods

The studies were performed on 45 sexually mature white male rats, which were divided into 3 groups: the first group consisted of 15 intact practically healthy animals, 2 group - 15 rats after resection of the left lateral part (31.5% of the liver parenchyma), 3 group - 15 animals after the removal of the right and left side parts of the liver (58.1% of the liver parenchyma) [2]. Euthanasia of experimental animals was carried out by bloodletting under conditions of thiopental anesthesia 1 month after the beginning of the experiment. All manipulations and euthanasia of rats were conducted in compliance with the basic principles of working with experimental animals in accordance with the provisions of the "European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes" (Strasbourg, 1986), "General Ethical Principles of Animal Experiments" approved by the first national congress on bioethics (Kyiv, 2001), as well as the Law of Ukraine "On Protection of Animals from Cruel Treatment" of February 21, 2006 [5].

The hemomicrocirculatory channel of the jejunum was studied by injection in its vessels into the cartilaginous gelatin mixture injected through the abdominal aorta. 3-4 hours after the filling of the gastrointestinal tract of the jejunum, a sample of bits of different parts of this organ was collected, fixed in 10.0% solution of neutral formalin for 2 weeks. On a freezing microtome, sections of 30-40 μm thickness were made, which were dehydrated in ethyl alcohol of increasing concentration, clarified in methylene ether of salicylic acid and placed in polystyrene. From the observation portion of the filled vessels with the cartilaginous gelatinous mixture of the intestine, histological micropreparations were prepared, stained with hematoxylin and eosin [8]. Morphometrically determined diameters of arterioles (DA), pre-capillary

arterioles (DPCA), hemocapillaries (DH), after capillary venules (DACV), venules (DV), microvessels density (MD) of the hemomicrocirculatory bed at 1 mm^2 of the gut tissues of experimental animals [1]. The measurements were carried out in 50 fields of view of the microscope. Quantitative values were processed statistically. The results were processed in the department of systemic statistical research of I. Gorbachevsky Ternopil State Medical University in the software package Statsoft STATISTIKA. The difference between the comparative values was determined by the Student criteria [1, 6].

Results

In experimental animals one month after resection 58.1% of the liver parenchyma at the interstitial peritoneal cavity revealed expansion of the hepatic portal vein, plethora and widening of the mesenteric veins and the visible venous channel of the small and large intestines. Mucous membrane of the jejunum is full-blooded, edematous, with single cells of point hemorrhages. The above described evidence of post-resection portal hypertension [3, 8, 22]. The resulting morphometric parameters of the vessels of the microhemocirculatory duct of experimental animals are shown in Table 1.

From the data presented in Table 1, it is evident that a month after removal of 31.5% of the liver parenchyma, the hemomicrocirculatory bed changes, changes and endings were insignificant. Thus, the diameter of the arterioles in the experimental data was reduced by only 2.2%, and the diameter of the pre-capillary arterioles - by 2.8%. The diameter of the hemocapillaries (exchange link of the hemomicrocirculatory channel of the jejunum) in the experimental data significantly ($p < 0.05$) decreased from (6.10 ± 0.09) microns to (5.65 ± 0.12) microns, that is, at 7.4%. The remote link (after capillary venules and venules) of the hemomicrocirculatory channel of the jejunum at the same time tended to expand. Thus, the diameter of the capillary venules of the investigated organ a month after the resection of 31.5% of the liver parenchyma was significantly ($p < 0.01$) increased by 12.1%, and the venule diameter - by 11.7%. The density of microvessels per 1 mm^2 of the jejunum tissue in the experimental data did not change significantly,

Table 1. Morphometric characteristic of the hemomicrocirculatory channel of the gut of experimental animals ($M \pm m$).

Indicator	Surveillance group		
	1	2	3
DA, μm	17.80 \pm 0.21	17.40 \pm 0.33	13.60 \pm 0.12***
DPCA, μm	10.50 \pm 0.12	10.20 \pm 0.15	8.10 \pm 0.09***
DH, μm	6.10 \pm 0.09	5.65 \pm 0.12*	4.70 \pm 0.03
DACV, μm	12.40 \pm 0.15	13.90 \pm 0.18**	16.80 \pm 0.18***
DV, μm	26.50 \pm 0.30	28.10 \pm 0.30**	34.10 \pm 0.33***
DM	3815.6 \pm 28,2	3793.4 \pm 30.3	2960.5 \pm 24.3***

Notes: * - $p < 0.05$; ** - $p < 0.01$; *** - $p < 0.001$ compared to 1 group of observations.

providing a complete blood supply to the structures of the investigated organ [6].

One month after the resection 58.1% of the liver parenchyma of the remodeling of the blood vessels of the hemomicrocirculatory channel of the jejunum was more pronounced than the previous group of observations. Thus, the diameter of arterioles at the same time with a high significant difference ($p < 0.001$) was lower by 23.4% compared with a similar control value. Diameters of pre-capillary arterioles and hemocapillaries also with a high degree of significant difference ($p < 0.001$) decreased by 22.8% and 22.9%, respectively. The diameter of the capillary venules in the given experimental conditions with a pronounced significant difference ($p < 0.001$) increased from $(12.40 \pm 9.15) \mu\text{m}$ to $(16.80 \pm 0.18) \mu\text{m}$, that is, by 35.5%, and the venules diameter - by 28.7%. The density of microvessels per 1 mm^2 of jejunum tissue one month after the removal of 58.1% of liver parenchyma decreased from (3815.6 ± 28.2) to (2960.5 ± 24.3) . Between the given morphometric parameters, a significant ($p < 0.001$) difference was found. At the same time, the last quantitative morphological index was lower than the previous one by 22.4%, indicating deterioration of the blood supply of the investigated organ [6, 7].

Discussion

The domination of the expansion of the venous part of the hemomicrocirculatory duct of the colon within one month after resection of 58.1% of the liver parenchyma is accompanied by venous enlargement, which is complicated by hypoxia. The latter leads to dystrophy, necrobiosis of cells and tissues, and in the remote postoperative period to infiltrative and sclerotic processes in the shells of the investigated organ [2, 7]. The above was confirmed by light-optical research of micropreparations of the intestine. Microscopically, in the membranes of the indicated organ, there were unevenly enlarged, twisted, full-blooded with numerical sacculations of the venous microvessels of the hemomicrocirculatory bed. In these vessels, stasis, thrombosis,

diapedeous hemorrhage, plasmorrhagia of the wall of venous structures and para-vascular tissues were detected. In the membrane of the wall of the intestine marked places of decrease of microvessels due to their reduction and non-vascular zones. Places of reduction of microvessels in micropreparations were visualized in the form of thick-walled fibrous grafts, sometimes with signs of hyalinosis. Endothelial cells of the microvessels with edema phenomena, dystrophic and non-fibrotically altered, acquired a rounded form of cells with desquamation. Some stromal structures and smooth myocytes were also dystrophic and necrobiotic changed. The revealed morphological changes in the wall of the jejunum within a month after resection of 58.1% of the liver parenchyma adequately demonstrate that the vessels of the hemomicrocirculatory channel assume an important role not only in the trophic maintenance of tissues of organs, but also in the pathomorphogenesis of their lesions [7, 25]. The expressive decrease in the density of microvessels per 1 mm^2 of tissues of the investigated organ indicated not only the deterioration of its blood supply, but also the violation of tissue structural homeostasis [1, 7].

Comprehensive, adequate, full-fledged study of the structural transformation of the vessels of the hemomicrocirculatory channel of the jejunum in post-resection portal hypertension will allow to significantly expand the diagnosis, correction and prevention of the studied pathology.

Conclusions

Resection of 58.1% of liver parenchyma leads to post-resection portal hypertension and marked remodeling of the vessels of the hemomicrocirculatory channel of the jejunum, which is characterized by a significant narrowing of the arterial lumen (arterioles, pre-capillary arterioles), exchange (hemocapillaries) of its parts, and the expansion of the after capillary venules and venules, a decrease in the density of the microvessels, venous plethora, hypoxia, dystrophy and necrobiosis of cells and tissues, infiltrative and sclerotic processes.

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МОРФОМЕТРИЧНИЙ АНАЛІЗ РЕМОДЕЛЮВАННЯ ГЕМОМІКРОЦИРКУЛЯТОРНОГО РУСЛА ПОРОЖНЬОЇ КИШКИ ПРИ РЕЗЕКЦІЯХ ПЕЧІНКИ

Гнатюк М.С., Татарчук Л.В.

Видалення великих об'ємів печінки призводить до пострезекційної портальної гіпертензії, що ускладнюється кровотечами із варикозно розширених вен стравоходу, шлунка, прямої кишки; асцитом, спленомегалією, вторинним гіперспленізмом, паренхіматозною жовтяницею та портосистемною енцефалопатією. Широка розповсюдженість даної патології, висока смертність від її ускладнень свідчать, що вона є важливою медичною та соціальною проблемою. Мета дослідження - кількісне морфологічне вивчення особливостей ремоделювання судин гемомікроциркуляторного русла порожньої кишки при резекціях різних об'ємів печінки. Дослідження проведені на 45 статевозрілих щурах-самцях, які були розділені на 3 групи. 1 група (15 інтактних тварин), 2-15 щурів після резекції лівої бокової частки (31,5% паренхіми печінки), 3-15 тварин після резекції правої та лівої бокових часток печінки (58,1%). Евтаназію тварин здійснювали кровопусканням в умовах тіопенталового наркозу через 1 місяць від початку експерименту. Гемомікроциркуляторне русло порожньої кишки вивчали за допомогою ін'єкції її судин туш-желатиною сумішшю, котру вводили через черевну аорту. Із порожньої кишки виготовляли просвітлені та гістологічні мікропрепарати, на яких морфометрично вивчали судини мікрогемодинамічного русла. Кількісні показники обробляли статистично, різницю між порівнювальними величинами визначали за критерієм Стьюдента. Встановлено, що вираженість структурної перебудови судин мікрогемодинамічного русла порожньої кишки залежить від об'єму видаленої паренхіми печінки. Виявлено, що через місяць після резекції 31,5% паренхіми печінки досліджувані морфометричні параметри судин гемомікроциркуляторного русла порожньої кишки змінювалися незначно. Встановлено, що резекція 58,1% паренхіми печінки призводила до пострезекційної портальної гіпертензії та вираженого ремоделювання судин гемомікроциркуляторного русла порожньої кишки, яке характеризувалося звуженням артеріол на 23,4%, передкапілярних артеріол - на 22,8%, гемокапілярів - на 22,9%, зменшенням щільності мікросудин - на 22,4%, розширенням закапілярних венул - на 35,5% і венул - на 28,7%, венозним повнокров'ям, гіпоксією, дистрофією, некробіозом клітин і тканин, інфільтративними процесами та склерозуванням. Таким чином, в результаті резекції 58,1% паренхіми печінки розвивається пострезекційна портальна гіпертензія, достовірно зменшуються просвіти судин приносячої та обмінної ланок, гемомікроциркуляторного русла, розширюються закапілярні венули та венули, збільшується їх повнокров'я, гіпоксія, дистрофія та некробіоз клітин і тканин, розвиваються інфільтративні та склеротичні процеси у стінці порожньої кишки.

Ключові слова: порожня кишка, ремоделювання, гемомікроциркуляторне русло, резекція печінки.

МОРФОМЕТРИЧЕСКИЙ АНАЛИЗ РЕМОДЕЛИРОВАНИЯ ГЕМОМІКРОЦИРКУЛЯТОРНОГО РУСЛА ТОЩЕЙ КИШКИ ПРИ РЕЗЕКЦИЯХ ПЕЧЕНИ

Гнатюк М.С., Татарчук Л.В.

Удаление больших объемов печени приводит к пострезекционной портальной гипертензии, которая осложняется кровотечениями из варикозно расширенных вен пищевода, желудка, прямой кишки, асцитом, спленомегалией, вторичным

гиперспленизмом, паренхиматозной желтухой и портосистемной энцефалопатией. Широкая распространенность данной патологии, высокая смертность от ее осложнений свидетельствуют, что она является важной медицинской и социальной проблемой. Цель исследования - количественное морфологическое изучение особенностей ремоделирования сосудов гемомикроциркуляторного русла тощей кишки при резекции различных объемов печени. Исследования проведены на 45 половозрелых крысах-самцах, которые были разделены на 3 группы: 1 группа (15 интактных животных), 2-15 крыс после резекции левой боковой доли (31,5% паренхимы печени), 3-15 животных после резекции правой и левой боковых долей печени (58,1%). Эвтаназию животных осуществляли кровопусканием в условиях тиопенталового наркоза через 1 месяц после начала эксперимента. Гемомикроциркуляторное русло тощей кишки изучали с помощью инъекции ее сосудов тушь-желатиновой смесью, которую вводили через брюшную аорту. Из тощей кишки изготавливали просветленные и гистологические микропрепараты, на которых морфометрически изучали сосуды микрогемомикроциркуляторного русла. Количественные показатели обрабатывали статистически, различия между сравниваемыми показателями определяли по критерию Стьюдента. Установлено, что выраженность структурной перестройки сосудов микрогемомикроциркуляторного русла тонкой кишки зависит от объема удаленной паренхимы печени. Выявлено, что через месяц после резекции 31,5% паренхимы печени исследуемые морфометрические параметры сосудов гемомикроциркуляторного русла тощей кишки изменялись незначительно. Установлено, что резекция 58,1% паренхимы печени приводила к пострезекционной портальной гипертензии и выраженному ремоделированию сосудов гемомикроциркуляторного русла тощей кишки, которое характеризовалось сужением артериол на 23,4%, передкапиллярных артериол на 22,8%, гемокапилляров на 22,9%, уменьшением плотности микрососудов на 22,4%, расширением посткапиллярных венул на 35,5% и венул на 28,7%, венозным полнокровием, гипоксией, дистрофией, некробиозом клеток и тканей, инфильтративными процессами и склерозированием. Резекция 58,1% паренхимы печени приводит к пострезекционной портальной гипертензии, выраженному уменьшению просветов сосудов приносящего и обменного звеньев гемомикроциркуляторного русла, расширению посткапиллярных венул и венул, их полнокровию, гипоксии, дистрофии и некробиозу клеток и тканей, инфильтративным и склеротическим процессам в стенке тощей кишки.

Ключевые слова: тощая кишка, ремоделирование, гемомикроциркуляторное русло, резекция печени.
