ЕКСПЕРИМЕНТАЛЬНІ ДОСЛІДЖЕННЯ

Формування біліодигестивних та міжкишкових анастомозів методом високочастотного електрозварювання тканин в експерименті

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Formation and evaluation of bilio–digestive and interintestinal anastomoses by the method of high–frequency electric welding of tissues in experiment

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Реферат
   Мета. Розробити новий спосіб формування біліодигестивних та міжкишкових анастомозів як за відсутності, так і за наявності запалення тканин.
   Матеріали і методи. В експерименті на 50 кролях методом високочастотного електрозварювання формували однорядні евертуючі холецистоентеро– та ентероентероанастомози на виключеній за Ру петлі тонкої кишки як за відсутності запалення тканин, так і на фоні жовчного перитоніту. Визначали прохідність, герметичність, міцність отриманих з'єднань, проводили їх макро– та мікроскопічну оцінку в різні терміни після операції.
   Результати. Всі анастомози, сформовані методом високочастотного електрозварювання, були прохідні та герметичні, а також мали достатню міцність (40 – 100 мм рт. ст.). З'єднання тканин відбувалося за рахунок термоадгезії, коагуляційний рубець був вузький, завершення епітелізації шва спостерігали через 3 міс, а дозрівання рубця – через 6 міс.
   Висновки. Метод високочастотного електрозварювання забезпечує формування надійних біліодигестивних та міжкишкових анастомозів як за відсутності, так і за наявності запалення тканин.
Ключові слова: біліодигестивний анастомоз; жовчовивідні протоки; жовчний перитоніт; високочастотне електрозварювання; експеримент.

Abstract
   Objective. To develop a new method of the anastomoses formation, that would allow to form bilio–digestive and entero–entero anastomoses both on unchanged and inflamed tissues.
   Materials and methods. In experimental on 50 laboratory rabbits the single–layer everting cholecysto–entero and entero–entero anastomoses on the Roux–defunctionalized loop of small intestine was created by the method of a high–frequency electric welding. The welding anastomoses were formed both on non–inflamed tissues and in the setting of biliary peritonitis. Patency, hermeticity, strength, macroscopic and microscopic pictures of the obtained joints were evaluated at different postoperative periods.
   Results. All anastomoses, formed by the method of a high–frequency electric welding, were not only patent and hermetic, but also sufficiently strong (40 – 100 mm Hg). The tissues were joined using thermo–adhesion; a coagulation scar was rather narrow, its complete epithelization was accomplished in 3 mo, and a scar maturation completed – in 6 mo.
   Conclusion. The method of a high–frequency electric welding permits to form both, bilio–digestive and inter–intestinal, anastomoses of equal reliability in the settings of non–inflamed and inflamed tissues.
Keywords: bilio–digestive anastomosis; biliary ducts; biliary peritonitis; high–frequency electric welding; an experiment.

Introduction.

The surgical practice of today is still facing the topical problem of using biliodigestive anastomoses to restore the major bile outflow. The formation of biliodigestive anastomoses is the main method of treatment in case of lesions of bile–excreting ducts, and also in case of impossibility of using the en-

doscopic methods in removing an injury of bile ducts in the setting of their benign or malignant lesions. Presently, Roux–en–Y hepaticojejunostomy occupies the dominant position among the methods of bile outflow recovery and is a standard operation [1 – 4].

However, the level of complications still remains rather high after applying hepatico–jejunoanastomoses, early complications (abscess formation, cholangitis, bile outflow from anastomosis) occur in about 20% of patients, long–term complications mainly appear in the form of strictures and make up 10 – 30% [1, 5, 6]. Besides, considerable difficulties arise in the setting of severe inflammation in the operative area, while the presence of purulent cholangitis or bile peritonitis is often a contraindication to reconstructive surgery, because of high threat of impossibility to apply sutural anastomoses [5, 7, 8].As of today, new methods of forming biliodigestive anastomoses are still being searched for the cases of both unchanged and inflamed tissues [9 – 12].

The aim of research was to develop a new method of forming anastomoses, that would allow to form biliodigestive and enteroentero anastomoses both on unchanged and inflamed tissues.

Materials and methods

Fifty rabbits were experimentally researched. This experimental research corresponded to the requirements of «EU Directive 2010/63/EU for Animal Experiments» and Order № 249 of the Ministry of Education and Science of Ukraine «On Approval of the Procedure of Conducting Animal Testsand Experiments by Scientific Establishments». The experiment was made at the Department of Experimental Surgery of the National Institute of Surgery and Transplantology named after O. O. Shalimov of the National Academy of Medical Sciences of Ukraine.

All animals were quarantined and then kept in individual cages. Surgical operations were performed in the operating room, which was equipped in the proper way. All operative interventions were conducted under general intraperitone-

al anesthesia, by injecting Thiopental solution 5% 3.0 ml and Propofol solution 0,1% 6,0 ml into the abdominal cavity. In the course of the operation, if required, the tested animals were injected with an additional dose of 1.5 – 3.0 ml Thiopental and 3.0 – 6.0 ml Propofol. In the postoperative period the rabbits were given pain relievers Ketorolac 3% – 0.5 ml intramuscularly twice per day for 3days and antibiotics (Ceftriaxone 0.1 intramuscularly twice per day for 3 – 5 day). Throughout the entire postoperative period, the animals obtained proper care. The animals were sacrificed by injecting the excessive dose of Thiopental solution into their abdominal cavity.

The animals were divided into the basic group (n=35) and comparison group (n=15). Biliodigestive anastomoses were applied to all rabbits. Because the diameter of the common bile duct of an adult rabbit is 1 – 2 mm, which makes it technically impossible to form hepaticojejunostomy, cholecysto–enteroanastomosis (CEA) was applied as the analog of hepaticojejunostomy. In order to bring the experimental conditions to clinical ones as close as possible, hepaticojejunostomy was formed on the Roux–defunctionalized loop of small intestine, then, the bowel content passing was restored by end–to–side entero–enteroanastomosis (EEA).

In the basic group, in the setting of both non–inflamed tissues and peritonitis, single–layer everting cholecysto–entero– and entero–enteroanastomoses were formed in the tested animals by the method of high–frequency (HF) electric welding with device «Patonmed EKVZ–300» in the «manual welding» mode. First of all, two П–shaped traction sutures were made at the opposite ends of the future anastomosis. These traction sutures kept the joined organs together and ensured everting of gallbladder and small intestine edges. Afterwards, spot welds (sutures) were made along the whole perimeter of anastomosis. Due to the fact that the welding sutures were everting, it was possible to achieve adhering of mucosa to mucosa in the most perfect way, so the second row of stitches was not needed [13]. EEA was formed in the similar way.

In the comparison group, anastomoses were formed by the traditional sutural method. CEA and EEA were imposed

Fig. 1.
Intraoperative determining of hermiticity and patencyof welding CEA by the hydro–pression method.

Fig. 2.
Intraoperative hydro–pression of welding EEA.

by a single–layer continuous suture, the suture material is PDS 5/0was used in the atraumatic needle. Typically the edges were everted into inside; the second row of stitches was not imposed.

Each group was respectively divided into 2 subgroups:

a) healthy animals – anastomoses were formed on unchanged tissues, and

b) animals with peritonitis – anastomoses were formed on inflamed tissues in the setting of simulated bile peritonitis.

Diffuse bile peritonitis was simulated by injecting the abdominal cavity with a suspension of laboratory culture of E.coli (in the volume of $1,0 \times 10^8$ colony–forming units/ml per 1 kg of body weight); this suspension was added to sterile medical bile (2 ml of bile per 1 kg of body weight). The suspension was injected with a syringe by white–line puncturing into the distal part of the abdomen. 24 hours later, diffuse serous–fibrinous or purulent–fibrinous peritonitis developed in the animals. To simulate diffuse serous peritonitis, the abdominal cavity was injected only with culture of E.coli, without adding any bile.

To check the level of safety and reliability of anastomoses, formed by the method of high–frequency electric welding, their patency, hermiticity and strength were defined, apart from that, macro– and microscopic evaluation of the weld area was conducted at different phases of postoperative period. The results, obtained in the basic group, were compared after imposition of anastomoses on the unchanged and inflamed tissues, as well as with the comparison group.

The hermiticity and strength of anastomoses were determined by hydro– and pneumo–pression. The method of hydro–pression allowed to intraoperatively define the hermiticity and patency of the obtained joints immediately after their formation. To do this, when evaluating CEA, the small intestine was pressed more distally from the place of anastomosis, and sterile saline was injected with a syringe there into, until the intestinal lumen and gallbladder became completely filled with liquid (*Fig. 1*). After that, the presence or absence of any leakage from the weld area was defined. The hermiticity was additionally assessed by light pressing on the liquid–filled bowel.

The hermiticity of EEA was assessed in the same way (*Fig. 2*).

The method of pneumo–pression was used to define the strength of anastomoses. Pneumo–pression was conducted in vitro, the animal was sacrificed and material sampling was performed. A trocar (5 mm in diameter) was inserted into the intersected end of the Roux loop, a manometer and 50 ml syringe were connected there to. The trocar, inserted into the loop of intestine, was hermetically fixed with ligatures, the specimen was put into a vessel with water and gradually pumped with air until it lost hermiticity. Right at the moment, when air bubbles rose in the area of anastomosis suture, the pressure value was fixed on the manometer. In the similar way, manometry of EEA was performed: the trocar was inserted into one of the loops, while the other two loops were blocked by clamps or tied up. This method allowed not only to assess the strength of anastomosis, but also to identify and evaluate its patency.

To define the changes that occurred in tissues during welding, the histological analysis of the weld area and surrounding tissues was conducted. After the animals were sacrificed, the organ parts were cut out from the area of their connection for the purpose of histological analysis. The obtained specimens were fixed in 10% solution of formalin for 2 days. 5 – 6 fragments were taken from ach anastomosis and sealed in paraffin. The slices 5 mcm thick were taken to be stained with hematoxylin and eosin, van Gieson's picrofuchsin, azure–II–eosin.

Results

The results were evaluated at different periods after the operation – during the operation, on the 2nd, 7th, 21st, 90th, 180thand 365thday.

The hermiticity and patency of weld anastomoses were defined by the hydro–pression method directly during the operation. When hydro–pression was applied, good hermiticity and patency of anastomoses was recorded in all cases.

The strength and patency of weld anastomoses were defined by the pneumo–pression method immediately after the operation, on the 2nd, 7th, 21st, 90th and180th day. The pressure,
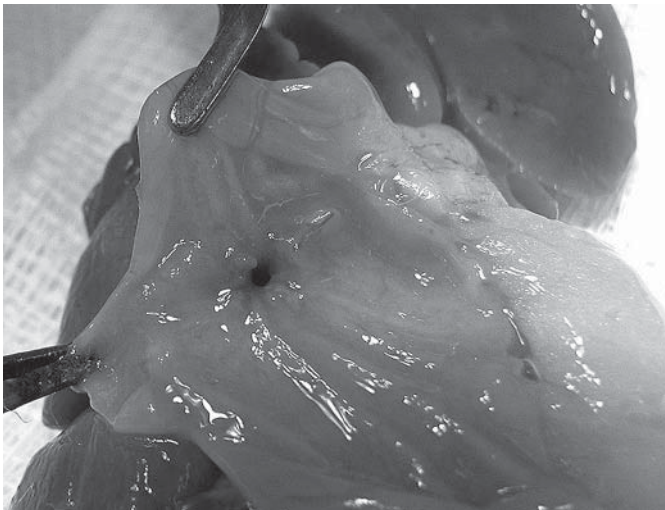
Fig. 3.
Welding CEA, second day after the surgery, view from the side of the small intestine lumen.
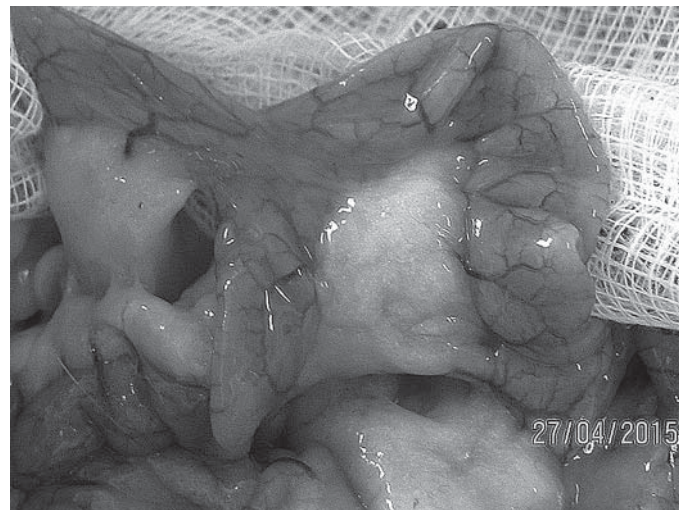
Fig. 4.
Welding EEA, 180 days after the surgery, external view.

ranging from 40 to 100 mm Hg, was applied right after CEA was formed. At the initial stages of study, this value ranged from 40 to 60 mm Hg; after the best mode of welding was selected and the technique of anastomosis formation was worked out and improved, the pressure of rupture increased to 80 – 100 mm Hg. On the second day, the manometry parameters remained the same (80 – 100 mm Hg), on the seventh day they rose to 140 – 150 mm Hg, and 21 days after the surgery the anastomosis strength was almost equal to the strength of intact bowel – 240–250 mm Hg.

In case of diffuse infected bile peritonitis and anastomosis–forming on the inflamed tissues, no significant difference was found between the manometry parameters – the initial strength of the welding joint also fluctuated within the above–mentioned range from 40 to 100 mm Hg. The postoperative period did not show any difference in parameters too. After the signs of inflammation disappeared, it was observed that the regeneration processes were the same in the weld area and the weld strength practically coincided at different periods after the operation.

The same can be also said about interintestinal anastomoses. Despite the fact that only intestine walls were welded during EEA formation (they are somewhat thicker and stronger, than gall bladder walls), the strength of the welding joint was practically the same in both types of anastomoses.

As concerns sutural anastomoses, here a sharp contrast was remarked depending on the conditions, they were formed in. Thus, when anastomoses were applied on the non–inflamed tissues, their initial strength was 80–100 mmHg. When suturing was performed in the setting of peritonitis, the manometry parameters were quickly dropping – in case of diffuse infected peritonitis and evident inflammation of tissues, the surgical sutures easily came out and anastomosis lost hermiticity at minimal pressure of 10–15 mm Hg. In case of local aseptic peritonitis and moderate or slight inflammation of the tissues, this value increased to 30–50 mm Hg, which was enough to preserve the hermiticity of anastomoses in the postoperative period. Similarly with welding anastomoses, the formed sutural anastomoses didn't show any significant difference between CEA and EEA strength.

The macroscopic assessment of external and internal view of anastomoses was performed immediately after the operation, on the 2nd, 7th, 21st, 90th, 180th and 365th day, their patency and precision of mucous membranes matching were determined.

Immediately upon welding, the welding joint looked like a cushion, which circularly embraced the anastomosis, being 1 – 2 mm in with and about 4 mm in height (from the edge of the organ wall to the free edge of the welding suture). The welding suture was gray in color, with no visible signs of necrosis (*Fig. 1, 2*). On the part of the anastomotic lumen, the suture had the appearance of a lightly grey fine stripe 1.5 – 2 mm wide, no thermal lesions of the mucous membrane were visually observed beyond the suture limits. The full patency of all anastomoses was noted, their inner diameter practically corresponded to the length of sections of the welded organ walls.

On the second day after the weld was formed, the weld was keeping the original shape of cushion, visually the tissues were completely viable, the areas of thermal impact did not spread

outside the weld, and also no narrowing of the anastomotic lumen was observed (*Fig. 3*).

7 days after anastomosis formation, the external view of the suture changed – it still had the shape of a cushion, but its height slightly decreased (to 2 – 3 mm) and the with increased (to 3 mm); the weld tissues, that underwent thermal influence, changed their color from grey to pink–white, though still differed from the surrounding intact tissues. From the side of the anastomotic lumen, the sutural line was seen very clearly, but its color changed likewise, from light–grey to rosy. There were no areas of necrosis and signs of stricture formation.

21 days after the surgery, the place of the suture was not visually found on the outside, the cushion, formed during the welding process, completely disappeared and the continuous serous layer passed from the afferent loop into the efferent loop. The weld color was the same, as the color of surrounding tissues, and only after careful examining, very closely, one could see a hardly noticeable line at the place of junction. Inside the anastomosis, at the junction place, a thin scar was seen in the form of pink cushion 1 – 2 mm wide. The lumen of anastomosis was of usual round shape, no signs of stricture formation were found.

90 days after the surgery, the place of junction was covered with renewed serous membrane on the outside, the scar was barely visible, the weld line was seen in CEA owing to the difference in color between gall bladder and small intestine tissues, while in EEA it was not found at all. Inside, the junction line was completely covered with renewed mucous membrane and hardly visually revealed. The anastomoses were completely passable, showing no signs of narrowing.

180 days after the surgery, the junction place of gall bladder and small intestine could be determined only due to difference in color and structure of these organs tissues, as for the weld place, it was not visually noticeable in the EEA outside or inside, besides, there were no signs of stenosis (*Fig. 4*).

365 days after the surgery, the picture was the same, as 180 days after the surgery. The gall bladder was normal in shape and color, the adhesive process in CEA area was minimally evident and seen only at the place of junction of gall bladder and small intestine. Inside, the gall bladder mucosa was visually of normal structure, showed no signs of inflammation and hyperplasia. The gall bladder contained normal bile with no sediment or calculi. When the bile was sampled for sterility, no growth of microorganisms was found therein. CEA was of round shape, d = about 4 – 5 mm, freely passable.

EEA 365 days after forming: color, structure and diameter of the afferent, efferent and Roux loops did not differ and met the normal characteristics of small intestine. The adhesive process was absent in the area of EEA. The weld place was not visually identified, the serous membrane and visible small vessels smoothly passed through the zone of junction. Inside, the junction place wasn't visually defined as well, the mucous membrane uniformly covered the weld area.No hypertrophy of the afferent loop walls, that would be indicative of stricture formation, was found. EEA was passable; the anastomotic diameter was 6 – 7 mm and corresponded to the diameter of small intestine.

During the macroscopic evaluation of anastomoses, formed in the setting of non–inflamed tissues, and anastomoses,

formed in the setting of peritonitis, there were no significant differences in structure of the weld and the healing time. In the setting of full–blown inflammation, one could note the initial swelling of welded organ tissues, which decrease antibiotic therapy on the second postoperative day after peritonitis liquidation. Starting from the 7th day, one could visually find no tissue edema or any other inflammatory phenomena in the abdominal organs, regeneration processes in the weld areas were the same in both subgroups of tested animals.

Anastomoses were also macroscopically evaluated after their formation by the traditional sutural method. In the first 3 days, one could notice a slight swelling and hyperemia in the area of the suture, which slightly increased on the 7th day. Given the initial everting of edges, in to it led to moderate narrowing of the anastomotic lumen by approximately 1/4th of its diameter. 21 days after the surgery, the junction place was seen as a thin whitish line from outside and as a cushion 2–3 mm wide from inside. Although the suture material was well–seen, the reactive swelling was practically absent and the narrowing of the anastomotic lumen was insignificant, if it was available at all. 90 days later, the line of anastomoses was barely visible from the outside. Inside, some fragments of the suture material were noticed, their destruction and rejection into the anastomotic lumen were observed. The junction line looked like a cushion or, in better words, a slight swelling. Visually the mucosa completely covered the suture line without any defects. The anastomotic patency was good, CEA diameter was about 4 – 5 mm, EEA diameter almost corresponded to the diameter of small intestine. On the 180th day, the condition of sutural anastomoses remained satisfactory, no fragments of suture material or signs of stricture formation were observed.

The pathomorphological study of the weld area was to analyze the changes, that occurred in the tissues during welding, and was performed immediately after the surgery, on the 2nd, 7th, 21st, 90th, 180th and 365th day.

As a result of the histological examination, performed immediately after formation of CEA and EEA, it was established that a coagulation scab was formed in the weld area, which captured all the layers of gall bladder and small intestine wall. On both sides from the suture line, the membranes of organ walls were swollen, there were big areas of mesothelium desquamation from the serous membrane surface. From the side of mucosa, there were fragmentation of fibers and epithelial desquamation. In the centre of thermal influence, the walls were thickened due to severe dehydration, while in the mucous and submucosal membranes there were areas of homogenization of collagen fibers. Due to evaporation, lacunas were formed in the submucosal membrane and surrounding circular layer of muscular coat. The signs of deepithelization were observed in the gall bladder areas, that surrounded the weld zone; increased desquamation of epithelial cells and fragmentation of some fibers were observed in small intestine. There were some areas of plethora and stasis in the vessels of the proper mucous plate. In the muscular coat, one could find destruction of some muscular fibers.

On the second day after the operation, in the surrounding areas around the coagulation scab, one could see severe desquamation of epithelial cells and destruction of villi, there were foci of coagulation necrosis, which mainly covered the mucosal and submucosal membrane.

On the seventh day, a small area of granulation tissue was formed in CEA. The density of arteriolo–venular bridge increased, mostly on the side of anastomotic lumen, the number of blood vessels was less in the deeper layers. The capillaries of the mucosal, submucosal membranes and muscular coat were expanded, full–blooded at some distance from the anastomosis area. The mucous membrane of small intestine was partially preserved; one could find increased desquamation of epithelial cells from the tops of the villi. Serous membrane: mesothelium was almost absent in the junction zone. On the side of the gall bladder mucosa, the epithelial lamina was missing at a considerable distance, the inner surface was covered with masses of detritus. The bladder walls showed more evident signs of edema, lymphocytic infiltration was observed together with neutrophilic granulocytes and macrophages. In the area of EEA, one could observe similar inflammatory changes; a granulation tissue was beginning to be formed between the fragments of coagulation masses.

On the 21st day after the welding, the newly formed connective tissue was vascularized in CEA area. In the area of the suture, one could find a partial restoration of the mucosa from both sides – from gall bladder and small intestine. 21 days later, in the area of EEA, quite a mature scar was formed by a mesh of collagen fibers and fibrocytes. In the deep layers of the scar there were small fragments of coagulation masses, surrounded by macrophages and imposed to lysis. In the sutural area, a large zone of the mucosa was renewed, epithelial cells were "crawling" onto the inner surface of the scar, however, the number of goblet cells was significantly reduced as compared to the intact areas.

90 days later, in CEA area, the mucosa was restored completely. The scar was mature, thin, without apparent collagen formation. There were no signs of deformation and stenosis. The signs of inflammation were absent both in the sutural area and the surrounding tissues. EEA: a thin mature scar was formed in the weld area, without apparent collagen formation. The mucous membrane was thinned in some areas along the sutural line, in others completely restored. But we found no signs of inflammation in the sutural area of the joint and surrounding tissues (*Fig. 5*).

CEA after 180 days: the mature, moderately dense, vascularized connective tissue was formed in CEA area in the sutural area. The scar tissue was mature without any signs of fibrosis, at some places it had diffuse lymphocytic infiltration. The sutural line was completely covered with renewed mucous membrane (*Fig. 6*). EEA: the small intestine wall was restored at the junction place, some areas of thickening were also seen together with chaotically located renewed bundles of smooth muscle fibers, besides, there were visible areas of thinned wall with a small number of smooth muscle bundles, mainly oriented in a circular way. No signs of inflammation, fibrosis and proliferative effects of connective tissue were found in the lumen of anastomoses.

To evaluate the long–term results, we also conducted a histological analysis 365 days after the surgery. In the weld area of CEA, a mature scar was formed without evident signs of collagen formation (fibrosis). The mucosa was restored completely. EEA – mature scar, with no signs of inflammation and fibrosis, the mucous membrane is renewed in the sutural area.
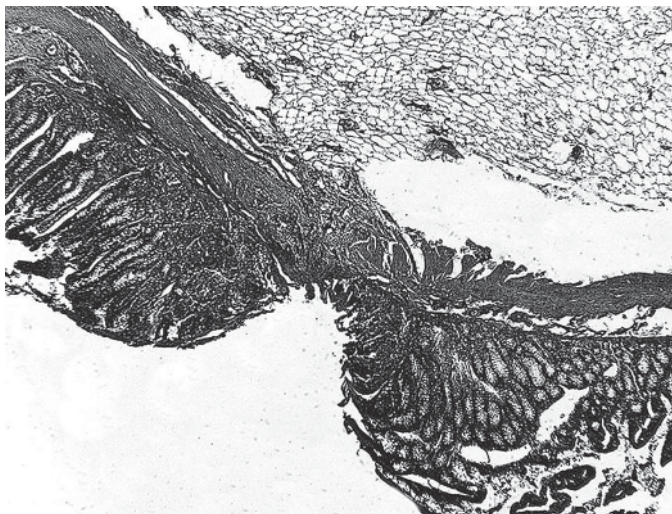
Fig. 5.
Welding EEA, 90 days after the surgery, restoration of mucous membrane in the weld place.
Hematoxylin and eosin applied. Number: ×40.
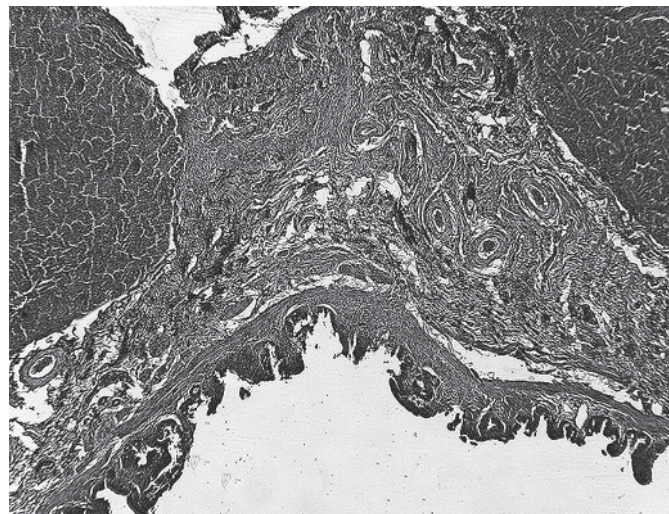
Fig. 6.
Welding CEA, 180 days, restored mucosa in the weld area.
Stained with van Gieson's picrofuchsin. Number: ×40.

As for anastomoses, formed in conditions of diffuse infected peritonitis in inflamed tissues, there was no significant difference in the histological picture immediately after welding, the structure of coagulation scar and changes in the membranes were the same, as after the formation of anastomoses on non–inflamed tissues. The difference was only in bigger edema of gall bladder and small intestine tissues, which appeared not as a result of welding, but because of inflammation in the abdomen.

On the second day, a swelling of gall bladder and small intestine walls was the same in size; blood clots were found in the veins and some arteries. Already on the seventh day, after inflammation became extinct in the abdomen, practically there were no differences in the structure of the weld line and surrounding tissues. In further periods we found no differences in the regeneration processes of anastomoses, formed in the conditions of inflammation, if compared with non–inflamed tissues.

In the comparison group, on the first day, some disorders of microhemocirculation were observed in response to the operational trauma, these disorders led to ischemic changes in the tissues. On the second day after the surgery, we observed fragmentation of villi and deepithelization from the surface of the mucous membranes of gall bladder and small intestine, besides, a moderate swelling of tissues appeared at the junction place. In case of suture anastomoses, in the setting of inflamed tissues and local serous peritonitis, multiple small foci of necrosis were revealed in the walls of these organs.

7 days after the surgery, dystrophy was found in the mucosa of both gall bladder and small intestine, as well as epithelial desquamation and villous fragmentation. A moderate swelling of tissues was unchanged; the sutural area was covered with masses of detritus from the side of anastomotic lumen. There were no significant differences in histology between the anastomoses, formed in the setting of serous peritonitis, and anastomoses, formed on non–inflamed tissues. 21 days later, a granulation tissue was formed, it replaced the tissues of submucosal, muscular and serous membranes at the junc-

tion place. The processes of epithelization were not found in the scar area, by contrast with the anastomoses, formed by the HF electric welding method.

90 days after the operation, a mature scar tissue was formed in the area of CEA. The mucosa renewed not completely, it was absent in some areas, in the center of the sutural line, however, some signs of regeneration were noticed; the epithelial lamina was beginning to cover the scar. In other parts, the mucosa was renewed. EEA – small intestine wall was thickened by 15 – 20% in the sutural area, the muscular coat was replaced by bundles of collagen fibers that were arranged in parallel. The serous membrane was restored, vascularized and covered with mesothelium.

180 days later, the mucous membrane was renewed in the weld region, but the villi were shorter and crypts were less deep, than on intact areas. The intestine wall was slightly thinned due to lack of full reconstruction of the muscular coat. Weak lymphocytic infiltration was observed in the sutural area and surrounding tissues.

Discussion

As it was established as a result of the given research, the initial strength of anastomoses, formed by the HF electric welding method, practically corresponded to the strength of sutural anastomoses and was sufficient to ensure a good welding junction. In the postoperative period, the weld strength 1.5 – 3 times increased by the 7th day, on the 21st day it reached the strength of intact bowel. The important advantage of welding is that the parameters of its strength are almost equal both in unchanged and inflamed tissues.

The tissues were joined by thermoadhesion. A weld was formed from dehydrated and coagulated tissues of submucosal membrane and muscular coat; the mucous and serous membranes were destroyed almost completely, so subsequently they did not play any significant role. Already during the first week, the regeneration processes were observed –a granulation tissue was beginning to be formed, proliferation of the arteriolo–venular bridge occurred. On the 21st day, quite a ma-

ture scar was formed and epithelization was beginning; scar formation and its epithelization completed after the period of 3 months, while the scar fully maturated prior to 6 months.

When comparing the results of tissue connection by the welding method and sutural method, it can be noted that regeneration processes occur after welding in the similar way, as when ligatures are applied. The histological and macroscopic research showed no abnormal or too slow formation of scar in the weld region. Owing to absence of foreign suture material and precise matching of tissues, the local reactive inflammatory response was weaker, so ultimately it led to a thinner scar and somewhat faster epithelization of the junction area. The significant advantage of anastomoses, formed by the high–frequency electric welding method, except the absence of suture material at the junction place, is lack of tissue prolapse into the lumen of anastomosis, which prevents the initial narrowing of anastomoses and further structure–forming due to excessive regenerative processes.

The high parameters of reliability and safety of HF electric welding method make its application reasonable in the clinical practice, where biliodigestive anastomoses are formed thereby.

Conclusions

1. The method of high–frequency electric welding lets form both biliodigestive and interintestinal anastomoses of equal reliability in the setting of non–inflamed and inflamed tissues, thus offering a great advantage over the traditional ligature method, by which it's extremely dangerous to form anastomoses because of inflamed tissues and respectively a high risk of failure to stitch them up.

2. All anastomoses, formed by the method of HF electric welding, were proven to be passable and hermetic.

3. Welding anastomoses had the sufficient level of initial strength. The weld strength in the postoperative period increased in a linear progression and did not depend on the presence or growth of tissue inflammation. 3 weeks later, the strength of the welding connection practically reached the strength of an intact bowel.

4. A reliable scar of connective tissue was formed in the weld region within 6 months, this period corresponded to the regeneration terms after anastomoses–forming by the traditional suture method.

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