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EXPERIMENTAL AND MORPHOLOGICAL SUBSTANTIATION OF TUBULAR BIOLOGICAL STRUCTURES OBLITERATION BY MEANS OF HIGH-FREQUENCY ELECTRIC WELDING OF TISSUES

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We investigated the effect of high-frequency electric current on the simulated fistula of the digestive canal. We have identified the optimal parameters of the generator necessary for the destruction of the mucous membrane. Morphological methods confirmed the effectiveness of the current in destroying the tunica serosa of the fistula.

Key words: electric welding of biological tissues, morphological changes, intestinal fistula.

The work is a fragment of the research project "Development of new techniques for the operative integrity restoration of vessels and elements in the gastrointestinal tract by means of electric welding and convection-infrared processing of live tissues", state registration No. 0116U004903.

Live Tissue Electric Welding (LTEW) was developed at the E.O. Paton NAS of Ukraine, by specialists of the experimental department at the Institute of Surgery and Transplantation, NAMS of Ukraine with the participation of "Welding" International Association and the CSMG company (USA). [1, 4] Some authors believe that due to the specially selected parameters of high-frequency current and the features of its technique's influence on the tissues, the connection of tissues is performed, which does not lead to the formation of coagulation scab, necrosis and loss of tissue's living activity. [1, 2, 3] Others claim that when used in the electrode area, a coagulation film or coagulation scab is formed, which perform the function of tissue fixation and sealing. [4, 5] The opinion of all authors agrees on the size of tissue damage within the range of high-frequency current, which does not exceed 1-2 mm from the applied electrodes.

LTEW is used in abdominal, thoracic, vascular surgery, oncology, neurosurgery, otolaryngology, gynecology and urology [2, 3, 4] Bipolar spherical or oval-shaped electrodes are used for endovascular obliteration of superficial veins of the lower extremity in varicose vein disease. [3] Optimal parameters for using a welding probe for vein obliteration were developed: the extraction rate was 0.5–1.0 cm/s, depending on the vein diameter, current power being 50%. [3]

This work was performed for experimental and morphological substantiation of the possible applying endoscopic high-frequency current welding of the hollow organs fistulas in the digestive tract. Fistulas account for 1-2% of all abdominal surgical pathology. Mortality in surgical treatment remains high, so the development of new minimally invasive therapies is relevant.

The purpose of the work was to study the nature of morphological changes in the vermiform appendix and small intestine tissues during endoscopic welding with a spherical electrode, under different modes of exposure to high-frequency electric current, to determine the optimal conditions for the mucous membrane destruction.

Materials and methods. The study was carried out in the pathoanatomical department of the Alexander Clinical Hospital in Kyiv on 106 fragments of the small intestine and vermiform appendix of the dead for the period from 01.02 to 30.12. 2018. The material was obtained in compliance with the rules of bioethics in the absence of the digestive tract pathology, during dissection, within 6-12 hours after death. The fistulous passage of various diameters was simulated by imposing a direct Bilroth clamp parallel to the antimesenteric margin of the dissected small intestine through all the layers of opposite walls (82 cases).

A spherical bipolar electrode was introduced into the lumen at the depth of the formed passage. While pulling the electrode, the passage welding was performed from inside. In the second series of the experiment, the lumen of the blindgut vermiform appendix (24 cases) was welded. To do this, the top of the appendix was cut off. An electrode was introduced into the blindgut lumen and the vermiform appendix was welded during the electrode pulling out. For high-frequency biological tissue welding, "EKWZ-300 Patonmed" generator and special spherical electrodes consisting of a spherical shaped working part with two S-shaped electrodes were used. Welding was performed in the "manual mode of the machine", at 50% of its power and at the maximum power, with the drawing speed of 0.5-2mm/s.

The electrodes used were of different diameters from 4 to 8 mm, depending on the vermiform appendix lumen diameter, reaching a firm adherence of the electrode to its wall. Macroscopic changes of the organ's wall during welding were determined, as well as changes of the mucous membrane after opening the modeled small intestine passage. The dependence of macroscopic and microscopic changes on the electric current power, the electrode drawing speed, integrity of the electrode adhesion to the wall were studied. The organ fragments were excised and fixed in 10% formalin solution, embedded into paraffin blocks. The 5 µm thick sections were stained with hematoxylin and eosin.

Results of the study and their discussion. At the stage of working out the methodology and developing the acceptable parameters, the necessity was established to achieve a firm adherence of the electrode to the wall of the welded organ. When welding is performed with a smaller diameter electrode there is a point, abrupt welding of the wall through. The vermiform appendix, or fragment of the formed gut canal, is deformed in the shape of beads in an irregularly shaped necklace. During the gut opening, the mucosa is mosaically damaged, the sites of coagulation alternate with the intact ones. This indicates unacceptability of using smaller diameter electrodes (than the canal lumen) to destroy its inner layer. Therefore, an electrode of 4-8 mm in diameter was used for the vermiform appendix, and a canal corresponding to the 8 mm diameter electrode was formed from the gut.

While stretching the electrode, the operator feels the moment of its ejection from the canal. But, if the electrode is retained for a longer time, coagulation occurs around and in front of the electrode ball. This resists its stretching and prevents it from moving evenly. Therefore, it the speed was selected at which the operator feels light resistance when stretching the electrode, that is, pulls it out with little effort at smooth advancing. In our case, the optimum mean electrode advance velocity was 1.45 mm/s. Macroscopically, when stretching the electrode, there is a blanching of the appendix or gut wall, contraction and reduction of their diameter.

When removing the clamp from the wall of the canal formed from the gut, the welding of the mucous membrane edges was determined in the closure area, which was torn with little effort. The canal's lumen was preserved and equalled 2-3 mm. The internal surface of the welded canal was dark gray, dry, wrinkled, and the mucous membrane was not identified. Thus, it can be concluded that endoscopic welding of the canal lined by the mucous membrane does not cause its complete welding and elimination of the lumen, but significantly reduces its diameter (from 8 to 2 mm) due to the coagulation and constriction of tissues.

When using the maximum power (100%) of the apparatus, a more pronounced deformation of the wall occurs both behind and before the electrode's movement, the evaporation of fluid is taking place from the surface of the intestine and the vermiform appendix. The resistance to the electrode was significantly increased. It was almost impossible to achieve smooth passage through the canal. This can indicate high temperature on the outer surface of the organ's wall and its severe damage. Therefore, we have limited the power of the device to 50%.

In microscopic study of the vermiform appendix walls, when using an electrode smaller than the diameter lumen, mosaic alternative changes are observed, which mainly concern the walls of blood vessels, individual bundles of collagen fibers in the submucous layer and in the mucous membrane itself, where focal destructive changes are detected with the glandular structures being preserved (fig. 1).

Morphological changes in the use of the electrode corresponding to the diameter of the canal at 50% of the apparatus power and the determined mean speed of stretching are characterized by different changes in the layers of the studied organs' wall. The mucous and submucous membranes are destructed, exfoliated and are not detected in histological slides (fig. 2).

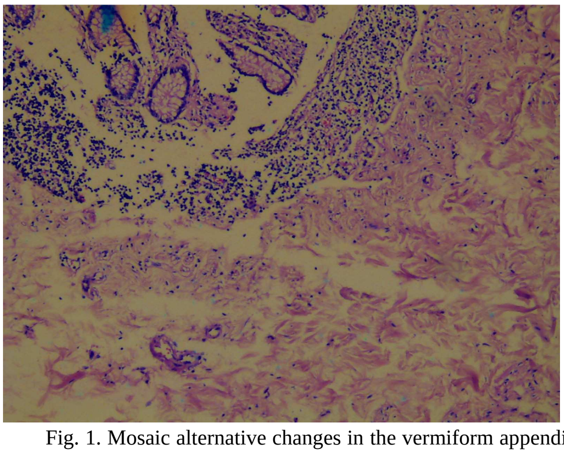

Fig. 1. Mosaic alternative changes in the vermiform appendix sites when using a small diameter electrode. Hematoxylin and eosin, X100.

Fig. 2. Destruction and elimination of the vermiform appendix mucous membrane (a) in the site of electric welding endoscopic exposure. Hematoxylin and eosin, X40.

The most preserved is the vermiform appendix myenteron, where only individual myocytes undergo coagulation changes. Smooth muscle cells retain their peculiar structure, but there is interstitial edema due to the formation of small vacuole-like structures; the nuclei of cells are compacted and acquire a single-vector orientation.

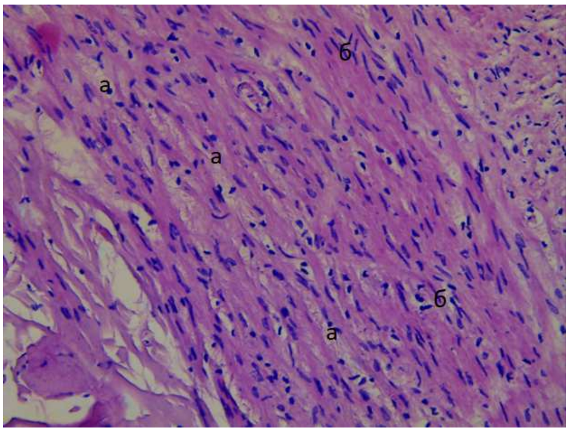

Fig. 3. Dystrophic changes in the muscular cells of the vermiform appendix with the formation of small vacuole-like structures in the cytoplasm (a), compaction of nuclei, and changes in their spatial reorientation (b). Hematoxylin and eosin, X200.

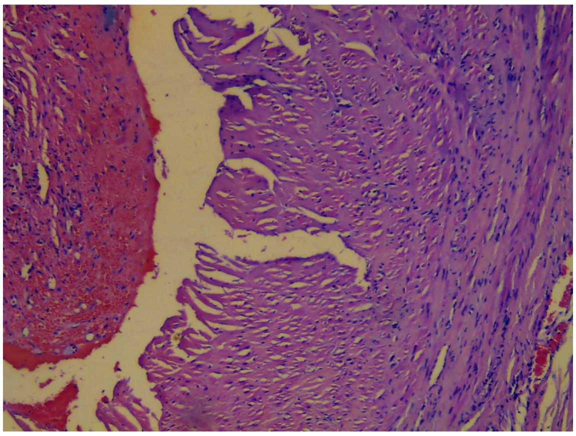

Fig. 4. Coagulation necrosis of the vermiform appendix tissue, which extends through the entire thickness of the wall and covers the structural elements of the mesentery. Hematoxylin and eosin, X100.

Small blood vessels, arterioles, venules of the muscular layer undergo coagulation with the preservation of the contours, destructively altered hemocytes can be detected in the lumens. Thus, using the developed optimal parameters of the high-frequency current influence histologically confirms the mucous membrane destruction of the canal created from the intestine and the vermiform appendix and the morphological preservation of the muscular layer with vascular damage phenomena.

When using 100% of the apparatus power, tissues of the vermiform appendix and small intestine undergo coagulation necrosis, which extends through the entire thickness of the wall and covers structural elements of the mesenterium (fig. 4). The walls of the vermiform appendix mesenterium blood vessels, including the appendicular artery, also undergo coagulation changes, overlap and become empty.

In our opinion, this indicates that the power of the electric current and the time of action affect the depth of the damage caused to the small intestine and the vermiform appendix tissues up to the formation of coagulation necrosis through the entire thickness of the wall. [1]

We have obtained results that correlate with the data of the authors who report the presence of coagulation necrosis in the electrode action zone. The spread and prevalence of the coagulation zone depends on the current capacity and the time of tissues exposure. The mechanism of a spherical electrode action differs from that used by the authors of bipolar clamp electrodes, where the coagulation zone is located between the clamp branches and does not extend more than 2 mm laterally. [2]

On a spherical tool, the distance between the electrodes is constant, and the tissues adhere to the electrodes rather than being compressed between them. Therefore, the severity of coagulation depends on the degree of the electrode adhesion to the tissues. This correlates with studies on the use of a spherical electrode for obliteration of lower extremities varicose veins, where the electrode adhesion is provided by filling of the space around the vein with fluid. [4] Our data suggest that using the apparatus at its maximum power causes deep necrosis of the tissues in the intestine and the vermiform appendix, and 50% power is sufficient to destroy the mucous membrane, as in the case of vein obliteration, where this power ensures the integrity of the surrounding tissues.

Conclusion

High-frequency electric current with using a spherical bipolar electrode causes the destruction of the mucous membrane of the simulated fistulous passages in endoscopic application. Optimal parameters of the impact are: 50% of the device power when welding in the “manual” mode with an electrode advance rate of 1.45 mm/s, which is confirmed by macro and microscopic data. At endoscopic welding with the use of a spherical electrode a residual cavity is formed, which needs to be filled to facilitate its elimination. Based on the data obtained, further studies can be carried out to use endoscopic welding for treatment of the hollow organs’ fistulas in the digestive tract.

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Реферати

ЕКСПЕРИМЕРТАЛЬНО-МОРФОЛОГІЧНЕ ОБГРУНТУВАННЯ ОБЛІТЕРАЦІЇ ТРУБЧАСТИХ БІОЛОГІЧНИХ СТРУКТУР ШЛЯХОМ ВИСОКОЧАСТОТНОГО ЕЛЕКТРОЗВАРЮВАННЯ ТКАНИН

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В експерименті на трупному матеріалі проведено дослідження впливу високочастотного струму ендоскопічним способом на змодельований канал нориці травного каналу. Визначені оптимальні параметри генератора ЕКВЗ-300 Патонмед необхідні для руйнування слизової оболонки. Морфологічними макро- та мікроскопічними методиками підтверджено ефективність впливу струму для руйнування слизової оболонки нориці.

Ключові слова: електрозварювання біологічних тканин, морфологічні зміни, кишкова нориця.

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ЕКСПЕРИМЕРТАЛЬНО-МОРФОЛОГИЧЕСКОЕ ОБОСНОВАНИЕ ОБЛИТЕРАЦИИ ТРУБЧАТЫХ БИОЛОГИЧЕСКИХ СТРУКТУР ПУТЕМ ВЫСОКОЧАСТОТНОЙ ЭЛЕКТРОСВАРКИ ТКАНЕЙ

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В эксперименте на трупном материале проведено исследование влияния высокочастотного тока эндоскопическим воздействием на смоделированный канал свища пищеварительного тракта. Определены оптимальные параметры генератора ЕКВЗ-300 Патонмед необходимые для разрушения слизистой оболочки. Морфологическими макро- и микроскопическими методиками подтверждена эффективность воздействия тока для разрушения слизистой оболочки свища.

Ключевые слова: электросварка биологических тканей, морфологические изменения, кишечные свищи.

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INVESTIGATION OF CALCIUM- AND HYALURONIC ACID-CONTAINING DRUGS OSTEOPLASTIC ACTIVITY IN RATS WITH PERIODONTITIS

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The aim of the research was to investigate the effect of subgingival injection of the solutions of calcium and hyaluronic acid on the condition of the bone tissue of the alveolar process of the lower jaws of rats with experimental periodontitis. The conducted experimental trials confirmed the intensification of the resorption processes in the jaw bone tissue of rats, which were fed peroxidized oil for a long time. Thus, the alimentary intake of lipid peroxides led to an increase in atrophy of the alveolar process of the lower jaw of rats and the loss of calcium in the bones of the jaws. Hydroxyapatite injections had a slight effect on the studied parameters, since the atrophy of the alveolar bone could not be slowed down, and the biochemical indicators, despite some improvements, did not reach normal values. Calcium in combination with unstabilized hyaluronic acid turned out to be much more effective. The authors insisted that further experimental trials are required in order to determine the frequency of subgingival calcium injections of calcium hydroxyapatite with non-stabilized hyaluronic acid.

Key words: experimental periodontitis, bone tissue, blood, hyaluronic acid, calcium hydroxyapatite, subgingival calcium injections.

This work is a fragments of the research project "To study disorders of mineralization and collagen formation in oral cavity in dental pathology and to improve the methods of these disorders early diagnosis and correction", state registration No. 0116U004077.

The bone tissue is a special type of connective tissue and the main component of human bones [9, 10]. The body is constantly undergoing renewal processes and the bone tissue is not an exception. Diseases, injuries or age-related changes can disrupt these processes and lead to the changes in the bone tissue, which can adversely affect the quality of life. For example, resorption of the bone tissue of the facial skeleton with age progression leads to changes in the individual bone structures and to a shift in the attachment of muscles and ligaments and, as a result, to the age-related changes in the face [14].

The possibility of strengthening the structure of the bone tissue would solve many questions in various fields of medicine (traumatology, dentistry, aesthetic medicine, and others). Is there any opportunity to strengthen the bone structure from the outside? Let us try to figure it out.