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ASSESSMENT OF THE EFFICIENCY TO USE NANO-CONTAINING BIODEGRADABLE POLYMER MATERIAL DURING SURGERY ON THE ABDOMINAL ORGANS (EXPERIMENTAL STUDY)

Abstract. *Complications associated with operations on the organs of the abdominal cavity, and purulent-inflammatory lesions and adhesions in particular, are a compolicated problem of modern surgery. In order to prevent such complications associated with soft tissue injury during surgery on the abdominal organs, an innovative biodegradable polymeric material has been developed. The objective of the study was to examine the properties of our biodegradable polymer material in abdominal surgery. Materials and methods. The research was carried out in accordance with the approved requirements and rules for the maintenance and humane treatment of animals in the mature rats line "Vistar" kept in Ivano-Frankivsk National Medical University Vivarium. Traumatic damage of the stomach wall was simulated and sutured with application of a polymeric membrane. Additionally, the membrane was saturated with antimicrobial solution containing decamethoxin and nanosized detoxifying agent with hydrated fullerene C_{60}. Results. Biodegradable polymeric membranes of rapid degradation saturated with active substances have been not found to cause pathological processes or changes in the tissues, are well degraded, possess anti-inflammatory effects, are highly effective means for early prevention of adhesive processes, infectious and purulent complications, and fullerene C_{60} is a highly effective detoxicant. membranes with a long period of degradation are less effective and, in several cases, cause local abscesses, inflammatory changes and adhesions, which makes it impossible to continue to use and study them. Conclusions 1. Biodegradation barriers in abdominal surgery are promising preventive means and require further experimental and clinical research. 2. Our biodegradable polymeric materials are safe to use, possess antimicrobial and anti-inflammatory properties and are highly effective means to prevent complications after surgery on the abdominal cavity organs.*
Key words: *polymer membranes, prevention of complications, conjunctions, abdominal surgery.*

Introduction. In recent years the rate of acute diseases of the abdominal organs remains high– on the level of 51,2–58,6% per 10 000 of population [1].

According to certain literary data purulent-inflammatory complications constitute 35–45% concerning all the cases of surgery [2, 3, 4].

Surgery performed on the abdominal organs is the main cause promoting the formation of commissures [5]. The problem of acute commissural intestinal obstruction has been a complicated, topical and unsolved one for many decades [6]. The development of commissures was likely to be investigated widely, although today there is no a conclusive strategy preventing their formation, since there are certain discussions concerning the efficacy of the preventive measures available. Moreover, the major part of available clinical literature deals with gynecological patients; there are nor recommendations or algorithms for those patients who experience general and/or abdominal surgery [7, 8].

Today to prevent commissure formation natural and synthetics, with adsorbing and non-adsorbing properties materials are used. Membranes, gels and other barrier materials are widely applied in experiments and clinic [9, 10, 11, 12].

In order to decrease the rate of occurring commissural processes in patients after surgery on the abdominal organs the studies have been

performed and special preventive barriers developed separating wound surfaces during the term necessary to make commissure formation impossible [13, 14].

A modern method to prevent formation of commissural process is application of covering materials isolating an injured surface of the scar from the surrounding tissues.

Objective: to assess the efficacy of use of nano-containing biodegradable polymer materials in abdominal surgery.

Materials and methods. Biodegradable polymer materials developed by us were used in the experimental study. They were in the form of membranes containing polyvinyl alcohol and gelatin soldered by means of lactic acid under the influence of microwave radiation. Two series of these polymers were made for the study: with degradation up to 5 hours (short degradation period) 0.3 mm thick and with degradation up to 48 hours 1.5 mm thick (long degradation period). The materials were in the basic version without reactants and those saturated with antiseptic decamethoxin and hydrated fullerene C_{60}.

The study was performed on 108 guinea pigs (Cavia porcellus) with the body weight of 350-400 g kept in clinical-biological base "Vivarium" of SHEE "Ivano- Frankivsk National Medical University", according to the sanitary-hygienic norms and regulations of the European convention for the protection of vertebrate animals used for experimental and other scientific purposes (Counsil of Europe. — Strasburg, 1986).

The experimental animals were distributed into groups 12 animals in each: group №1 – membranes were not applied; group №2 – membranes of a short degradation without reactants; group №3 membranes of a short degradation saturated with decamethoxin; group №4 – membranes of a short degradation with hydrated fullerene C_{60}; group №5 – membrane of a short degradation saturated with decamethoxin and hydrated fullerene C_{60}; group №6 – membrane of a long degradation; group №7 – membranes of a long degradation saturated with decamethoxin; group №8 – membrane of a long degradation saturated with hydrated fullerene C_{60}; group №9 – membrane of a long degradation saturated with decamethoxin and hydrated fullerene C_{60}. In general the membrane were applied on 96 animals including those 48 with a short period of degradation and 48 with a long period of degradation. The animals were not fed on two days before surgery. Surgery was performed under general anesthetization: 0,15 ml of sodium oxybutyrate per 100 g of the body weight injected intramuscularly. Under sterile conditions of the operating room after thee operative field was treated, superior-median laparotomy was performed and access to the stomach was obtained. Its wall 15 mm thick seen in the wound and adjacent to the anterior abdominal wall was cut. The surrounding tissues stomach walls were washed with decamethoxin solution. Simulated wound of the stomach was sutured, and the stitches were covered with a strip of the prepared polymer membrane and the laparotomy wound was sutured layer by layer. The condition and behavior of animals were assessed during post-operative period. The animals were decapitated under narcosis 6 hours later. Re-laparotomy was performed on the 1st, 3rd and 7th day, the state of abdominal organs and pathological reaction available (abscesses, commissures) were assessed; the material was taken for pathomorphological examination.

Results. On the first day the animals were given warm water, and on the second day they were given warm broth. During the first day the animals were restricted in their movements, and maximal motor activity was found on the second day. Every day at the same time the dressings were changed, and the stitches were treated with betadine. Disturbed behavior, movements and feeding were found in animals with peritonitis and local abscesses. The appetite of those animals was very poor, their behavior was inert, and their hair was grey without shining.

The membranes of a short degradation period were applied on 48 animals, where re-laparotomy was performed 6 hours later. The remains of the membrane in the form of jelly-like content was visually seen in all the animals, and on the first day they were completely dissolved irrespective of the introduced reactants.

The membranes with a short degradation period without any reactants were applied on 12 animals. Inflammatory changes were found in 2 cases, on the 6th hour and the 1st day of the basic membranes, and in 2 cases of membranes

saturated with decamethoxin. Inflammatory reaction was not found even on the first day in animals where the membrane saturated with fullerene was applied.

In the groups of animals where the degradation period was 2 days, the membranes were partially dissolved or not dissolved 6 hours and 1 day later. On the 3rd day the remains of the membrane and jelly-like accumulation of the undissolved particles of the basic membranes were found in 3 cases, in 3 cases with membranes saturated with decamethoxin, 2 cases with membranes saturated with fullerene, and 2 cases of membranes saturated with fullerene and decamethoxin. On the 7th day jelly-like accumulation were found in sub-hepatic space in 2 cases with basic membranes and the membranes saturated with decamethoxin, and one case with the membrane saturated with fullerene. Single abscesses were found on the 7th day in the groups of animals with basic membrane and the membrane saturated with decamethoxin in one case each, two cases with the membrane saturated with fullerene.

Autopsy revealed that in animals where polymer membranes with a short degradation were applied the signs of commissure formation were found in 1 case, and the rest of animals did not develop such signs. Pronounced adhesive processes were found in animals without treatment: on the 1st day – in two cases, on the 3rd day – in two cases, on the 7th day – in three cases. In animals with single abscesses and inflammatory changes of tissues on the 3rd day dense commissures were formed on the 7th day.

Post-operative skin scars healed without peculiarities and suppuration.

Peritonitis was found in 2 cases in animals without treatment on the 1st and 3rd day. Those animals were inactive, their hair was not shining, the abdomen was bloated and hard during palpation. Autopsy found suture failure and pouring out of the stomach content, the intestine was bloated too. The peritoneum and the surrounding tissues were grey and sluggish. Those animals die of peritonitis.

The membranes saturated with dehydrated fullerene C_{60} and decamethoxin produced a positive effect on the healing of the stomach scar of animals.

Discussion. Application of polymer materials to prevent complications and formation of commissures is a topical issue in abdominal surgery. It is widely used both in experimental and clinical studies, as well as presented in the world scientific literature. The result of efficient application of polyvinyl alcohol and lactic acid suggested in our research with the aim to prevent commissural process was evidenced by foreign authors [15, 16]. The obtained results to apply biodegradable materials in abdominal surgery are confirmed by the investigations conducted by the scientists from foreign countries. Long dissolution of polymers in abdominal surgery is not always effective and it can provoke pathological process in the injured area. Application of polymers with a short period of degradation appears to be more promising in the sphere of investigation and effective in use [17].

Conclusions: 1) The suggested biodegradable polymer membranes are highly effective method of early prevention of complications and infection in case of surgery on the abdominal organs.

2) Polymer membranes with a long degradation could provoke local abscesses which can cause development of peritonitis and associated complications.

3) Application of biodegradable polymer materials with a short period of degradation in combination with active substances gives considerable perspectives of their use in surgery.

4) Biodegradable polymer materials of a comprehensive action require further experimental studies and clinical introduction into surgical practical work.

Prospects of further studies. Development and experimental study of polymer covering materials with the opportunity of dosed degradation and introduction of the reactant into the area of injury is rather promising for further use in surgery, which in its turn, will enable to increase the efficacy of treatment, provide reliable prevention of infectious and adhesive complications after surgery on the abdominal organs.

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