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Two-Component Mesh Repair of Medium-Sized Ventral Hernias

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ABSTRACT

In order to reduce the frequency of adhesions which are accompanying hernial repair procedure, various types of combined prostheses are offered. At the same time many researchers are still searching for a more profitable combination of synthetic materials. Experimental studies were performed on 8 rabbits. Animal weight was varying from 2.2 to 3 kg. General endotracheal anesthesia was performed. We developed a two-component prosthesis model consisting of two layers, firs layer (lower) was a polytetrafluoroethylene (PTFE) and was placed in the abdominal cavity and the second (upper) was a prolene layer and located above the muscular aponeurosis of the anterior abdominal wall. The absence of adhesions of the visceral peritoneum after establishing PTFE prosthesis was determined by a macroscopic method. On the 10th day, the formation of a thin capsule covering the lower prosthesis was visually observed. Morphological studies have shown that the use of a two-component prosthesis does not affect the course of the wound regeneration process and the wound healing time, the upper polypropylene film is integrated with the surrounding tissues and neovascularization is observed already by the 14th day.

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Keywords

Ventral hernia, Synthetic PTFE prosthesis, Two-component mesh for ventral hernia repair, Intraperitoneal prosthesis, Intra-abdominal prosthesis adhesions.

INTRODUCTION

The choice of the surgical treatment volume, and an abdominal wall repair type is still a discussable issue in giant hernias. Postoperative ventral hernia (POVH) repair is also a topic of ongoing discussion [1]. Not all types of surgeries using synthetic mesh are able to provide the basic principle of modern hernial surgery – and specially its main principle - absence of tissue tensioning. The use of synthetic prostheses has led to a rather high percentage of wound complications (seroma, fistula of the anterior abdominal wall, suppuration) and the appearance of new complications that had not occurred before in autoplasty: migration of the prosthesis into the abdominal cavity or lumen of hollow organ, the development of intestinal fistula on the basis of arosie intestinal wall of the implant, the formation of cysts in the area of the implant, rejection of the implant, etc. [2, 3].

Intra-abdominal location of the mesh can create serious problems. Depending on the method of plastics and mesh type, and the adhesions formation is observed in 80% of patients [4, 5]. Adhesions of the internal organs with the mesh can cause serious complications such as chronic abdominal pain, intestinal obstruction, strangulation, intestinal fistula [6, 7].

In order to reduce the incidence of adhesions, various combined prostheses were offered, as well as the searching for a combination of synthetic materials with biological, such as the amniotic membrane, xenopericardium. In addition, there are situations where the necessary an anti-adhesive coating synthetic material due to economic constraint and the health system, and the patients themselves are absent.

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Aim of the study was to conduct an experimental observation of the anterior abdominal wall tissue reaction as well as the abdominal cavity organs reaction to implantation of two-component prosthesis in animals.

MATERIAL AND METHODS

This study was conducted at the department of «General Surgery» at the Republican Specialized Surgery Centre named after academician V.V. Vakhidov. In all experiments part with animals we adhered to Interdisciplinary Principles and Guidelines for the use of animals.

Characteristics of the applied prosthesis:

Polypropylene mesh (parieten, prolene, promesh). Polypropylene was introduced into production in 1954. It was synthesized from ethylene with the addition of methyl groups to the molecules. The first experimental work on the use of polypropylene was published by Usher et al. in 1958 [8]. Polypropylene mesh consists of monofilament threads, so they cause a much smaller inflammatory reaction. The risk of infectious complications when using polypropylene is also significantly lower. This is due to the fact that micro-organisms are not colonized on monofilament threads, as in a number of cases it is observed when using knitted and woven synthetic materials.

Polytetrafluoroethylene (e-PTFE) was synthesized in 1938 and was widely used in engineering and medicine, widely called - Teflon. Mesh which made with polytetrafluoroethylene, have both positive and negative properties. On the one hand, they are strong, elastic, practically do not decompose in tissues, do not cause allergic reactions, soft enough to touch, do not cause adhesions and adhesions to internal organs, so they can be used intraperitoneally; Easy to sterilize, because they are since the withstand autoclaving. On the other hand, they have quite large pores (10 μm), which are easy to get micro-organisms (Staphylococcus diameter – 1 micron) and can't get macrophages (diameter of 18-35 microns) and the blood (diameter 15-20 μm). Therefore, phagocytosis within these mesh much more difficult. This leads to the possibility of suppuration and rejection of mesh.

Experimental studies were performed on 8 rabbits weighing 2.2 to 3 kg. Endotracheal anesthesia was used. We have developed a two-component prosthesis model consisting of two types of implants, the lower PTFE (polytetrafluoroethylene) located in the abdominal cavity and the upper (prolen) located above the aponeurosis. Both prostheses are connected along the length by a prolene suture conditionally simulating the "white line" (Figure 1).

After a median laparotomy, the animals were implanted combined prosthesis (Figure 2). The lower leaf of the design was fixed by nodal U-shaped sutures to the rectus abdominal wall muscles. The lateral margins of the prosthesis are set at a depth of up to 2 cm along the entire perimeter of the defect. Thus, the bottom sheet (PTFE) delimits the internal organs of the abdominal cavity from the top sheet. The last (polypropylene) has been used to strengthen the anterior abdominal wall, and located above the aponeurosis with fixation by nodal or continuous sutures without suturing the defect (Figures 3 and 5).

Ethical approval

The review board and ethics committee of Surgery Institution approved the study protocol and experimental study

RESULTS

Dynamic monitoring of the wound process was carried out. Postoperative wounds in experimental animals healed by primary tension. On the 10th, 20th and 30th day, by overdosing anesthetics, the animals were removed from the experiment. The absence of adhesions of the visceral peritoneum with the PTFE prosthesis was determined by a macroscopic method. The loops of the intestine lie freely. On the 10th day, the formation of a thin capsule covering the lower denture was visually observed (Figure 5). The top sheet (polypropylene) of the structure is integrated with a connective tissue. As evidenced by the germination of the cells of the prosthesis (Figure 6) Samples of the tissues of the anterior abdominal wall with the endoprosthesis were subjected to morphological examination.

The study by light microscopy of samples from the area of abdominal wall plasty with an integrated use of PTFE mesh and discovered that the contact structures of PTFE and the grid components they do not prostrate to the changes, indicating their interaction, leading to structural changes (Figure 7) Contact of PTFE with the tissues of the aponeurosis and muscles does not appeal any pathological reactions (Figure 8) Light-optical studies show that in the muscle tissue large cavities are formed, usually round-oval. Sometimes they merge with each other, forming large

fields in which a homogeneous eosinophilic content is determined, which is the remains of the mesh structures exposed to the organic substances used during wiring and coloring of the tissue and sections. In the rounded cavities, the remnants of the filaments from which the link is formed are often determined. At the border of the muscle with the aponeurosis and in the thickness of the aponeurosis itself, the cavities formed by the mesh fragments often have an irregular shape and often merge with each other. In their lumen, a homogeneous weakly eosinophilic substance and individual fragments of the mesh fibers are also determined (Figures 9 and 10).

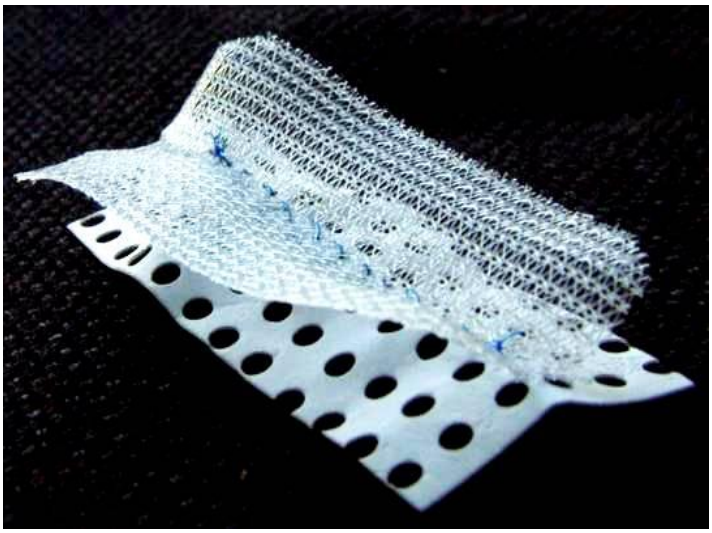

Figure 1. Model (design) two-component prosthesis.

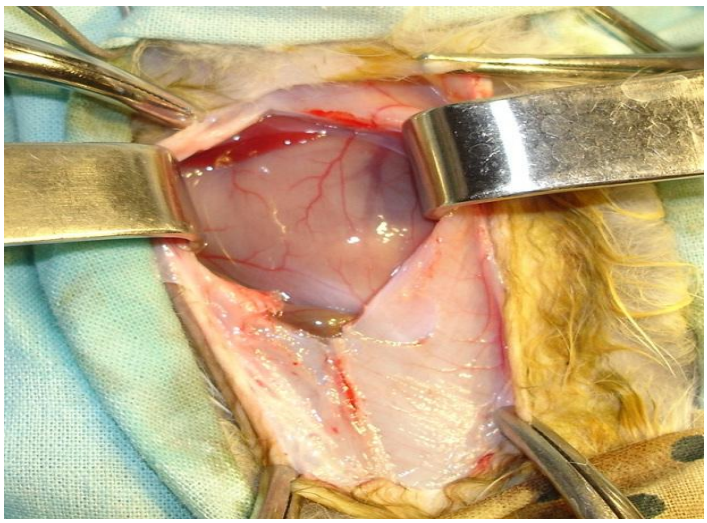

Figure 2. The median laparotomy

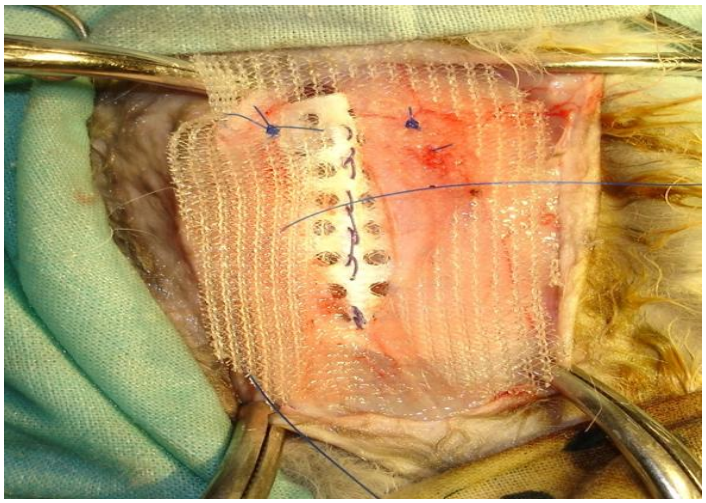

Figure 3. A method for implanting a two-component construction

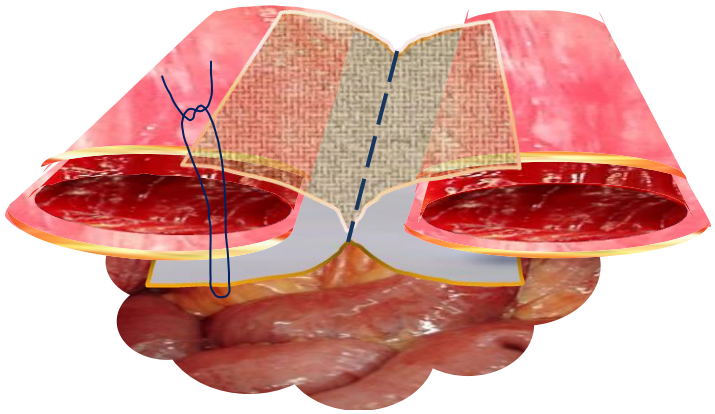

Figure 4. Scheme of fixation of a two-layer prosthesis to the anterior abdominal wall

Figure 5. Encapsulated PTFE at 10th day after surgery

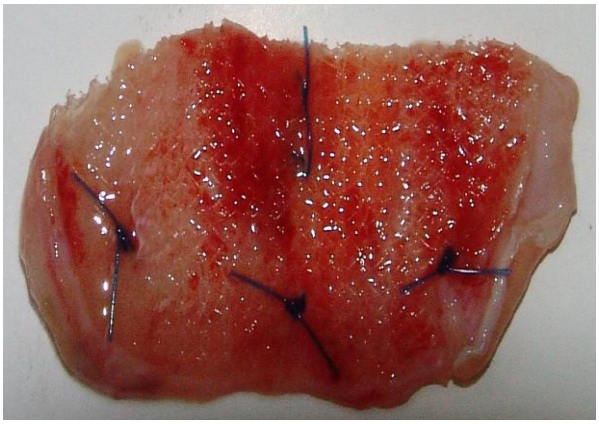

Figure 6. Propylene prosthesis cells, sprouted surrounding tissues

Figure 7. Contact fragments of a prolene mesh and a film. H-E 10x10

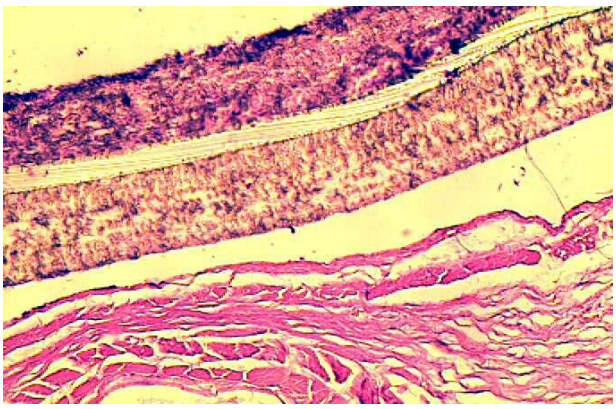

Figure 8. Contact the film with the muscles. H-E10x10.

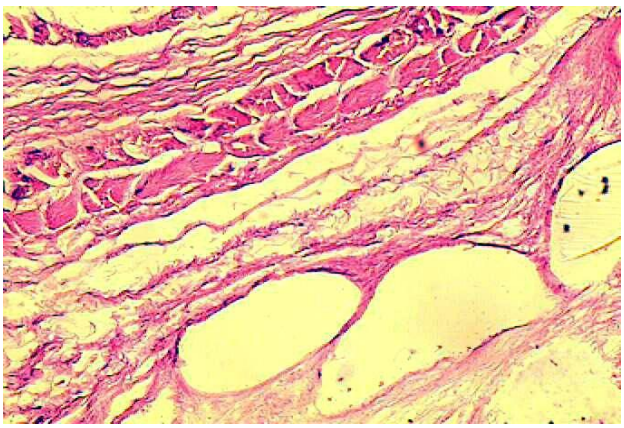

Figure 9. Isolated and fused with each other with remnants of mesh. H-E10x10.

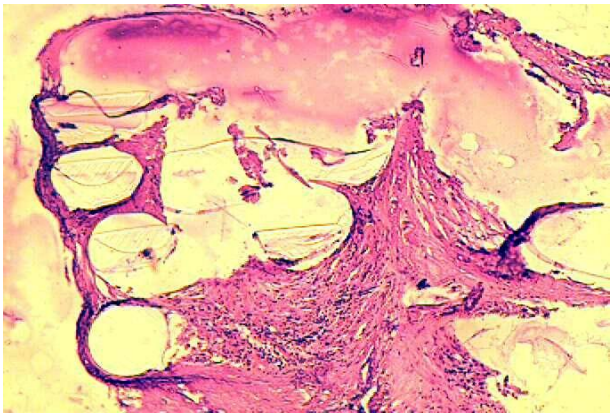

Figure 10. Cavities with traces of the mesh a rounded cavity at the border of the muscle and aponeurosis. H-E10x10.

DISCUSSION

The most commonly used in practice prosthesis is made from polypropylene because of their relative cheapness, availability, almost unchanged with time strength. The resolution of the conference of herniologists, held in Moscow in 2006, was to consider the technique of sublay as a method of choice. It is believed that the plastic sublay method, in the presence of a large omentum, isolating the prosthesis from the internal organs, is most reliable [9, 10].

In a situation where it is impossible to separate the prosthesis, the contact of the polypropylene mesh with the abdominal organs can cause the formation of intraperitoneal adhesion [11]. The polytetrafluoroethylene (PTFE) prosthesis used for sublay plastic has a number of disadvantages: it has low resistance to infection and when the wound infection develops, the prosthesis needs to be removed, the pore size of 10 μm does not ensure through penetration by the connective tissue that covers the prosthesis from the outside and does not provide reliable fixation. Insignificant pore size, high hydrophobicity, negative electric charge prevents cellular ablution, promotes the persistence of bacteria, as they are protected in cells from destruction by macrophages.

Therefore in the experimental work held by Zaikov et al. [12] used combined polypropylene mesh prostheses with biological coatings (amniotic membrane and modified xenopericardium). At the same time, the absence of intra-abdominal adhesion was observed in comparison with the use of a combination of polypropylene mesh with synthetic coatings (polyoxyalkanoate and experimental absorbable polymeric membrane), which was accompanied by the formation of adhesions between the prosthesis and the abdominal organs [13].

The opposite results in the experiment were observed by Sidelnikov and Mikheev [13] using a combined endoprosthesis (amniotic membrane with a polypropylene mesh). A macrophage granuloma was formed around the polypropylene after 3 months and the inflammatory reaction was chronic. The combined endoprosthesis was encapsulated after a month and its fusion with the abdominal cavity organs (the omentum) took place. Where the author concludes that a combined endoprosthesis from an amniotic membrane and a polypropylene mesh for purposes of hernioplasty is unsuitable, since it contributes to a prolonged inflammatory reaction, repair of own tissues is untenable [14].

Biosynthetic mesh [15, 16] have certain advantages compared with synthetic mesh. They are resistant to infection, contribute to remodeling, because they synthesize their own collagen. Animal studies have shown a marked decrease in the adhesion level matrixes, their strength and area, the risk of bacterial infection, and the matrix for angiogenesis and the synthesis of their own collagen [17]. However, recommendations for methods of hernioplasty using these materials have not been developed to date.

A wide distribution for ventral hernias with a hernia gate size> 10 cm has received composite prostheses. Using a combined VentrioTM Hernia Patch (consisting of a resorbable ring (polydioxanone, polytetrafluoroethylene (ePTFE) and polypropylene), 119 patients achieved good results. Complications were observed in the form of: serome in 4.2%, intestinal impossibility in 1.7%, in two patients it was necessary to remove the prosthesis due to its infection [17].

Another type of Composix Kugel Mesh prosthesis is also made up of ePTFE and polypropylene, with a memory ring for convenience and self-alignment of the prosthesis in the abdominal cavity. Greenberg [18] reports the use of this prosthesis in 138 patients with good results. But the literature describes the cases of complications after the implantation of Composix Kugel, such as infection of the prosthesis, the appearance of intestinal fistulas due to the arising defects of the supporting ring and its implementation into the intestinal loops [19].

According to the Food and Drug Administration (FDA) of the United States, from 1996 to 2004 there were 13 intestinal complications [20]. As of January 2007, the number of Composix Kugel Mesh withdrawn products exceeded 100,000 units. Of these, the FDA received 34 reports of a ring break, 21 of which caused serious damage to patients and one resulted in death. Another type of combined mesh is Parietex ® and Proceed® [21]. These nets consist of a nonabsorbable material (polyester, polypropylene), and the lower layer (visceral) in Parietex ® is covered with collagen, and. Proceed® is covered by cellulose oxide. Experimental studies conducted by Winny et al. [22], on the basis of macroscopic and histological results, proved that the use of Parietex ® nets or. Proceed ® does not significantly reduce the development of intestinal adhesions with the prosthesis. In comparison with these data, the use of UltraPro ® in combination with 4DF gel shows a significantly higher ability to prevent adhesion ($p < 0.0001$) [20].

Another pilot study was aimed at comparing the tendency for adhesions of four surgical mesh which available on the market, polypropylene (Marlex®), polyglactin 910 (Vicryl®), polypropylene with poliglecaprone (UltraPro®) and polyester with a collagen layer (Parietex®) Analysis of the results showed that none of the four mesh had antiadherent properties, although polyglactin 910 Mesh (Vicryl®) showed a lower incidence of adhesions [22].

CONCLUSION

Based on the above, it can be concluded that there are no safe prosthetic mesh for intraperitoneal implantation, and the available mesh for hernioplasty lead to more or less intra-abdominal complications.

Thus, the conducted experimental and morphological studies have shown that the use of a two-layer prosthesis does not affect the course of the wound process and the healing time of the wound. Macroscopic studies showed a lack of adhesion of the visceral peritoneum with PTFE mesh in animals. 30 day film is covered with a thin connective tissue film. As seen from microscopy, the upper polypropylene film is integrated with the surrounding tissues and neovascularization is observed by the 14th day. Double prosthetics simulates the white line of the abdomen and does not cause any structural changes and pathological reactions with the tissues of the aponeurosis, muscles and visceral peritoneum.

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Authors' Contributions
All authors contributed equally to this work.

Competing interests
The author declares that they have no competing interests.

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