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## TRANSABDOMINAL PREPERITONEAL ALLOPLASTY OF INGUINAL HERNIAS USING A NANOMODIFIED MESH IMPLANT

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Surgical treatment of 142 patients with inguinal hernias who underwent transabdominal preperitoneal allohernioplasty was analyzed. The author's mesh was used in group I patients, and in group II patients, a classical polypropylene mesh was used. Statistically, significantly better results were obtained in patients of group I compared with group II: seroma was found in 1.4 % and 7.0 % of patients, respectively. Chronic pain was observed in 5.6 % of patients in group II compared to group I, with no such complications, hernia recurrence – in 8.5 % and 1.4 % of patients, respectively. The duration of inpatient treatment in group I was 2.3±1.2 days, in group II – 5.2±1.1 days. Surgical treatment of inguinal hernias using nanomodified polypropylene mesh was more effective than using classical polypropylene mesh, as evidenced by a decrease in the seroma frequency from 7.0±1.3 to 1.4±0.3 %, chronic postoperative pain – from 5.6±0.2 to 0 %, hernia recurrence – from 8.5±0.3 to 1.4±0.2 %.

**Key words:** inguinal hernia, nanomodified polypropylene mesh, postoperative wound complications.

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## ТРАНСАБДОМІНАЛЬНА ПРЕПЕРИТОНЕАЛЬНА АЛОПЛАСТИКА ПАХВИННИХ ГРИЖ ЖИВОТА З ВИКОРИСТАННЯМ НАНОМОДИФІКОВАНОГО СІТЧАСТОГО ІМПЛАНТАТУ

Проведено аналіз хірургічного лікування 142 пацієнтів з пахвинними грижами живота в яких виконували операцію трансабдомінальну преперитонеальну алогерніопластику. У хворих групи I використовували розроблену сітку, у хворих групи II класичну поліпропіленову сітку. Статистично значущо кращі результати отримано у хворих групи I порівняно з групою II: серому виявлено відповідно у 1,4 % та 7,0 % хворих. Хронічний біль спостерігався у 5,6 % хворих групи II на відміну від групи I де таких ускладнень не було, рецидиви грижі – відповідно у 8,5 % і 1,4 % хворих. Тривалість стаціонарного лікування в групі I становила 2,3±1,2 доби, в групі II – 5,2±1,1 доби. Хірургічне лікування пахвинних гриж живота з використанням наномодифікованої поліпропіленової сітки є ефективнішим порівняно з використанням класичної поліпропіленової сітки, про що свідчило зменшення частоти сероми з 7,0±1,3 до 1,4±0,3 %, хронічного післяопераційного болю – з 5,6±0,2 до 0 %, рецидиву грижі – з 8,5±0,3 до 1,4±0,2 %.

**Ключові слова:** пахвинна грижа живота, наномодифікована поліпропіленова сітка, післяопераційні ранові ускладнення.

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In recent years, transabdominal pre-peritoneal (TAPP) alloplasty has become more widely used in surgical practice for inguinal hernias (IH). This is due to low trauma, speed of surgery, a short length of stay in the hospital and faster postoperative rehabilitation compared to open surgery [1, 3, 8, 9]. However, it should be noted that the recurrence rate of inguinal hernias after transabdominal preperitoneal alloplasty is 5.3–10.0 % [2]. The causes of recurrent inguinal hernias after transabdominal preperitoneal alloplasty surgery are insufficient overlap of the medial and lateral inguinal fossae with a mesh implant due to the small size of the implant and the lack of fixation at the level of the iliac vessels.

Particular frame meshes, which do not require fixation and self-fixing meshes, are not widely used in transabdominal surgery because the frequency of inguinal hernia recurrence after such operations is high. This is mainly due to the migration of the mesh implant and also due to its shrinkage when using traditional polypropylene mesh implants [6, 7]. The use of composite mesh implants based on polypropylene combined with monocrylic, titanium coating, coating of Omega-3 fatty acids, etc., help to reduce the inflammatory response of abdominal wall tissues compared to the traditional polypropylene mesh. But the frequency of seroma occurrence and duration remains relatively high (30.4 %), which increases the risk of infection of abdominal wall tissues. In our opinion, using the developed nanomodified polypropylene mesh with the antiseptic polyhexamethylene guanidine chloride will improve the surgical treatment of inguinal hernias.

**The purpose** of the study was to improve the results of surgical treatment of inguinal hernias using a nanomodified mesh implant.

**Materials and methods.** The analysis of surgical treatment for the period from 2015 to 2019 was performed by 142 patients with IH in whom TAPP surgery was performed on the basis of the Department of Surgery and Proctology of the Shupyk National Medical Academy of Postgraduate Education. All patients underwent special preoperative training on an average of  $10.0 \pm 3.4$  days on an outpatient basis, which included: 1) adaptation of the cardiovascular and respiratory systems, 2) increased reserves from the cardiopulmonary activity, 3) corrective therapy of comorbidities, 4) prevention of thromboembolic complications, 5) prevention of infectious complications from the postoperative wound, 6) maximum bowel cleansing. Patients were divided into two groups depending on the type of mesh implant used in TAPP surgery.

In 71 (50 %) patients of group I, TAPP surgery was performed using a nanomodified mesh implant [4, 5, 10]. The classic TAPP surgery technique was performed. It involved the isolation of the hernia sac and the mobilization of the preperitoneal space at the level of the ligament of Cooper and the iliac vessels, as well as placement of a nanomodified mesh implant with an antiseptic size of  $10 \times 10$  cm at the level of these anatomical structures. Mesh fixation was performed with a herniostepler to muscles, aponeurosis and Cooper's ligaments along the upper medial edge. The operation was completed by closing the parietal peritoneal defect and draining the wound with PVC drainage. Drainage was removed on the second day after surgery.

In group II, 71 (50 %) patients underwent TAPP surgery using a polypropylene mesh implant.

In the early postoperative period, therapeutic measures included correction of disorders of the cardiovascular and respiratory systems, stimulation of intestinal functions. Ketorol (Dr. Reddy's Laboratories, India) was administered i.m. for analgesia at the dose of 1.0 g twice daily. To prevent stress ulcers of the gastrointestinal tract, Kvamatel (Gedeon Richter, Hungary) was prescribed i.m. at the dose of 75 mg twice a day. Antibacterial therapy using cefosulbine 1 g twice a day was continued in all patients since they had an increased risk of infectious complications from the wound.

The licensed data analysis software STATA 12 was used for statistical analysis. When calculating the parameters of descriptive statistics, the distribution of qualitative parameters (characteristics) (in %) was determined. For quantitative parameters, the arithmetic mean – (M) was calculated. Data variability was determined using the standard (mean square) deviation (SD). To assess the representativeness of the results, the mean error of the indices (m) and the 95 % confidence interval (95 % CI) were determined. Comparison of qualitative parameters in groups with an estimation of the difference statistical probability was performed by comparing proportions (Z-criterion), Chi-square criterion ( $\chi^2$ ) and Fisher's exact criterion. Taking into account the assessment of the normality of these quantitative parameters distribution, group comparisons were performed according to the T-test or the Wilcoxon test, Mann-Whitney U-test.

**Results of the study and their discussion.** We prefer using the developed nanomodified polypropylene mesh with the antiseptic polyhexamethylene guanidine chloride in the surgical treatment of patients with abdominal hernias, namely when performing transabdominal preperitoneal alloplasty of inguinal hernias. When carrying out surgical treatment of patients with abdominal hernias, namely when performing an advanced technique of transabdominal preperitoneal alloplasty of inguinal hernias using the developed nanomodified polypropylene mesh with the antiseptic polyhexamethylene guanidine chloride, a much smaller number of postoperative purulent-inflammatory complications are noted both in the early and long-term postoperative periods. The results of surgical treatment of postoperative abdominal hernias in patients of groups I and II were evaluated by studying and comparing postoperative complications in both the early and long-term postoperative periods (table 1).

**Results of surgical treatment of patients with inguinal hernias in the early and long-term postoperative periods**

Complications	Group I	Group II
Results of surgical treatment	n=71	n=71
Seroma	1.4 % (1/71)	7.0 % (5/71)*
Chronic pain	0	5.6 % (4/71)
Recurrent hernia	1.4 % (1/71)	8.5 % (6/71)*

\* The difference relatively to group I is statistically significant ( $p < 0.05$ ).

Results of surgical treatment. Statistically, significantly better results were obtained in patients of group I, in whom surgical treatment used improved methods of surgical treatment of transabdominal preperitoneal alloplasty of inguinal hernias and developed nanomodified polypropylene mesh with antiseptic polyhexamethylene guanidine chloride. In contrast to patients of group II, in whom the surgical treatment used classical techniques of transabdominal preperitoneal alloplasty of inguinal hernias of the abdomen, and also used a classic polypropylene mesh. Seroma was detected much less frequently in group I than in group II ( $p < 0.05$ ). Seroma was detected in 1.4 % (i.e., in 1 patient out of 71 study patients) of group I patients, in contrast to 7.0 % (i.e., in 5 out of 71 studied patients) of group II patients. Chronic pain in the abdominal wall area within 6–8 months after surgery was observed in 5.6 % (i.e., in 4 out of 71 patients studied) of group II patients, which was eliminated by prescribing physiotherapy and nonsteroidal anti-inflammatory drugs in contrast to the group I where such complications were not detected at all. Hernia recurrences were found in 8.5 % (i.e., six out of 71 studied patients) of group II patients in contrast to 1.4% (i.e., one patient out of 71 studied patients) of group I patients. The duration of inpatient treatment in group I was  $2.3 \pm 1.2$  days, in group II –  $5.2 \pm 1.1$  days. From the above materials, it is known that in the surgical treatment of abdominal hernias with the use of an improved method of transabdominal preperitoneal alloplasty and developed nanomodified polypropylene mesh with antiseptic polyhexamethylene guanidine chloride; it is possible to reduce by two times the length of stay of patients in the hospital and to improve the course of the postoperative period of these patients in contrast to the group of patients in whom surgical treatment of abdominal hernias used classical methods and classic polypropylene mesh.

In connection with performing an improved technique of transabdominal alloplasty of inguinal hernias using the developed nanomodified polypropylene mesh implant with antiseptic polyhexamethylene guanidine chloride [4, 5, 10], which provided for the isolation of the hernial sac and mobilization of the preperitoneal space at the level of the Cooper ligament and iliac vessels, as well as the placement of the developed nanomodified polypropylene mesh implant with antiseptic size 10×10 cm at the level of these anatomical structures. Mesh fixation was performed with Securestrap herniostepler to the muscles, aponeurosis, and Cooper's ligament along the upper medial edge. The surgery was completed by closing the parietal peritoneal defect and draining the wound with PVC drainage of the space above the mesh. After that, the trocar was removed, and the trocar wounds were sutured. An aseptic dressing was applied to the wounds. Drainage was removed on the first day after surgery. The course of the early and long-term postoperative period in almost all patients was without complications. For anaesthesia, Ketorol was administered at a dose of 1.0 g twice a day. In order to prevent stress ulcers of the gastrointestinal tract, Kvamatel was prescribed according to the scheme. Antibacterial therapy with cefosulbine 1 g twice daily was continued because patients had an increased risk of infectious complications from the wound. Prevention of thromboembolic complications was carried out with Clexane at a dose of 40 mg for 7–9 days. Sutures were removed on day 3, and patients were discharged from the hospital. This technique was performed in 71 patients. In contrast to patients who performed the classic transabdominal alloplasty of inguinal hernias using the traditional polypropylene mesh, significantly reducing postoperative purulent-inflammatory complications in both early and remote postoperative periods, confirmed by statistical data, the licensed data analysis program STATA 12 was applied. According to the literature, seroma in such operations is observed in 7.0 % of patients. When performing an improved method of surgical treatment using the developed nanomodified polypropylene mesh with antiseptic polyhexamethylene guanidine chloride, seroma was observed in 1.4 % of patients (i.e., in 1 patient out of 71 patients studied), which used the developed nanomodified polypropylene mesh with antiseptic polyhexamethylene guanidine chloride, which is confirmed by statistics ( $p=0.409$ ). Comparison of qualitative parameters in groups with an estimation of the statistical probability of difference was performed by comparing proportions (Z-criterion), Chi-square criterion ( $\chi^2$ ) and Fisher's exact criterion. Analysis of the relative risk of complications in patients was determined by calculating the odds ratio (OR) with a 95 % confidence interval – OR (95 % CI). Recurrence of hernia in such surgical interventions was observed in 8.5 % of patients. When using advanced methods of surgical treatment using the developed nanomodified

polypropylene mesh with antiseptic polyhexamethylene guanidine chloride, it was observed in 1.4 % (i.e., in 1 patient out of 71 ones), who used an improved technique and developed nanomodified polypropylene mesh with antiseptic polyhexamethylene guanidine chloride, which was confirmed by statistics ( $p=0.175$ ). The analysis of the relative risk of complications in the main and comparison groups was determined by calculating the odds ratio (OR) with a 95 % confidence interval – OR (95 % CI). Chronic postoperative pain was not observed in patients in whom the operation was performed using an improved technique using nanomodified polypropylene mesh with the antiseptic polyhexamethylene guanidine chloride. In those patients in whom surgery was performed using the classical method and the classic polypropylene mesh, complications were observed in 5.6 % of patients. Thus, significantly better results of surgical treatment were in patients who used an improved technique and developed nanomodified polypropylene mesh with antiseptic polyhexamethylene guanidine chloride, compared with those who used classical treatment in surgical treatment in combination with classic polypropylene mesh. Because we used an improved technique in combination with the developed nanomodified mesh implant with the antiseptic polyhexamethylene guanidine chloride in our patients, it was possible to achieve a reduction in the frequency of seroma in the early postoperative period by five times, compared with those patients where the classical technique was used for surgical treatment in combination with the classical polypropylene mesh. There was also a significant reduction in chronic pain in the postoperative period by four times, compared to those patients where the classical technique was used for surgical treatment combined with the classical polypropylene mesh. We observed a sharp reduction in the recurrence of hernias in the postoperative period by six times, compared with those patients where surgical treatment used the classical method combined with the classical polypropylene mesh. This significant reduction in the occurrence of complications in the postoperative period is due to the improved method of surgical treatment and the properties of polypropylene mesh, which is nanomodified with carbon nanotubes and antiseptic polyhexamethylene guanidine chloride. It has a high sorption, hygroscopic and antiseptic effect, which reduces the intensity of aseptic inflammation of tissues around the mesh, serous fluid exudation and risk of infection. It reduces the risk of infection migration and shrinkage of the mesh. In contrast, classic polypropylene mesh does not have such properties.

### Conclusion

Surgical treatment of inguinal hernias using nanomodified polypropylene mesh was more effective than using classical polypropylene mesh, as evidenced by a decrease in the seroma frequency from  $7.0 \pm 1.3$  to  $1.4 \pm 0.3$  %, chronic postoperative pain – from  $5.6 \pm 0.2$  to 0 %, hernia recurrence – from  $8.5 \pm 0.3$  to  $1.4 \pm 0.2$  %. It also reduces patients' length of stay in the hospital from  $5.2 \pm 1.3$  to  $2.3 \pm 1.2$  days.

*Prospects for further research. Developed nanomodified polypropylene mesh implants will be introduced into the clinical practice of surgical departments, which will significantly reduce postoperative purulent-inflammatory complications in the early and late postoperative periods and improve the quality of life of patients in the surgical treatment of abdominal hernias.*

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