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Advantages of using nanomodified polypropylene mesh in the surgical treatment of postoperative large abdominal hernia

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Abstract

Surgical treatment of large postoperative abdominal hernias (PAH) with the use of classic techniques of allogeneoplasty (sublay, onlay) is often accompanied by an increase in intra-abdominal pressure (IAP) and a decrease in the volume of the abdominal cavity, which in the postoperative period leads to abdominal compartment syndrome (ACS). 2.4 - 3.6% of cases and mortality in 1.2 - 3.4% of observations [1, 2]. This requires a special method of closing a large defect of the abdominal wall, which would not increase IAP. The use of the method of dividing the anatomical components of the anterior abdominal wall according to the modified technique of Ramirez operation in combination with sublay alloplasty contributes to the creation of the optimal volume of the abdominal cavity and improves the results of treatment, in particular, the frequency of ACS decreases [3, 4, 5]. However, the use of a combined operation with a classic polypropylene mesh leads to a high frequency of complications from the postoperative wound, such as seroma (30.8 - 60.4%), suppuration of the postoperative wound (4.8 - 6.4%), ligature fistula (1.2 - 3.0%), meshoma (0.06 - 1.60%)

[6, 7]. One of the causes of postoperative wound complications is the development of aseptic inflammation of the tissues of the abdominal wall as a result of their contact with the classic polypropylene mesh. Long-term aseptic inflammation of the subcutaneous base, muscles, aponeurosis, and fascia inhibits the process of germination of the polypropylene mesh by the connective tissue, which leads to its shrinkage, and in the case of infection, to the migration of the mesh and recurrence of the hernia. In our opinion, the use of a modified polypropylene mesh with an antiseptic of polyhexamethyleneguanidine chloride and carbon nanotubes in combination with a modified technique of the Ramirez operation will make it possible to improve the results of operative treatment of PAH.

Aim – to improve the results of surgical treatment of large postoperative abdominal hernias (PAH) by using a modified technique of the Ramirez operation in combination with «sublay» alloplasty using a modified polypropylene mesh.

Materials and methods. An analysis of the surgical treatment of 164 patients with large-sized PAH was performed. Depending on the type of mesh implant used during operative treatment, the patients were divided into two groups. In 82 (50%) patients of group I, surgery was performed according to the modified Ramirez technique in combination with «sublay» alloplasty using a modified polypropylene mesh, in group II, 82 (50%) patients underwent surgery according to the modified Ramirez technique in combination with «sublay» alloplasty using classic polypropylene mesh.

Results and discussion. Statistically significantly better results were obtained in patients of group I compared to group II. The duration of inpatient treatment in group I was (7.0±1.0) days, in group II – (12.0±2.2) days.

Conclusion. Operative treatment of large PAH using the modified technique of the Ramirez operation, combined with the «sublay» technique using the modified polypropylene mesh, is much more effective compared to the use of the classic polypropylene mesh, which was evidenced by a decrease in the frequency of postoperative complications.

Key words: abdominal hernia; nanomodified polypropylene mesh; postoperative wound complications.

Introduction. Surgical treatment of large postoperative abdominal hernias (PAH) with the use of classic techniques of allogeneoplasty (sublay, onlay) is often accompanied by an increase in intra-abdominal pressure (IAP) and a decrease in the volume of the abdominal cavity, which in the postoperative period leads to abdominal compartment syndrome (ACS).

2.4 - 3.6% of cases and mortality in 1.2 - 3.4% of observations [1, 2]. This requires a special method of closing a large defect of the abdominal wall, which would not increase IAP. The use of the method of dividing the anatomical components of the anterior abdominal wall according to the modified technique of Ramirez operation in combination with «sublay» alloplasty contributes to the creation of the optimal volume of the abdominal cavity and improves the results of treatment, in particular, the frequency of ACS decreases [3, 4, 5]. However, the use of a combined operation with a classic polypropylene mesh leads to a high frequency of complications from the postoperative wound, such as seroma (30.8 - 60.4%), suppuration of the postoperative wound (4.8 - 6.4%), ligature fistula (1.2 - 3.0%), meshoma (0.06 - 1.60%) [6, 7]. One of the causes of postoperative wound complications is the development of aseptic inflammation of the tissues of the abdominal wall as a result of their contact with the classic polypropylene mesh. Long-term aseptic inflammation of the subcutaneous base, muscles, aponeurosis, and fascia inhibits the process of germination of the polypropylene mesh by the connective tissue, which leads to its shrinkage, and in the case of infection, to the migration of the mesh and recurrence of the hernia. In our opinion, the use of a modified polypropylene mesh with an antiseptic of polyhexamethyleneguanidine chloride and carbon nanotubes in combination with a modified technique of the Ramirez operation will make it possible to improve the results of operative treatment of PAH.

Purpose of the work to improve the results of surgical treatment of large postoperative abdominal hernias by using a modified technique of the Ramirez operation in combination with «sublay» alloplasty using a modified polypropylene mesh.

Materials and methods

An analysis of the operative treatment for the period from 2011 to 2018 of 164 patients with large-sized PAH aged from 30 to 70 years using the modified technique of Ramirez operation in combination with the «sublay» technique was carried out. There were 102 (62.2%) women, 62 (37.8%) men. Concomitant diseases with a predominance of chronic cardiovascular pathology were found in 51 (31.1%) patients, II-III degree obesity - in 86 (52.4%), chronic bronchitis - in 6 (3.7%), diabetes - in 13 (7.9%), chronic venous insufficiency of the lower extremities - in 8 (4.9%). According to the EHS classification for incisional abdominal wall hernias of the European Association of Herniological Surgeons (Ghent, Belgium, 2008) [10], the distribution of hernias was as follows: M1 - 4W3R0 - in 115 (70.1%) patients, M1 - 4W3R1 - 4 - in 49 (29.9%). Contracture of rectus abdominis muscles was observed in 75 (45.7%) people. All patients underwent special pre-operative preparation

on an outpatient basis for an average of (10.0 ± 3.4) days, which included: 1) adaptation of the cardiovascular and respiratory systems and an increase in ACS, 2) an increase in the reserves of cardiopulmonary activity, 3) corrective therapy of accompanying diseases, 4) prevention of thromboembolic complications, 5) prevention of infectious complications from the postoperative wound, 6) maximum cleansing of the intestines. To clean the intestines and reduce its volume, patients were recommended a slag-free diet excluding bread, flour and potato dishes, and prescribed laxatives ("Regulax", "Dufalak") and cleansing enemas. In this way, it is possible to achieve maximum cleaning and reduction of the volume of intestines and hernial protrusion, as well as reduction of the patient's body weight. Abdominal circumference decreases by an average of 14-16 cm, and in some patients inoperable hernias become operable. On the eve of the surgical intervention, 12 hours before the operation, Fortrans was prescribed according to the scheme. Adaptation of the respiratory and cardiovascular systems to increased ACS was carried out with the help of a dosed bandage compression of the abdomen and a special complex of respiratory gymnastics. The abdomen was dosed with a bandage based on the patient's well-being. Bandage compression was performed only in patients with correctable postoperative hernias, as it can lead to entrapment in non-correctable hernias.

The effectiveness of preoperative preparation was controlled by monitoring the function of the cardiovascular system and the function of external respiration. Antibacterial prophylaxis was carried out using III generation cephalosporins (cefosulbin) for 2 hours before surgery. In order to prevent thromboembolic complications, "Clexan" was used in a dose of 40 mg subcutaneously for 12 hours before the operation and once a day after the operation for 7-9 days, as well as compression underwear for the lower limbs during the operation and for 1 month in the postoperative period.

Depending on the type of mesh implant used when performing the modified Ramirez operation technique in combination with «sublay» alloplasty, the patients were divided into two groups that were comparable in terms of age, sex ratio, and size of the PAH.

In 82 (50%) patients of group I, surgery was performed according to the modified Ramirez technique in combination with «sublay» alloplasty using a modified polypropylene mesh [8, 9]. After excision of the old postoperative scar and extensive mobilization of aponeurotic tissues from the subcutaneous base to the aponeurosis of the external oblique muscles with maximum preservation of vessels and nerves. After cutting the hernial sac, the adhesions between the intestine and the large cap were separated, and the abdominal cavity

was thoroughly inspected. The outer border of the aponeurotic sheath of the rectus abdominis muscle was palpated and visually determined. Stepping back 1 cm from the edge of the aponeurotic sheath of the rectus abdominis muscle (laterally), the aponeurosis of the external oblique muscle of the abdomen was cut and the external oblique muscle was bluntly separated from the internal oblique and transverse. Due to this, the rectus muscle is shifted medially to the midline by 10 cm. Then, on the opposite side, the outer border of the aponeurotic sheath of the rectus abdominis muscle was palpated and visually determined. Stepping back 1 cm from the edge of the aponeurotic sheath of the rectus abdominis muscle (laterally), the aponeurosis of the external oblique muscle of the abdomen was cut and the external oblique muscle was bluntly separated from the internal oblique and transverse. Due to this, the rectus muscle is shifted medially to the midline by 10 cm. After that, the aponeurotic sheaths of the rectus abdominis muscles were cut along the medial edges of the abdominal wall defect and the «sublay» technique was performed. The back walls of the aponeurotic sheaths of the rectus abdominis muscles were separated from the muscles and sewn up with a continuous suture. A modified polypropylene mesh implant of the appropriate size (average - $(30 \times 30) \pm 2.2$ cm) was placed and fixed under the rectus muscles above the sutured back walls of the aponeurotic sheaths of the rectus abdominis muscles. One or two silicone drains for vacuum drainage were connected to the modified polypropylene mesh implant, and the edges of the anterior aponeurotic walls of the rectus abdominis muscles were sutured together with the muscles with a continuous suture or separate sutures. The aponeurotic areas between the rectus and external oblique muscles on the right and left were reinforced with modified polypropylene mesh implants of appropriate sizes (average - $(10 \times 10) \pm 2.4$ cm). The mesh implants were fixed along the perimeter to the aponeurotic tissues with a continuous suture. After that, the subcutaneous wound was drained with vacuum polyvinyl chloride drains and the subcutaneous base and skin were sutured.

In group II, 82 (50%) underwent surgery using the modified Ramirez technique combined with «sublay» alloplasty using a classic polypropylene mesh.

In the early postoperative period, treatment measures included the correction of disorders of the cardiovascular and respiratory systems, stimulation of intestinal functions. All patients were prescribed "Dikloberl" in a dose of 3 ml intramuscularly for 7 days after the operation to reduce the inflammatory reaction of the abdominal wall to mesh implantation. In order to prevent stress ulcers of the gastrointestinal tract, "Kvamatel" was prescribed according to the scheme. Antibacterial therapy with the use of cefosulbin 1g twice a day was

continued in all patients, since all of them had an increased risk of infectious complications from the wound. Prevention of thromboembolic complications was carried out with "Clexan" in a dose of 40 mg for 7-9 days.

Statistical calculations were carried out using the integrated system STATISTICA® 5.5 (STAT+SOFT® Snc, USA), with the use of a licensed program (AXX 910A374605FA).

Results and discussion

The results of surgical treatment of large-sized PAH in patients of groups I and II were evaluated by studying and comparing immediate and long-term postoperative complications (table).

Table - Immediate and remote results surgical treatment of patients with postoperative abdominal hernias of large size

Complication	Group I	Group II
Immediate results	n=82	n=82
AKS	1	3
Seroma	6	25*
Postoperative wound suppuration	1	8*
Inflammatory infiltrate	1	10*
Remote results	n=75	n=75
Ligature fistulae of the anterior abdominal wall	0	5*
Meshoma	0	3
Chronic pain	1	6
Recurrence of hernias	1	7*

AKS – abdominal compartment syndrome

*The difference with respect to group I is statistically significant ($p < 0,05$).

Immediate results of treatment. An increase in IAP to (11.5 ± 2.2) mmHg was observed in 1 (1.2%) patient in group I, and in 3 (3.6%) patients in group II, which was accompanied by the occurrence of ACS I degree, which was eliminated by conservative measures.

Statistically significantly better results were obtained in patients of group I: seroma, suppuration of the postoperative wound and inflammatory infiltrate were detected much less frequently than in group II ($p < 0.05$). The duration of inpatient treatment in group I was (7.0 ± 1.0) days, in group II – (12.0 ± 2.2) days.

The long-term results were studied by the method of repeated examinations and questionnaires in 75 patients of group I and in 75 patients of group II within 1 to 5 years. Chronic pain in the area of the abdominal wall during 6-8 months after the operation was observed in 6 (8.0%) patients of group II and in 1 (1.3%) of group I ($p > 0.05$), which was

eliminated by the method of prescribing physiotherapeutic procedures and nonsteroidal anti-inflammatory drugs.

Thus, significantly better immediate and long-term results were obtained in patients of group I. Regarding the general complication, in particular, ACS, which arose as a result of intra-abdominal hypertension of the first degree and was comparable in patients of the two groups and was eliminated after the restoration of intestinal peristalsis.

Due to the fact that in patients of group I, a modified polypropylene mesh implant was used, it was possible to achieve a reduction in the frequency of seroma by 4.6 times, suppuration of the postoperative wound by 6.1 times, inflammatory infiltrate by 9.1 times, and the occurrence of ligature fistulas of the anterior abdominal wall by 6 times, meshes in 3 times. Such a significant reduction in the frequency of complications from the postoperative wound is due to the properties of the polypropylene mesh, which is modified with carbon nanotubes and the antiseptic polyhexamethyleneguanidine chloride, namely, it has a high sorption, hygroscopic and antiseptic effect, thanks to which it is possible to reduce the intensity of aseptic inflammation of the tissues of the abdominal wall, the exudation of serous fluid and the risk infection, while the classic polypropylene mesh does not have such properties.

The long-term results of the surgical treatment of large PAH also confirm the advantages of the modified Ramirez operation technique in combination with the «sublay» technique using a modified polypropylene mesh compared to the use of a classic polypropylene mesh, which is associated with a decrease in the frequency of wound infection complications, migration and shrinkage of the mesh and prevents recurrence of PAH.

Conclusions

Operative treatment of large postoperative abdominal hernias using the modified technique of the Ramirez operation in combination with the «sublay» technique with the use of a modified polypropylene mesh is more effective compared to the use of a classic polypropylene mesh, as evidenced by a decrease in the frequency of seroma from (30.5 ± 1.2) to $(7.3 \pm 0.5)\%$, suppuration of the postoperative wound - from (9.8 ± 0.5) to $(1.2 \pm 0.2)\%$, inflammatory infiltrate - from $(12.2 \pm 0, 6)$ to $(1.2 \pm 0.2)\%$, ligature fistulae of the anterior abdominal wall - from (6.7 ± 0.5) to 0% , meshomas - from (4.0 ± 0.3) to 0% , chronic postoperative pain - from (8.0 ± 0.6) to $(1.3 \pm 0.2)\%$, hernia recurrence - from (9.3 ± 0.6) to $(1.3 \pm 0.2)\%$.

Perspectives of the further researches

On the basis of further research, new approaches to the surgical treatment of abdominal hernias will be developed using new types of nanocomposite mesh implants with antimicrobial properties of domestic production, which will reduce the number of postoperative complications and recurrences of hernias and improve the quality of life of patients in the postoperative period and will give a significant economic effect.

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