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Management of ventral hernias: treatment results based on the developed algorithm

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The surgical treatment of anterior abdominal wall hernias is one of the most common procedures in elective surgery. However, the rate of laparoscopic hernioplasty is lower when compared to open methods. Experience in treating large ventral hernias (≥ 10 cm) using minimally invasive techniques is limited due to the inability to compare the edges of the hernial defect without component separation.

Objective — to develop an algorithm for choosing a surgical treatment method for patients with ventral hernias and to evaluate the results of treatment.

Materials and methods. A prospective multicenter study was conducted, which included 534 patients with ventral hernias of various sizes. All patients were treated from September 2011 to November 2024. Preoperatively, patients with hernias ≥ 10 cm were injected with 100 Units of botulinum toxin type A (BTA) into the muscles of the anterior abdominal wall. The mean age of the patients was 56.49 ± 14.59 years, with 307 (57.5 %) women and 227 (42.5 %) men. All patients underwent hernia surgery using laparoscopic and open hernioplasty methods according to the developed algorithm.

Results. The algorithm classified patients into three groups based on their hernia size: group 1 — patients with hernias < 4 cm wide (n = 269; 50.4 %), group 2 — with a size of 4—10 cm (n = 173; 32.4 %), and group 3 — with a size of ≥ 10 cm (n = 92; 17.2 %). The mesh was placed intraperitoneally during laparoscopic hernia repair. In all three groups, laparoscopic hernioplasty demonstrated a significantly lower rate of complications and length of hospital stay compared to open procedures ($p < 0.01$). Seromas were among the most common complications in all three groups in our study (n = 19; 7.1 % vs n = 26; 15.0 % vs n = 14; 50 %), and their frequency increased with hernia defect size. In group 3, among patients with large hernias, BTA administration allowed for the reduction of the aponeurosis defect to ≤ 10 cm in size in 89.4 % of cases and the performance of laparoscopic surgery in patients who agreed to it. The recurrence rate after laparoscopic surgery was 0.8 %, while after open surgery, it was 1.1 %.

Conclusions. The use of the algorithm for selecting the hernioplasty method allows implementing a personalized approach to the surgical treatment of patients with ventral hernias. Laparoscopic hernioplasty with intraperitoneal mesh placement demonstrates significantly better results compared to open methods of hernia repair in terms of length of hospital stay and complication rate ($p < 0.01$). The use of BTA for hernias ≥ 10 cm in the preoperative period makes it possible to perform hernioplasty using laparoscopic techniques and minimize surgical trauma in case the patient refuses laparoscopy.

Keywords
postoperative hernia, ventral hernia, hernia repair, botulinum toxin type A.

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Anterior abdominal wall hernias are among the most common pathologies in surgery and are often caused by weakness of individual areas of the abdominal wall or increased intra-abdominal pressure. According to the classification of the European Hernia Society (EHS), primary ventral (umbilical, linea alba, and other locations) and incisional hernias (IH) are distinguished [16]. Primary ventral hernias occur almost twice as often as incisional ones [14]. The occurrence of the latter largely depends on the method of wound closure and associated factors, including healing of the surgical wound. Common risk factors

for hernia development include obesity, decreased physical activity and increased life expectancy, and previous surgical interventions [8, 21]. The presence of a hernial defect more than 10 cm wide makes it problematic to suture the hernia without tension and use additional methods, including separation of abdominal wall components [2].

Laparoscopic hernioplasty has proven its effectiveness in the treatment of anterior abdominal wall hernias and demonstrates a significant reduction in the time spent in the clinic and the duration of the patient's rehabilitation after surgery [18]. However, there are contradictory data from different authors regarding the frequency of recurrences after laparoscopic hernioplasty. Some studies show that hernia repair with intraperitoneal onlay mesh (IPOM) yields better [19], comparable [1], and even worse [23] results than the open hernia repair technique. At the same time, the use of a mesh in any of the selected hernioplasty methods is recommended when suturing hernial defects with a diameter of more than 1 cm [2]. The main factors influencing recurrence are advanced age, overweight and obesity, diabetes, smoking, and reduced immunity [17]. Surgical complications, such as seromas or infections, significantly increase the risk of hernia recurrence. In the case of umbilical hernias, recurrences are more common in large defects, reaching 30—40 %. The recurrence rate of IH can reach 37 % after 4 years. In fact, factors such as the type of mesh selected, its placement, adequate mesh overlap, defect closure, the use of separation techniques in hernia repair, and the alignment of aponeurosis edges influence the rate of hernia recurrence after surgery [2, 8, 12, 25]. A personalized approach to choosing a surgical treatment method for hernia repair can be crucial for minimizing the risk of hernia recurrence and postoperative complications.

Objective — to develop an algorithm for choosing a surgical treatment method for patients with ventral hernias and to evaluate the results of treatment.

Materials and methods

General characteristics of patients

A prospective multicenter study was conducted from September 2011 to November 2024 at the clinical sites of the Department of General Surgery No. 2 of Bogomolets National Medical University, namely at the Kyiv City Clinical Hospital No. 3 and the Leleka Medical Center. The study included 534 patients with ventral hernias (primary and incisional) who underwent preoperative preparation and had various types of scheduled surgical interventions for hernia repair. The average age of the patients was 56.49 ± 14.59 years, and among those examined, there were 307 (57.5 %) women and 227 (42.5 %) men. Detailed characteristics of the patients are given in Table 1.

Inclusion criteria for the study

The inclusion criteria included:

- age from 18 to 90 years;
- uncomplicated ventral hernias;
- compensated concomitant pathology;
- scheduled hernia surgery;
- consent to hernioplasty with mesh prosthesis;
- patient consent to hernioplasty with or without suturing of the hernia defect.

The possibility of performing laparoscopic prosthetic hernioplasty with IPOM was also agreed upon with the patients. In case of refusal of the proposed laparoscopic surgery, the patient underwent open hernioplasty.

Patients with hernial defects of 10 cm or greater in width were asked to provide additional consent or refusal to inject botulinum toxin type A (BTA) into the muscles of the anterior abdominal wall in the preoperative period. In this study, we administered BTA «off-label» using our patented methodology (Ukrainian patent for utility model No. 142997 dated 10.07.2020 «Method for treating large ventral hernias by injecting botulinum toxin type A into the muscles of the anterior abdominal wall»). BTA was injected 4—5 weeks before the operation

Table 1. **Demographic and pre-operative data (n = 534)**

Characteristic	Value
Women	307 (57.5 %)
Men	227 (42.5 %)
Age, years	56.49 ± 14.59
Body mass index, kg/m^2	30.27 ± 4.33
ASA score	
I	136 (25.4 %)
II	379 (71.0 %)
III	19 (3.6 %)
IV	0
Obesity	209 (39.1 %)
Smoker	108 (20.2 %)
Type of hernia	
Primary ventral	293 (54.9 %)
Incisional	241 (45.1 %)

Note. ASA — American Association of Anesthesiologists. Data are presented as M ± SD or abs. (%).

into the transverse, external, and internal oblique muscles of the abdominal wall under double control of the drug injection at 6 points, 3 on the right and 3 on the left, with a total volume of 100 Units (Botox, Allergan, USA).

Exclusion criteria from the study

Exclusion criteria included:

- patients under 18 or over 90 years old;
- complicated ventral hernias (including strangulated);
- decompensated concomitant pathology;
- urgent operation;
- refusal of mesh hernioplasty;
- subxiphoid or suprapubic localization of the hernial defect.

Algorithm for choosing the surgical treatment method for hernias

In all patients, during the perioperative period, the physical examination was supplemented with an ultrasound examination (US) of the abdominal cavity and anterior abdominal wall to determine/clarify the localization and size of the hernial defect, as well as the number of aponeurosis defects.

The EHS classification [16] divides primary ventral hernias (PVH) and IH into small, medium, and large hernias using several approaches. PVH is classified as having a hernial defect larger than 4 cm, and IH as having an average aponeurosis defect width of 4—10 cm. IH with a width of ≥ 10 cm is considered large. PVH of ≥ 10 cm is significantly less common than IH of similar size. However, a significant width of divergence in the edges of the aponeurosis poses a significant challenge in eliminating the hernia, irrespective of the cause of its occurrence [8]. Since the width of the hernial defect has a direct proportional effect on the tension in the area of suturing the edges of the aponeurosis, we chose to use the width of the hernia as the primary criterion for grouping patients based on treatment method.

According to the proposed algorithm, we divided patients into 3 groups based on the width of the hernial defect. Group 1 included patients with hernias (PVH and IH) < 4 cm in size (n = 269; 50.4 %), group 2 — with a size of 4—10 cm (n = 173; 32.4 %), group 3 — with a size of ≥ 10 cm (n = 92; 17.2 %).

In establishing the algorithm, we considered the patient's age, consent to laparoscopic intervention with intra-abdominal mesh placement, and consent to the introduction of BTA 4—5 weeks before surgery for hernia width ≥ 10 cm. Taking into account the literature data and our studies on the reliability of mesh fixation to the anterior abdominal wall, we proposed performing hernioplasty without suturing the hernia defect when choosing a laparoscopic option for surgery in patients over 65 years of age and in the presence of concomitant somatic pathology. This reduces surgery duration and intraoperative trauma [11]. Patients under the age of 65 were regarded as working, and when choosing a laparoscopic option for hernioplasty, we proposed suturing the hernia defect to preserve the functional activity of the anterior abdominal wall muscles. The proposed algorithm for choosing a surgical treatment method for hernias is presented in Figure.

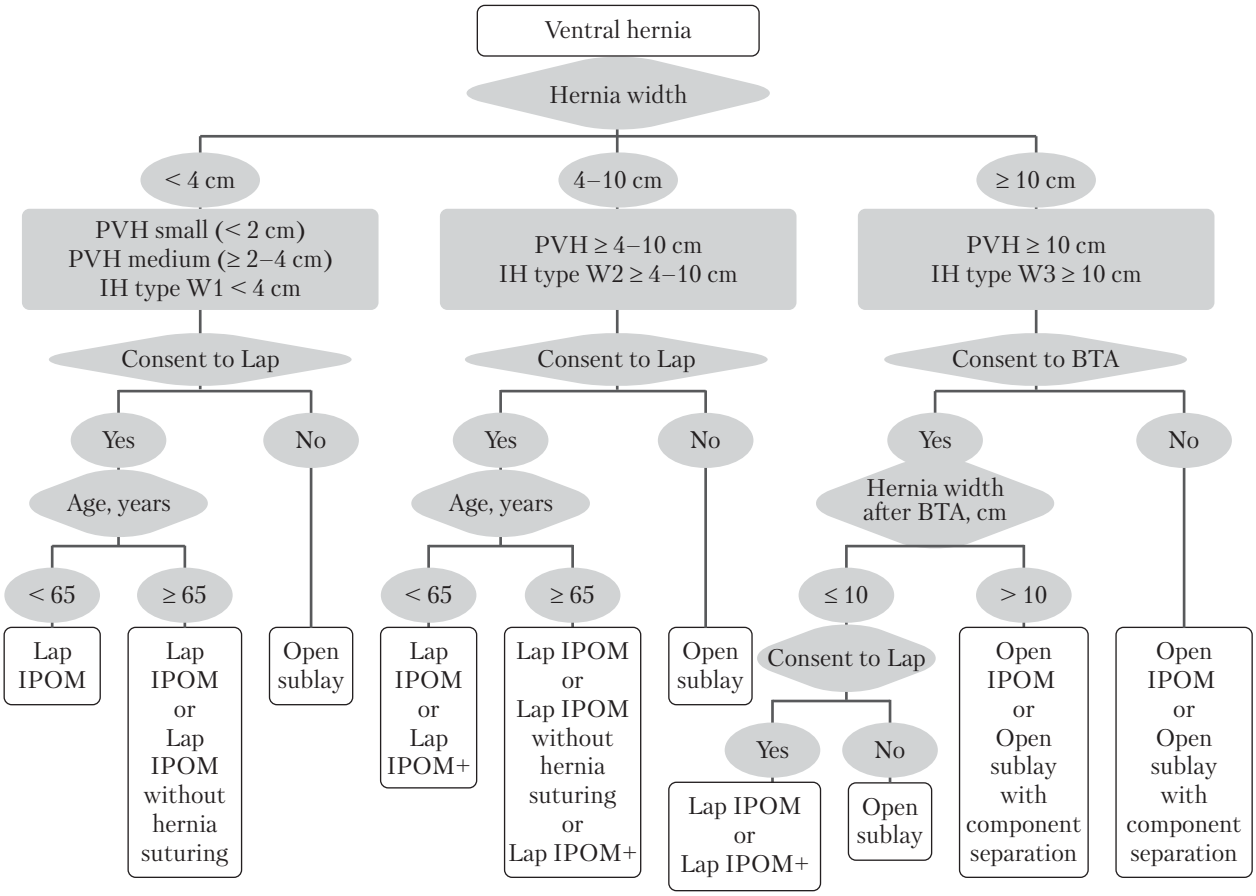
All patients who smoked were advised to quit 1 month before surgery. Patients with overweight and obesity were encouraged, if feasible, to follow a diet in an attempt to normalize their weight before surgery. All patients who were diagnosed with type 2 diabetes mellitus underwent appropriate conservative treatment in the preoperative period, if necessary, in order to stabilize their glycaemic levels and achieve diabetes compensation at the time of surgery.

Technique of surgical interventions

In each of the three groups of patients, the choice of hernioplasty technique was carried out according to the above algorithm. In all cases, hernioplasty was performed using a mesh. The size of the mesh was chosen according to the size of the hernial defect and the type of surgery. Thus, for open surgical interventions, the overlap of the edge of the hernial defect with the mesh was calculated to be at least 3 cm, and for laparoscopic ones, at least 5 cm [8, 9].

In case of the patient's consent to laparoscopic surgery, one of the options for its implementation was chosen according to the algorithm: laparoscopic hernioplasty using the IPOM method, which involved suturing the hernial defect before mesh placement (Lap IPOM); laparoscopic hernioplasty using the IPOM method without suturing the hernial defect (Lap IPOM without suturing); laparoscopic hernioplasty using the IPOM method with open suturing of the hernial defect through a mini-incision in the skin directly above the hernial hilum (Lap IPOM+). In the case of Lap IPOM+ in patients with IH, partial or complete excision of the old scar and excess skin of the hernial protrusion was performed to achieve a better cosmetic effect of the operation.

Laparoscopic surgery began with revision of the abdominal cavity. After determining the location, size, and number of hernial defects, the anterior abdominal wall was prepared for mesh installation, namely, viscerolysis, mobilization of the round and falciform ligaments of the liver as needed. When performing Lap IPOM, the hernial defect was sutured with non-absorbable sutures, capturing the



PVH — primary ventral hernia; IH — incisional hernia; Lap — laparoscopic hernia repair, IPOM — intraperitoneal mesh placement; IPOM+ — intraperitoneal mesh placement with open hernia suturing; BTA — botulinum toxin type A.

Figure. **Algorithm for choosing a surgical treatment method for ventral hernias**

entire thickness of the aponeurosis in order to avoid cutting through the sutures. After that, the pneumoperitoneum was deflated and the points of transaponeurotic mesh fixation were marked. Then, the pneumoperitoneum was restored, a composite mesh with an anti-adhesive coating was installed in the abdominal cavity, and it was fixed to the anterior abdominal wall at previously determined points with transaponeurotic sutures in order to avoid mesh displacement. After that, the main fixation of the mesh was performed directly with tackers using the «double crown» technique.

In Lap IPOM without suturing, the operation was performed similarly to the above-described technique, but without suturing the hernial defect. In this operation, after the stage of preparation of the anterior abdominal wall, the mesh was immediately fixed, controlling the minimum overlap of the mesh 5 cm from the most protruding edge of the aponeurosis from the center.

In Lap IPOM+, the difference in the performance of hernioplasty from Lap IPOM was that the stage of suturing the hernial defect was performed openly. After preparing the anterior abdominal wall, the pneumoperitoneum was deflated, and a mini-incision of the skin was performed directly above the hernial hilum. If necessary, the excess skin and the old postoperative scar were also excised. Then, the aponeurosis defect was sutured openly, with a continuous suture of non-absorbable double thread 1—0. After that, the laparoscopic stage was continued with the placement and fixation of the mesh, as mentioned above.

We performed open hernioplasty using one of three options. For hernias ≤ 10 cm in size, open hernioplasty was performed using the sublay method with the placement of a light macroporous polypropylene mesh retromuscularly preperitoneally and suturing the hernial defect (Open sublay). In the case of a hernial defect larger than 10 cm, one of the following two options was performed: hernioplasty using the sublay method with suturing the hernial defect and separation of the anterior abdominal wall components to minimize tension (Open sublay with CS); herniolaparotomy, mobilization of the edges of the hernial defect, with the placement of

a composite mesh with an anti-adhesive coating intraperitoneally, its fixation in at least 8 points with separate transaponeurotic sutures to the anterior abdominal wall, with, if possible, subsequent suturing of the aponeurotic defect with a continuous suture with non-absorbable double monofilament thread 1—0 (Open IPOM). If necessary, wound drainage according to Redon was performed during open hernioplasty.

Determination of possible postoperative complications

In order to objectify the detection of possible complications in all patients before discharge from the hospital, as well as during follow-up examinations in the clinic, the physical examination was supplemented with ultrasound of the abdominal cavity and anterior abdominal wall. If complications were detected, they were categorized according to the Clavien–Dindo classification [6].

The presence of seroma was determined in the case of local fluid accumulation, without signs of inflammation, in the thickness of the anterior abdominal wall, in the area of mesh placement and in the area of the hernia sac (after laparoscopic hernioplasty with IPOM or IPOM without suturing the hernia defect). During follow-up examinations in the postoperative period, if there was persistent pain in the area of mesh placement and no signs of inflammation, an ultrasound of this area was required to exclude/confirm possible fluid accumulation in this area. The type of seroma was determined according to the Morales-Conde classification [15].

Surgical site infections (SSIs) were assessed according to the criteria proposed by The United States Centers for Disease Control and Prevention (CDC) [10].

We defined hernia recurrence as the presence of a hernial protrusion in or around the surgical site, combined with a defect of the anterior abdominal wall in this area, which was confirmed both clinically and instrumentally. In patients who underwent laparoscopic hernioplasty using the IPOM technique without suturing the hernial defect, and who showed protrusion of the anterior abdominal wall without any signs of mesh displacement according to ultrasound, the situation was classified as mesh prolapse (bulging) without hernia recurrence.

Statistical analysis

Data were analysed with the statistical package IBM SPSS Statistics Base (version 22). All results were considered statistically significant at a value of $p < 0.05$. Quantitative data are presented as mean ± standard deviation (SD), unless otherwise stated. The normality of the data distribution was checked using the Shapiro-Wilk test ($p > 0.05$). For data not normally distributed, comparisons were made using the paired Student's t-test for related samples and the Student's t-test for unrelated samples. For data not normally distributed, comparisons were made using the Wilcoxon signed-rank test for related samples and the Wilcoxon-Mann-Whitney test for unrelated samples.

Results and discussion

A total of 534 patients with ventral hernias participated in the study. In group 1, among patients with a hernia defect up to 4 cm according to the EHS classification [16], there were 66 (12.4 %) patients with small PVH (< 2 cm), 125 (23.4 %) patients with medium PVH (2—4 cm) and 78 (14.6 %) patients with IH type W1 (< 4 cm). Group 2 included 74 (13.9 %) patients with large PVH and hernia defect width ≥ 4—10 cm, and 99 (18.5 %) patients with IH type W2 (≥ 4—10 cm). Group 3 included 28 (5.2 %) patients with large PVH and hernia width ≥ 10 cm and 64 (12 %) patients with IH type W3 (≥ 10 cm). More detailed treatment effectiveness indicators for each group of patients are presented in Table 2.

Given the variety of types of ventral hernias by location and the wide range of possible surgical options, which are presented in Table 2, it is statistically difficult to assess individual complication rates for each of the detailed samples. In order to analyze the effectiveness of the developed algorithm, the treatment results were assessed for each group, depending on the size of the hernial defect and not the cause of the hernia formation or its localization.

In group 1, 125 (46.5 %) patients chose laparoscopic surgery, while 144 (53.5 %) insisted on an open version of hernioplasty using the sublay method. Among patients who underwent laparoscopic surgery, there were 65 patients younger than 65 years old who underwent Lap IPOM with suturing of the hernial defect. There were also 60 patients in this group whose age was ≥ 65 years. 46 (76.7 %) of them underwent Lap IPOM without hernia repair, and 14 (23.3 %) patients ≥ 65 years of age underwent Lap IPOM with hernia repair.

In group 1, open surgeries resulted in a longer hospital stay than after laparoscopic procedures ($p < 0.001$). In patients ≥ 65 years of age, Lap IPOM without hernia repair resulted in comparable length of hospital stay ($p = 0.956$) compared to Lap IPOM with aponeurosis repair. At the same time, the frequency of complications in this age group when performing Lap IPOM without hernia repair was lower

Table 2. **Patient and hernia characteristics, and surgical outcomes (n = 534)**

Type of hernia	N	Type of operation	N	Hospital stay, day	Recurrence	Total complication	Seroma	Hematoma	SSI
Group 1, hernia size < 4 cm (n = 269)									
Small PVH (< 2 cm)	66 (12.4 %)	Lap IPOM	24	1.42 ± 0.58	0	0	0	0	0
		Lap IPOM WS	14	1.36 ± 0.50	0	0	0	0	0
		Open sublay	28	3.57 ± 0.69	0	1 (0.4 %)	1	0	0
Medium PVH (2—4 cm)	125 (23.4 %)	Lap IPOM	31	1.45 ± 0.57	0	4 (1.5 %)	4	0	0
		Lap IPOM WS	19	1.53 ± 0.51	0	0	0	0	0
		Open sublay	75	3.97 ± 0.99	0	8 (3.0 %)	5	2	0
IH type W1 (< 4 cm)	78 (14.6 %)	Lap IPOM	24	1.46 ± 0.51	0	3 (1.1 %)	3	0	0
		Lap IPOM WS	13	1.46 ± 0.52	0	2 (0.7 %)	2	0	0
		Open sublay	41	4.17 ± 0.92	0	8 (3.0 %)	4	3	1 (0.4 %)
Group 2, hernia size 4—10 cm (n = 173)									
Large PVH (4—10 cm)	74 (13.9 %)	Lap IPOM	15	1.40 ± 0.51	0	2 (1.1 %)	1	0	0
		Lap IPOM WS	13	1.46 ± 0.52	0	4 (2.3 %)	4	0	0
		Lap IPOM+	5	3.20 ± 0.45	0	2 (1.1 %)	0	2	0
		Open sublay	41	5.32 ± 0.99	1 (0.6 %)	15 (8.7 %)	7	5	2 (1.1 %)
IH type W2 (4—10 cm)	99 (18.5 %)	Lap IPOM	15	1.64 ± 0.63	0	3 (1.7 %)	3	0	0
		Lap IPOM WS	22	1.73 ± 0.55	1 (0.6 %)	1 (0.6 %)	1	0	0
		Lap IPOM+	7	3.29 ± 0.49	0	0	0	0	0
		Open sublay	55	5.04 ± 1.11	2 (1.1 %)	19 (11.0 %)	10	14	5 (2.9 %)
Group 3, hernia size ≥ 10 cm (n = 92)									
Large PVH (≥ 10 cm)	28 (5.2 %)	Lap IPOM	13	1.69 ± 0.79	0	1 (1.1 %)	1	0	0
		Lap IPOM+	11	3.73 ± 0.64	0	0	0	0	0
		Open sublay	0	-	0	0	0	0	0
		Open IPOM	3	3.67 ± 0.58	0	0	0	0	0
		Open sublay with CS	1	5	0	1 (1.1 %)	1	0	0
IH type W3 (≥ 10 cm)	64 (12.0 %)	Lap IPOM	12	1.75 ± 0.62	1 (1.1 %)	3 (3.3 %)	3	0	0
		Lap IPOM+	20	3.35 ± 0.81	0	1 (1.1 %)	0	0	1 (1.1 %)
		Open sublay	3	3.67 ± 0.58	0	1 (1.1 %)	1	0	0
		Open IPOM	5	3.8 ± 0.84	0	2 (2.2 %)	2	0	0
		Open sublay with CS	24	6.79 ± 1.35	0	14 (15.2 %)	6	3	3 (3.3 %)

Note. WS — without suturing; IPOM+ — intraperitoneal mesh placement with open hernia suturing; CS — component separation.

Table 3. **Postoperative complications (the Clavien–Dindo classification)**

Group	Hernia size	N	Complications						
			Total	Grade I	Grade II	Grade IIIa	Grade IIIb	Grade IVa	Grade IVb
1	< 4 cm	269	26 (9.6 %)	17 (6.3 %)	8 (2.9 %)	1 (0.4 %)	0	0	0
2	4—10 cm	173	46 (26.5 %)	21 (12.1 %)	20 (11.5 %)	3 (1.7 %)	2 (1.2 %)	0	0
3	≥ 10 cm	92	23 (25.0 %)	12 (13.0 %)	7 (7.6 %)	4 (4.4 %)	0	0	0
Total		534	95 (17.8 %)	50 (9.4 %)	35 (6.5 %)	8 (1.5 %)	2 (0.4 %)	0	0

(n = 2; 4.3 %) than after Lap IPOM with defect repair (n = 1; 7.1 %), and in both cases the complications were represented by seromas (Grade I).

The overall incidence of complications in group 1 after laparoscopic operations was 3.3 %; after open sublay, it was 6.3 %. Only in 1 case of hematoma development after open sublay was there a need for surgical treatment with hematoma evacuation, which we classified as Grade IIIa according to the Clavien–Dindo classification. In all other cases, complications were classified as Grade I and Grade II. The distribution of complications according to the Clavien–Dindo classification, identified in each group, is presented in Table 3. Superficial infections in the postoperative wound area were observed in 1 (0.37 %) case. In addition to the SSI indicated in Table 2, there was also 1 (0.37 %) case of urinary tract infection after open sublay in this group. In both cases, the administration of antibacterial drugs was effective in eliminating the infection and did not require additional interventions. We did not observe any hernia recurrences within 12 months after surgery in this group.

Similar to group 1, group 2 patients were more likely to choose open hernioplasty using the sublay method (n = 96; 55.5 %) over laparoscopic IPOM (n = 77; 44.5 %). Given the larger hernial protrusion in this group compared to group 1, 12 (15.6 %) patients opted for Lap IPOM+ among laparoscopic methods, motivating this by the desire to remove excess skin over the protrusion and the old scar in the hernia area. The duration of the operation was the shortest in the Lap IPOM without suturing and Lap IPOM groups; the duration of Lap IPOM+ and Open sublay was significantly longer ($p < 0.001$). The lowest complication rate was observed in the Lap IPOM group without suturing (14.3 %); complications after Lap IPOM with hernia repair and Lap IPOM+ were comparable (16.6 % vs. 16.6 %; $p > 0.05$), and the highest complication rate was after Open sublay (35.4 %). In the age group ≥ 65 years, Lap IPOM without suturing also demonstrated a lower complication rate (n = 5; 14.3 %) compared to laparoscopic hernioplasty methods with hernia defect suturing (n = 4; 22.2 %). It is worth noting that all these complications were Grade I (n = 8) and Grade II (n = 1), were represented by seromas (n = 7) and hematomas (n = 2), and were eliminated by puncture under ultrasound control. While after Open sublay, a wide range of complications was observed: superficial SSI (n = 5; Grade II), deep SSI (n = 2; Grade IIIb), urinary tract infections (n = 1; Grade II), seromas (n = 17; Grade I — 12, Grade II — 5) and hematomas (n = 9; Grade II — 6, Grade IIIa — 3).

In group 2, after Lap IPOM without suturing the hernial defect, mesh prolapse (bulging) was observed in 2 (5.7 %) patients. According to Liang et al., postoperative bulging occurs in 21.5 % of patients after laparoscopic hernioplasty, while after open intervention this figure is only 1.3 % [13]. At the same time, the development of bulging did not require repeated surgical intervention. Ultrasound examination of the anterior abdominal wall confirmed the absence of latent hernia recurrence.

There were also 4 (2.3 %) recurrences in this group, 1 after Lap IPOM without hernia repair and 2 after Open sublay. In all cases, patients reported an episode of excessive physical exertion before the onset of signs of hernia recurrence, and in 1 case after Open sublay, superficial SSI also occurred in the postoperative period.

Group 3 included patients with a hernia width of ≥ 10 cm. In this group, the possibility of performing laparoscopic operations was considered only after preliminary preoperative preparation, namely, the introduction of BTA 4—5 weeks before the operation. 66 (71.7 %) patients agreed to the introduction of BTA before the operation. At the same time, in 59 (89.4 %) patients, the hernia defect decreased to ≤ 10 cm postoperatively, thereby enabling the offer of laparoscopic hernioplasty to these patients. The high trauma of traditional open operations for large hernias prompts the search for possible options to minimize surgical trauma [20] and demonstrates the patients' commitment to laparoscopy. Given this, as well as the lower prevalence of these hernias and

their concentration mainly in specialized centers, we observed the highest rate of laparoscopic operations (n = 56; 60.9 %) in group 3 compared to open (n = 36; 39.1 %) operations among all three groups of patients. In this group, we noted the widest range of possible surgical options, which is presented in Table 2. For example, all patients who refused BTA (n = 26; 28.3 %) or whose hernia size remained more than 10 cm after BTA (n = 7; 7.6 %) were offered Open IPOM or Open sublay with CS. At the same time, all patients after BTA underwent Open IPOM at their insistence, and all of them refused Open sublay with CS. Among patients who refused BTA, only 1 patient underwent Open IPOM and 25 patients were treated by Open sublay with CS.

In group 3, three patients with a defect width reduced to ≤ 10 cm after BTA (n = 59) refused laparoscopic surgery and instead underwent Open sublay with hernial defect closure without tension and without the need for component separation. Laparoscopic surgery was performed in 56 patients, of which 25 (44.6 %) patients underwent Lap IPOM with hernia closure and 31 (55.4 %) patients underwent Lap IPOM+. We believe that the higher percentage of Lap IPOM+ selection is due to the patient's desire to improve the cosmetic appearance of the anterior abdominal wall by removing excess skin over a large hernial protrusion and postoperative scar, which is observed in the vast majority of cases with large hernias.

Patients in group 3 experienced the shortest hospital stay duration following Lap IPOM with hernia suturing. Patients who underwent Lap IPOM+ and Open IPOM had a longer postoperative hospital stay compared to those who underwent Lap IPOM, but comparable to each other ($p > 0.05$). This may be due to the presence of an open stage of surgery in Lap IPOM+ and less intraoperative trauma to the anterior abdominal wall in Open IPOM, compared to sublay techniques. Open sublay with CS required the longest hospital stay for the patient after surgery, as its implementation requires extensive dissection of the anterior abdominal wall tissues.

The complication rate in group 3 was lower among patients who underwent BTA (n = 7; 10.6 %) compared to those who refused this procedure (n = 16; 61.5 %). When comparing laparoscopic and open operations, the complication rate after laparoscopic operations was also lower (n = 5; 8.9 % vs n = 18; 50.0 %). Thus, after Lap IPOM, 4 cases of seroma (Grade I — 3; Grade II — 1) were observed, and after Lap IPOM+, 1 case of superficial SSI (Grade II) was seen. After open operations, the spectrum of complications was much wider. The largest number of cases was observed after Open sublay with CS (n = 15), namely: superficial SSI — 3 (Grade II), urinary tract infections — 2 (Grade II), seromas — 7 (Grade I — 5, Grade IIIa — 2), and hematomas — 3 (Grade I — 1, Grade IIIa — 2). After Open sublay, there was only 1 case of seroma (Grade I), but it should be noted that the number of cases observed in this group was limited (n = 3). The group of patients who underwent Open IPOM was also small (n = 8), but considering the volume of intervention for large hernias, the complication rate was significantly lower than that after Open sublay with CS (n = 2; 25.0 % vs n = 15; 60.0 %). Complications after Open IPOM were represented by seromas (n = 2; Grade I).

In group 3, a 65-year-old patient (1.1 %) was diagnosed with hernia reccurence 11 months after Lap IPOM with suturing of the L3-L4 type of IH after an episode of excessive physical exertion. During reoperation, the suture of the aponeurosis was found to be intact at the site of the previous defect. However, there was a separation of the edge of the aponeurosis of the abdominal oblique muscles, resulting in the formation of a hernial defect adjacent to and below the previously addressed defect, accompanied by the migration of the lower edge of the mesh into the hernial sac. A partial resection of the mesh in the hernial sac was performed, followed by open suturing of the aponeurosis defect and the laparoscopic placement of an additional mesh using the IPOM+ method.

No mortality was observed in all three groups. Repeated surgical interventions under general anesthesia within 30 days after surgery were also avoided.

Summarizing our results, it is worth noting that the presence of a wide range of possible surgical interventions for ventral hernias [2, 4, 20], as well as the variety of hernia locations on the anterior abdominal wall according to the EHS classification [16], prompts the search for a unified approach to the choice of surgical operation. Professional organizations provide specific surgical treatment guidelines for PVH and IH [8, 9, 21], as well as general guidelines for both types of ventral hernias [2—5]. For example, according to the recommendations of the European and American Hernia Societies for the treatment of PVH, hernias larger than 4 cm should be treated similarly to the treatment tactics for IH [9]. That is why, when developing an algorithm for choosing a treatment method, we chose the size of the hernia defect as the main criterion and not the etiological factor.

In our study, we chose the IPOM for laparoscopic mesh placement, as it is the most studied and the advantages of its use have been proven in practice, unlike other laparoscopic hernioplasty methods, the experience of which is currently being accumulated [9].

In all three observation groups, laparoscopic operations demonstrated a significantly lower rate of complications and length of hospital stay compared to open methods of hernioplasty ($p < 0.01$). Our data on a significantly shorter hospital stay coincide with the data from other studies [2, 22, 26]. There is no consensus in the literature on the overall rate of complications after laparoscopic hernioplasty compared to open surgery. For example, a significantly lower frequency of wound infection after laparoscopic interventions has been proven, but a higher percentage of intraoperative intestinal damage and the development of intestinal fistulas, compared to open methods of hernia repair [2, 4, 24, 26]. In all 3 groups, we did not observe any cases of intraoperative complications, including intestinal damage. However, it is worth noting that all laparoscopic operations were performed by surgeons with advanced skills in laparoscopy.

Seromas are one of the most frequent complications in ventral hernia repair [15]. This tendency was also observed in all three groups (n = 19; 7.1 % vs. n = 26; 15.0 % vs. n = 14; 50 %), and the frequency of seromas increased with increasing hernia defect size. Hematomas were also found in all three groups (n = 5; 1.9 % vs. n = 11; 6.3 % vs. n = 3; 3.0 %), but mostly after open sublay hernioplasty, and only in 1 case in group 2 after Lap IPOM+. In all cases, fluid accumulations were not observed on ultrasound for more than 3 months and were classified as Type I and Type IIa according to the Morales-Conde classification.

The prevalence of laparoscopic methods of surgery in the treatment of hernias, in addition to the complication rate, may be influenced by their higher economic cost [22]. In groups 1 and 2, we observed a lower frequency of choosing the laparoscopic version of hernioplasty compared to the open one (46.5 % vs. 53.5 % and 44.5 % vs. 55.5 %). However, our rates of laparoscopy are higher than in the analysis of 161,415 cases of ventral hernia hernioplasty in the United States presented by B. Fry et al. in the period 2010 to 2020. For example, the frequency of laparoscopic hernioplasty during this period decreased from 23.8 % to 11.9 %, and the frequency of open hernioplasty — from 74.2 % to 66.2 % [7].

In group 3, we observed a higher prevalence of laparoscopic operations compared to open ones (60.9 % vs. 39.1 %). The use of BTA in the preoperative period allowed for a reduction in the initial width of the hernia defect and the introduction of minimally invasive operations in the category of patients with large hernias (≥ 10 cm). Laparoscopic operations are usually considered as an alternative to open procedures only for hernias < 10 cm [4], or even < 8 cm [5]. The rapid recovery of the patient after surgery and a reduction in the period of hospital stay, compared with open traumatic operations, may provide significant justification when considering the economic feasibility of choosing laparoscopy. At the same time, according to B. Fry et al., there is a tendency toward an increase in the number of expensive robotic-assisted hernia repairs against the background of a decrease in the number of laparoscopic and open operations, while the recurrence rate is highest for robotic-assisted hernioplasty [7].

The recurrence rate in our study after laparoscopic operations was 0.8 %, and after open operations, it was 1.1 %, which is a comparable indicator. This may indicate both the effectiveness of the selected algorithm for choosing a treatment method, precise preparation in the preoperative period with minimization of risk factors, and the need for a longer observation period.

Limitations of our study are the limited duration of observation (in most patients within 12 months), a limited sample of patients in certain subgroups and the study of the effectiveness of a single dose of BTA (100 Units) with preoperative administration in patients with hernias of ≥ 10 cm. Additionally, there were no patients with hernias wider than 20 cm in our study, most likely because these hernias are extremely rare according to the literature. In the study, we observed a low rate of hernia recurrence and a low rate of complications after laparoscopic operations. In order to further study the influence of individual factors (hernia type, localization) on the level of complications and hernia recurrences with different hernioplasty techniques, we consider it advisable to continue observation in a more distant period and increase the sample of patients.

Conclusions

The use of the algorithm for selecting the hernioplasty method allows implementing a personalized approach to the surgical treatment of patients with ventral hernias. Laparoscopic hernioplasty with intraperitoneal mesh placement demonstrates significantly better results compared to open methods of hernia repair in terms of length of hospital stay and complication rate ($p < 0.01$). The use of BTA for hernias ≥ 10 cm in the preoperative period makes it possible to perform hernioplasty using laparoscopic techniques and minimize surgical trauma in case the patient refuses laparoscopy.

Declaration of interests

The authors declare that they have no conflicts of interest.

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Authors contributions

O. Y. Ioffe: work concept and design, critical review;
T. V. Tarasiuk: work concept and design, data collection and analysis, statistical analysis, writing the manuscript;
M. S. Kryvopustov: statistical analysis, critical review;
O. P. Stetsenko: critical review.

Ethics approval and written informed consents statements

The study followed the Ethical Principles of Medical Research Involving Humans, set forth in the Declaration of Helsinki of the World Medical Association and current regulatory acts of Ukraine. The study protocol was approved by the ethics committee of the Bogomolets National Medical University. Written informed consent was obtained from all patients.

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Менеджмент вентральних гриж: результати лікування на основі розробленого алгоритму

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Хірургічне лікування гриж передньої черевної стінки є одним із найпоширеніших у плановій хірургії, але частота застосування лапароскопічної герніопластики є меншою порівняно з відкритими методами. Досвід лікування вентральних гриж великих розмірів (≥ 10 см) із використанням малоінвазивних технологій є обмеженим через неможливість з'єднання країв грижового дефекту без сепарації її компонентів.

Мета — розробити алгоритм вибору методу хірургічного лікування пацієнтів із вентральними грижами та оцінити результати лікування.

Матеріали та методи. Проведено проспективне багатоцентрове дослідження із залученням 534 пацієнтів із вентральними грижами різного розміру. Пацієнти проходили лікування з вересня 2011 р. до листопада 2024 р. Пацієнти з грижами розміром ≥ 10 см у доопераційний період отримували ін'єкції ботулотоксину типу А (БТА) у дозі 100 МО в м'язи передньої черевної стінки. Середній вік пацієнтів становив (56,49 ± 14,59) року. Серед них було 307 (57,5 %) жінок і 227 (42,5 %) чоловіків. Усім пацієнтам проведено оперативне втручання з приводу грижі з використанням лапароскопічних та відкритих методів герніопластики відповідно до розробленого алгоритму.

Результати. При розробці алгоритму вибору методу лікування основним критерієм було обрано розмір грижового дефекту, відповідно до якого пацієнтів розподілили на три групи: група 1 — ширина грижі < 4 см (n = 269; 50,4 %), група 2 — 4—10 см (n = 173; 32,4 %), група 3 — ≥ 10 см (n = 92; 17,2 %). При лапароскопічних операціях з ліквідації грижі сітку розміщували інтраабдомінально. У всіх групах лапароскопічні операції продемонстрували статистично значущо меншу частоту ускладнень і тривалість перебування в стаціонарі порівняно з відкритими методами герніопластики ($p < 0,01$). Сероми були одним з найчастіших ускладнень у всіх групах (n = 19; 7,1 %, n = 26; 15,0 %, n = 14; 50 % відповідно). Цей показник зростав у міру збільшення розміру грижового дефекту. У групі 3 уведення БТА у 89,4 % випадків дало змогу зменшити дефект апоневрозу до ≤ 10 см і виконати лапароскопічну операцію в пацієнтів, які дали на неї згоду. Частота рецидиву після лапароскопічних операцій становила 0,8 %, після відкритих — 1,1 %.

Висновки. Використання алгоритму вибору методу герніопластики дає змогу імплементувати в практику персоналізований підхід до хірургічного лікування пацієнтів із вентральними грижами. Лапароскопічна герніопластика з інтраабдомінальним розміщенням сітки демонструє статистично значущо кращі результати порівняно з відкритими методами ліквідації грижі при оцінці тривалості перебування в стаціонарі та частоти розвитку ускладнень ($p < 0,01$). Використання в доопераційний період БТА при грижах розміром ≥ 10 см дає змогу виконати герніопластику за допомогою лапароскопічних методик і мінімізувати операційну травму в разі відмови пацієнта від лапароскопії.

Ключові слова: післяопераційна грижа, вентральна грижа, герніопластика, ботулотоксин типу А.

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