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Prevention of Postoperative Wound Complications in Rappeded Abdominal Hernia

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Abstract:

The results of surgical treatment of 225 patients for strangulated abdominal hernia were analyzed, including 127 in the main group and 98 in the control group. In order to prevent postoperative wound complications, the authors for the first time used the method of photodynamic debridement of the wound during the operation with the photosensitizer of methylene blue. In the control group, dioxidine solution was used for the rehabilitation of the surgical wound. The optimal concentration of methylene blue, exposure time, LED radiation modes were determined. The developed method of prophylaxis made it possible to reduce postoperative wound complications, to shorten the average length of hospital stay. The proposed method allowed the authors to use prosthetic hernia repair with a polypropylene mesh in case of a strangulated hernia in conditions of infection. The optimal surgical tactics were proposed depending on the duration of the infringement and the presence of risk factors for the occurrence of postoperative complications.
Key words: strangulated hernia; wound complications; photodynamic wound debridement.

INTRODUCTION

Despite the achievements of modern surgical science, the results of treatment of patients with strangulated hernias remain unsatisfactory, primarily due to the development of local purulent-inflammatory postoperative wound complications [2, 4, 6, 7, 11, 15, 17, 25].
It is known that a large number of methods and methods for the prevention of purulent-inflammatory wound complications in urgent surgery of hernias of the anterior abdominal wall have been developed and implemented into practice [14, 16, 20, 22, 26, 27]. Nevertheless, the incidence of local wound postoperative complications remains high and, according to some authors, reaches 50% [3, 5, 11, 15]. Thus, it can be concluded that the problem of treating patients with strangulated hernias requires the development of new approaches to the prevention of postoperative wound complications using modern technologies [9, 12, 18, 19, 21, 24]. It is known that photodynamic therapy (PDT) using coherent laser and incoherent light-emitting diode radiation, as well as sensitizers is used as a method for the prevention of pyoinflammatory wound postoperative complications in various sections of surgical practice [1, 13, 23, 26, 27]. The method has a pronounced bactericidal activity, anti-inflammatory effect, causes a positive immune response, preventing dystrophic and sclerotic processes [1,8]. A distinctive feature of photodynamic therapy is the exclusively local nature of the action, and the bactericidal and bacteriostatic effect is limited to the zone of laser irradiation, which avoids many of the side effects observed during antibiotic therapy [Stranadko EF. et al., 2017; GrossA. et al. 2014; Schlegel R.A. et al., 2018].
In the surgical treatment of restrained hernias, this method of prevention has not been previously used. All of the above facts determined the purpose and objectives of this study.

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PURPOSE OF THE STUDY.

To improve the results of surgical treatment of patients with strangulated abdominal hernias using photodynamic antibacterial therapy in order to prevent postoperative pyoinflammatory wound complications.

MATERIALS AND METHODS.

In this work, we conducted a comparative analysis of the results of surgical treatment of 225 patients with strangulated abdominal hernias of various localization, operated by traditional methods and using allohernioplasty in 2016 - 2020.
In the main group, the age of patients is from 31 to 79 years. The average age is 64.7 ± 9.7 years. There were 45 men (45.9%) and 53 women (54.1%). There were 23 (23.5%) patients over 70 years old.
In the control group, the age of patients ranged from 27 to 78 years. The average age is 61.7 ± 9.7 years. There were 61 men (48%), 66 women (52 %%). There were 35 patients over 70 years old (27.5%).
In the main and control group of operated patients, the age was over 50 years old and in this regard, many patients had from one to three different concomitant diseases. Table 1 presents patients by the type of restrained hernia. To compare the results of surgical treatment, patients with strangulated hernias were divided into 2 groups: the comparison group and the main group.

Table 1
Distribution of patients in the main group and the comparison group by the type of hernia

Hernia type	Main		Control		Total
Inguinal	58	45,7%	39	39,8%	97
Umbilical	29	22,8%	31	31,6%	60
Femoral	5	3,9%	5	5,1%	10
P / o ventral	35	27,6%	23	23,5%	58
Total	127	100%	98	100%	225

In the comparison group during the operation, dioxidine solution was used to sanitize the wound and prevent wound complications, and in the main group, photodynamic sanitation of the surgical wound was used using a solution of methylene blue at a concentration of 0.05%, while the exposure time of LED radiation by the device of domestic production "FDU- 1 "with a radiation wavelength of 630 ± 20nm - having a special attachment. The radiation spectrum of the installation has a maximum in the wavelength range of 600-660 nm, which corresponds to the absorption spectrum of MS solutions, and also a new domestic local hemostatic “Hemogubka” collagen was used locally for hemo- and lymphostasis from the edges of the surgical wound to prevent seromas. The method developed by us for the prevention of postoperative wounds in strangulated hernias is as follows: as a possible source of infection, the hernial sac was excised regardless of the time of admission of the patient and the operation, the nature of the hernial water was excised in compliance with the antiseptic rules in both groups, then in the main group a napkin was applied to the surgical wound

moistened with 0.05% MS solution for 5-7 minutes. Then the wound was washed with warm saline solution, dried and the wound was irradiated with an LED lamp for 3-5 minutes. Then, for control, a smear was again taken from the wound for culture. Alloplasty was performed in the onlay position; prolene 2/0 threads were used to fix the mesh. In order to prevent hemo- and lymphorrhea, a collagen hemogon was poured onto the mesh and along the edges of the wound. According to indications, the wound was drained according to Redon. In the control group, the same rules were followed, but the operating field was treated with an antiseptic "dioxidine", while a napkin moistened with dioxidine was applied to the wound for 5-7 minutes. Before plastic hernia orifice, a smear was taken from the wound for sowing. Determination of the sensitivity of the isolated bacteria to antibacterial drugs was carried out by the disk diffusion method with standard disks according to the Bauer method. At the same time, to determine the sensitivity to medicines and to the photosensitizer MS in various concentrations and LED irradiation in various parameters, we selected cultures of bacteria most often detected from hernial waters. When studying the qualitative and quantitative composition of the microflora of hernial waters and exudates, 8 different types of microorganisms and a wide range of microbial associations were identified in both groups.
The main microorganisms in the hernial waters were various types of staphylococci, mainly represented by Staphylococcus aureus, St. epidermidis, St. viridans, as well as representatives of gram-negative bacteria E. coli, Enterococcus faecalls, Klebsiellapneumoniae, Proteus vulgaris, Pseudomonas aeruginosa, sometimes they were sown as a combined flora.

Since these microorganisms are the most important pathogens in the occurrence of postoperative wound suppuration, we consider it necessary to bring data on the spectrum of sensitivity of the isolated strains of Escherichia coli and a number of bacteria to the antibiotics most often used in the clinic, then in a comparative aspect to study the antibacterial properties of the APDT method we propose.
Our in vitro bench tests to determine the bactericidal properties of PDT showed that the optimal concentration of MS for PDT is 0.05% MS solution, and the optimal exposure time is 5-10 minutes, the radiation power density is 50-100 mW / cm2, and the energy density is 25-35 J / cm2, radiation area up to 10 cm2.

The experimental results obtained in vitro indicate that PDT is promising in the prevention of purulent-inflammatory wound complications in strangulated abdominal hernias.
When sanitizing the operating field in the control group, a dioxidine solution was used.
When processing the operating field using PDT with 0.05% MS solution at a radiation power density of 100 mW / cm2, an energy density of 25-35 J / cm2, an exposure time of 5 minutes, it was possible to destroy microorganisms up to 96%.
After the operation, as a material for the study, we used the discharge through drainage tubes in both groups of patients (in the main and control groups). The collection of discharge through the drains was carried out under sterile conditions on the 1st day after the operation.
In the main group, due to the use of PDT, the microorganisms of hernial exudates were inactivated in the vast majority of cases (96%). The antimicrobial effect of PDT with MS was more pronounced than that of dioxidine. It should be noted that in the control group, microorganisms were found in 47% of the examined.
The well-being of the course of the postoperative period was judged by the severity of the pain syndrome, the length of stay in the hospital, the frequency and type of complication.
The analysis of statistical data was carried out using Microsoft Office Excel. To calculate the reliability indicators, we used the Pearson's test x2, Student's t-test. Differences were considered statistically significant if the error probability was $p < 0.05$.

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RESULTS AND DISCUSSION.

In general, the overwhelming majority of patients in all groups had a smooth postoperative period. In all patients with giant abdominal hernias, both with the use of their own tissues and alloplasty, long-term wound drainage was required.

We analyzed the frequency of wound purulent-septic complications depending on the time of the onset of the disease. From table 2 it follows that purulent-septic complications in patients with strangulated hernias in the main group occurred within 6 hours or more from the time of strangulation.

With an increase in this time for more than 12 hours, a peak in the occurrence of complications was observed, when there was an increase in complications by more than 3 times, and then there was a relative stabilization of this indicator and amounted to 26.6%, almost the same indicators in the control group (Table 3).

Table 2
Frequency of wound purulent-inflammatory complications depending on the time of hernia infringement in the study group

Time of illness, hours		Number of operated (n=127)	The absolute number of purulent complications	Relative number of complications,%
<2	abs.	41	-	-
	%	32,3±4,2	-	
from 2-6 hours	abs.	29	-	-
	%	22,8±3,7	-	
from 6 to 12	abs.	23	1	4,3±4,3
	%	18,1±3,4*	0,8±0,8	
>12	abs.	19	3	15,8±8,6
	%	15,0±3,2**	2,4±1,4	
>24	abs.	15	4	26,7±11,8^
	%	11,8±2,9**	3,1±1,6	

Note: *- Reliably compared with the indicators, the time of illness is less than two hours (* - P <0.05; ** - P <0.01)
^ - significantly compared with the indicators, the time of illness from 6 to 12 hours (^ -P <0.05)

Table 3
Frequency of wound purulent-inflammatory complications depending on the time of hernia infringement in the control group

Time of illness, hours		Number of operated patients (n = 98)	The absolute number of purulent complications	Relative number of complications,%
<2	abs.	31	-	-
	%	31,6±4,7	-	

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from 2-6 hours	abs.	21	1	4,8+4,8
	%	21,4±4,2	1,0±1,0	
from 6 to 12	abs.	17	3	17,6+9,5
	%	17,3±3,8*	3,1±1,7	
>12	abs.	12	5	41,7+14,9^
	%	12,2±3,3**	5,1±2,2	
>24	abs.	17	7	41,2+11,9^
	%	17,3±3,8*	7,1±2,6*	

Note: *- Reliably compared with the indicators, the time of illness is less than two hours (* - P <0.05; ** - P <0.01)
^ - significantly compared with the indicators, the time of illness from 2 to 6 hours (^ -P <0.05)

In the main group, 10 patients, and in the control group, 7 patients underwent Lichtenstein alloplasty for inguinal hernias, respectively, for umbilical ones, 8 and 9 patients underwent alloplasty in the onlay position, for femoral hernias, traditional Bassini hernia repair was performed. With ventral hernia, 11 in the main group and 8 in the control group underwent alloplasty in the onlay position. Thus, in the main group, only 30, and in the control group, 23 patients underwent alloplasty of the hernial orifice using a PP mesh in the onlay position.

As follows from Table 4, the duration of wound drainage in the comparison group was significantly longer than in the main group, which can be explained by the occurrence of tissue edema at the time of infringement, infection of the hernial water, tissues surrounding the hernial sac, in addition, with infringement of the intestine with the development of intestinal obstruction. Moreover, the duration of the outflow separated by the drains largely depended on the size of the restrained hernia, and, consequently, on the volume of surgical trauma and the degree of tissue mobilization..

Table 4
Duration of wound drainage after hernia repairs for strangulated abdominal hernias

Types of hernias	Control group (n = 69)			Main group (n = 53)		
	to / day	abs.	%	to / day	abs.	%
Inguinal hernia	2,7±0,15	27	39,1±5,9	1,5±0,12***	17	32,1±6,5
Umbilical hernia	4,6±0,24	18	26,1±5,3	3,1±0,23***	12	22,6±5,8
Femoral hernia	3,7±0,33	3	4,3±2,5	2,1±0,33*	3	5,7±3,2
Ventral hernia	8,1±0,25	21	30,4±5,6	5,3±0,20***	21	39,6±6,8

Note: *- reliable compared with the indicators of the control group (* -P <0.05; *** - P <0.001)

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In the main group and in the comparison group in 30 patients in both groups, we studied the nature of aerobic and facultative anaerobic bacteria isolated from the contents of the drainage in patients after surgery, depending on the method of debridement of surgical wounds during surgery (Table 5). Bacteriological examination of drainage revealed microbial contamination in 12 (40%) of 30 examined patients in the comparison group and in 4 (13.3%) patients in the main group. The seeding rate varied from 103 to 106 CFU / ml. Patients with a concentration of microorganisms in the test material ≥104 CFU / ml (58.3%) dominated. Three of them had sterile previous cultures.
Comparison of the microflora of the contents of the hernial sac and drainage revealed the identity of the isolated microorganisms in the examined patients.

Table 5
Aerobic and facultative anaerobic bacteria isolated from the contents of the drain in patients after surgery

Prevailing flora in the wound	Number of seeding			
	Control group (n = 30) (dioxidine)		Main group (n = 30) (PDT)	
	абс.	%	абс.	%
Staphylococcus saprophiticus	0	0	1	3,3
Staphylococcus aureus	1	0	1	3,3
Staphylococcusepidermidis	0	3,3	0	0
Enterococcusfaecalls	0	3,3	0	0
Enterococcus faecium	1	3,3	0	0
Escherichia coli	7	23,3	2	6,6
Klebsiellapneumoniae	1	3,3	0	0
Proteusvulgaris	0	0	0	0
Pseudomonasaeruginosa	2	6,7	0	0
Candidaalbicans	1	3,3	0	0
Всего	12	40,0	4	13,3

Note:subcutaneous tissue was drained exclusively in patients with giant hernias and obesity, as well as after allohernioplasty with PP mesh.

Thus, the seeding of the drainage in half of the patients was probably due to hospital strains. The following microorganisms were isolated: opportunistic enterobacteria of the genera Klebsiella, Enterobacter, Pseudomonas spp., Staphylococcus aureus. We considered containers for active aspiration of discharge from wounds to be the most likely source of secondary infection. Replacing the containers on a daily basis completely eliminated this problem.
Table 6 shows the nature of field-operative complications in the main group and in the control group. It follows from Table 6 that in the main group of 127 patients with strangulated hernias, early complications were observed in 8 (6.3%) patients, in the comparison group - in 16 (16.3%) patients. In patients with hernia orifice repair with the Esfil mesh, among the complications, seroma was most often formed - in 4 (3.1%) cases. Hematoma in the postoperative period was detected in 2 (1.6%) patients. Wound suppuration

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was observed in 2 (1.6%) patients. There were no infiltrates in the wound, as well as marginal skin necrosis.

Table 6
Early postoperative wound complications among patients of the main and control groups

Complication type	Main group n = 127		Control group n = 98	
	abs.	%	abs.	%
Seroma	4	3,1±1,6	7	7,14±2,6
Hematoma	2	1,6±1,1	1	1,02±1,0
Suppuration of the wound	2	1,6±1,1	5	5,10±2,2
Infiltrate	-	-	2	2,04±1,4
Marginal skin necrosis	-	-	1	1,02±1,0
TOTAL	8	6,3±2,2*	16	16,3±3,8

Note: *- reliable compared with the indicators of the control group (* -P<0.05)

Among 98 patients of the control group, seroma was observed in 7 (7.1%) patients, hematoma was detected in 1 (1.02%) patient, and wound suppuration in 5 (5.1%), infiltration in 2 (2.04%)) and marginal skin necrosis in 1 (1.02%). It should be noted that a decrease in seroma formation in the main group by more than 2 times, and wound suppuration by more than 3 times, is associated, firstly, with the use of Hemogubka seroma for intraoperative prophylaxis in combination with the antiseptic miramistin, and secondly, only local the use of electrocautery for the purpose of hemostasis in the main group. “Hemogubka” provided almost instant hemo- and lymphostasis in the surgical wound, and miramistin, as part of the hemoguba, created an antibacterial environment for 5-6 days, due to the slow biodegradation of the hemoguba. In the comparison group, hemostasis was carried out by electrocoagulation, and the collagen “hemogubka” was not used.

A relatively large number of seromas (7.1%) during plastic surgery using a PP mesh in the onlay position is explained by extensive tissue dissection, with prolonged capillary bleeding, lymphorrhea, tissue burns during electrocoagulation, contact of the mesh prosthesis with subcutaneous adipose tissue, peculiarities of tissue response to the introduction of synthetic material, the timing of the germination of the mesh by connective tissue and is not associated with the development of infectious complications. In the main group, due to the use of a hemoguba, a drug that provides instant hemostasis and lymphostasis, while practical electrocoagulation is not used. Moreover, the coating of the PP mesh with an inert composite (hemogloss) reduces the “foreign body-tissue” reaction, and this was confirmed by us earlier in experiments.

It is known that seroma is easily diagnosed using ultrasound. Moreover, thanks to the use of ultrasound, we were able to see the contents of the hernial sac (a strand of the greater omentum, intestinal loop) before the operation. In all cases, assuming it, we managed to cope with these complications without any consequences. We studied the microbial landscape of the contents of the hernial sac, as well as a biopsy of tissue around the hernial sac. In case of infringement of the greater omentum in patients, it was revealed that the level of contamination of the effusion in the hernial sac and tissues around the hernial sac remained below the critical level - 105 microbial bodies / g. The dissemination of effusion into the hernial sac with infringement of the small intestine, when the strangulated hernia was often accompanied by intestinal obstruction in our observations, exceeded the critical level in 2–4

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hours from the moment of infringement. The critical level is 109 microbial bodies / g. However, the dissemination of tissues around the hernial sac remained at a significantly lower level and reached a critical level after 6–8 hours. On the basis of microbiological studies of hernial water and biopsy of tissues around the hernial sac in the clinic, it was found that when various organs of the abdominal cavity are infringed, the critical level of bacterial flora develops 6 hours after the beginning of the infringement. Moreover, the bacterial flora was represented by gram-negative flora (E. Coli, Klebsiella spp., Enterobaster spp., Pseudomonas spp., Citrobacter spp., Proteus spp., Serratia spp.) And gram-positive flora (Enterococcus, Streptococcus spp., Bacter) and corresponds to the literature data. Based on the studies carried out in the clinic, the indication for prosthetic repair in patients with incarcerated postoperative ventral hernias is up to 6 hours from the moment of incarceration. However, the use of PDT sanitation in combination with a local hemostatic allowed us, in the presence of indications (large size of the hernial orifice, weakness of the musculo-aponeurotic complex), to perform allohernioplasty to eliminate ventral hernias under conditions of infection.

In the main group, we performed allohernioplasty for strangulated ventral hernias in 2 out of 35 patients, and in the control group - in 16 out of 23 patients. there are indications to perform allohernioplasty of ventral hernias in 21 patients with bowel strangulation for more than 6 hours. Postoperative wound complications in the main group of patients after allohernioplasty were observed in 3 patients (seroma - in 2, hematoma - in 1), and in the control group, in terms of infringement more than 6 hours, postoperative wound complications were noted in 8 (seroma - in 4, hematoma - in 2, wound suppuration - in 1, infiltration - in 1) patients.

Thus, a comparative analysis shows that the use of PDT in combination with a hemoguba for restrained postoperative hernias reduces the number of postoperative complications in the early postoperative period by more than 2.5 times, even if the time of restraint is more than 6 hours after performing allohernioplasty in patients with restrained postoperative ventral hernias.

Table 7 shows the percentage of the total number of early postoperative wound complications for each type of hernia.

Table 7
The incidence of early postoperative wound complications among patients with various types of hernias

Hernia type	Main group		Control group	
	abs.	%	abs.	%
Inguinal	2	1,6±1,1	4	4,1±2,0
Umbilical	2	1,6±1,1	5	5,1±2,2
Femoral	-	-	1	1,0±1,0
Ventral	4	3,1±1,5	6	6,1±2,4
Total	8	6,3±2,2*	16	16,3±3,8

Note: *- reliable compared with the indicators of the control group (* -P <0.01)

When comparing the incidence of postoperative wound complications in different types of hernias and different methods of plasty, it was found that the proportion of complications is higher due to ventral hernias, while they are in no way associated with the use of alloplasty.

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As follows from the table, it was possible to reduce the number of postoperative complications due to the use of PDT in combination with hemoguba and miramistin.
Table 8 shows the length of hospital stay for patients with various types of strangulated abdominal hernias. As can be seen from the table, when comparing the data of hospitalization of patients operated on for inguinal, umbilical, femoral and incisional hernias, it is significantly different. The longest stay of patients on the bed was required after hernia repair for ventral hernias, especially after allohernioplasty. The use of PDT in combination with a hemogloss made it possible to significantly reduce the length of hospital stay from 10.0 ± 0.67 in the control group to 7.3 ± 0.77 in the main group.

Table 8
Length of stay of patients with various types of hernias in the main and control groups

Hernia type	Main group n = 127		Comparison group n = 98		Probability P
	Sick	to / day	Sick	to / day	
Inguinal	58 (45,7%)	6,7±0,21	39 (39,8%)	8,9±0,29	P<0,001
Umbilical	29 (22,8%)	5,8±0,22	31 (31,6%)	9,1±0,30	P<0,001
Femoral	5 (3,9%)	7,2±0,37	5 (5,1%)	10,4±0,51	P<0,001
P / o ventral	35 (27,6%)	9,4±0,32	23 (23,5%)	11,8±0,42	P<0,001
Bed-day	7,3±0,77		10,0±0,67		P<0,05

An increase in the length of stay of patients in the hospital is associated with the development of a greater number of pyoinflammatory complications in the postoperative period and the need to treat them in a hospital setting. Reducing the bed-day of a patient's stay in the hospital brings with it not only economic benefits - a decrease in the cost of providing treatment for a patient, a decrease in the total day of disability for workers, but also social.

CONCLUSIONS:

1. Hernial waters with high cytosis are characterized by a high content of aerobic and facultative anaerobic bacteria (Staphylococcus aureus, St. epidermidis, St. viridans, E. coli, Enterococcus faecalls, Klebsiellapneumoniae, Proteus vulgaris, Pseudomonas aeruginosa).
2. Our bench tests have shown that the optimal concentration of MS for photodynamic debridement of an operating wound is 0.05% solution, and the optimal exposure time is 5-10 minutes, the radiation power density is 50-100 mW / cm2, the energy density is 25-35 J / cm2, at radiation area up to 10 cm2.
3. In case of strangulated hernias, to prevent wound infection and implant rejection during allohernioplasty under conditions of infection, a set of measures is shown, including traditional antibiotic therapy, complete excision of the hernial sac during surgery, photodynamic debridement of the surgical wound using 0.05% methylene blue solution.
4. The use of an innovative method of photodynamic debridement for the prevention of postoperative wound complications in strangulated hernias made it possible to reduce the incidence of wound complications from 16.3 ± 3.8 to 6.3 ± 2.2, and the length of hospital stay was reduced from 10.0 ± 0.67 up to 7.3 ± 0.77 bed-days.

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