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ЗАГАЛЬНА ХІРУРГІЯ

Quality of life in patients with chronic slow-transit constipation according to the PAC-QOL questionnaire and the effectiveness of conservative therapy

Postoperative complications and hernia recurrence after the use of various ventral hernia repair techniques

Lemniscate intestinal loop through an internal hernia after Roux-en-Y gastric bypass cause of coecum mobile

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Yurii Voronyi – a surgeon who was ahead of his time

The article outlines the historical milestones in the biography of the outstanding Ukrainian surgeon, Professor Yurii Voronyi, who was a disciple of Professor Yevhen Cherniakhivskyi. The study includes a compilation of historical records, archival sources, and other materials illustrating the life of Professor Voronyi. It highlights the professional and public achievements of Yurii Voronyi, particularly his participation in the struggle for Ukrainian independence between 1917 and 1921.

Learn and read, and learn from others,
And don't shy away from yours
Taras Shevchenko
To the Dead, the Living and the Unborn...

Christian Bernard and Joseph Murray are well-known names among surgeons and doctors of various specialties. In 1967, Christian Bernard performed the world's first successful heart transplantation in South Africa. In 1954, Joseph Murray performed the first successful kidney transplantation in the United States. These facts are considered axiomatic. Unfortunately, Ukraine still pays insufficient attention to the figure of Yurii Voronyi, who was de facto the first in the world to carry out human-to-human kidney transplantation. He transplanted a kidney from a cadaveric donor to a recipient. Consequently, he was the first to explant an organ from a cadaver for further transplantation and to transplant a well-functioning organ from one individual to another. This historic event for medicine and humanity took place in Kharkiv in 1933. The idea significantly advanced the understanding of the functioning of the human immune system and the principles of tissue compatibility at the time. The story that changed the world's medicine began in Kyiv, at 17 Shevchenko Boulevard, in the Faculty Surgical Clinic of the Medical Faculty of Kyiv St. Volodymyr University (now Kyiv City Clinical Hospital No. 18), with the experimental work of Professor Yevhen Cherniakhivskyi, whose student Yurii Voronyi later became. In addition to their professional initiatives, Professors Voronyi and Cherniakhivskyi had strong commitments to civic engagement and fought for Ukrainian state independence from 1917 until 1921. Regrettably, the Soviet repressive regime became aware of this fact. It is unknown what breakthroughs these scientists would have accomplished if not for the Soviet government's inhumane punitive power apparatus. However, the modern medical community should recognise their achievements on a global scale and give them the attention they deserve.

Family

Yurii Voronyi (according to metric records, Heorhii Heorhiiovych Voronyi) was born in the village of Zhuravka in the Chernihiv region in 1895. His father, Heorhii Voronyi, was a world-renowned mathematician and professor at the University of Warsaw. His scientific contributions and mathematical concepts are still relevant and widely used in modern programming and IT. Scientists from various countries continue to cite Heorhii Voronyi's mathematical research works, even after over a century. Yurii Voronyi's grandfather, Feodosii Voronyi, had a university degree. He graduated from the Faculty of History and Philology at Kyiv St. Volodymyr University. He was a teacher, a well-known public figure, and a representative of the Ukrainian intelligentsia of the time. He knew Mykhailo Drahomanov, Olena Pchilka, and Hryhorii Galagan. Oleksandr Voronyi, the brother of Yurii Voronyi, had a medical degree, worked as a surgeon, became chief

physician at the hospital in Yahotyn (Kyiv region), and pursued both theoretical and practical oncology. His theoretical work on malignant tumour development was based on mathematical calculations and the basics of biological statistics [3, 4].

Vicissitudes in the midst of war

Yurii Voronyi completed his secondary education at a gymnasium in Pryluky. In 1913, he entered the medical faculty of Kyiv St. Volodymyr University, but the First World War interrupted his studies. During the war, Yurii Voronyi volunteered as a member of the medical company of the South-Western Regional Zemstvo Committee for the Care of Sick and Wounded Soldiers. In 1917, he voluntarily joined the army of the newly formed Ukrainian People's Republic. On January 29, 1918, he participated in the battle of Kruty as part of the Reserve Student Kuren of the Sich Riflemen, formed from students of Kyiv St. Volodymyr University and the Ukrainian National University. Despite receiving wounds in the battle, he managed to survive [1].

Early years of professional life

Yurii Voronyi continued his medical education at the Kyiv Institute of Healthcare (renamed Bogomolets National Medical University following restructuring), from which he graduated in 1921. He was offered postgraduate studies by the Department of Surgery, which recognized him as one of the top graduates. Professor Yevhen Cherniakhivskyi, an experienced surgeon, noticed the young, promising graduate and became his mentor. Thus, Yurii Voronyi joined the Faculty Surgical Clinic of the Kyiv Medical Institute (the institution's name after the next reorganisation in 1922) [2]. Professor Mykola Volkovych headed the department, but Professor Yevhen Cherniakhivskyi took over the position shortly after. The latter introduced Yurii Voronyi to vascular surgery and experimental transplantation. Under Yevhen Cherniakhivskyi's leadership, the department conducted not only medical work but also experimental research on organ transplantation. Yurii Voronyi was fascinated by Professor Cherniakhivsky's scientific ideas, which influenced his future scientific and practical activities in this area [3].

About the teacher Yevhen Cherniakhivskyi

After graduating from the medical faculty in 1902, Yevhen Cherniakhivskyi worked as a surgeon at the Oleksandrivska Hospital in Kyiv. He wrote the first report in the local scientific literature on the successful closure of a heart wound after a stabbing. At the Oleksandrivska Hospital, he worked under the supervision of Professor Mykola Volkovych, who founded the Kyiv Society of Surgeons in 1908. Yevhen Cherniakhivskyi became the society's first secretary. In addition to his medical work, he conducted scientific research on transplantation. On May 23, 1913, at a meeting of the Physico-Medical Society at St. Volodymyr University, he reported on the results of research on kidney transplantation in dogs using the vascular suture he had developed. During the revolutionary events of 1917—1921, Professor Cherniakhivsky took an active pro-Ukrainian position. Together with his brother Oleksandr, he helped create the Medical Faculty of the Ukrainian National University, the first higher education institution with Ukrainian as the language of instruction. In 1918, he served as chief physician of the Oleksandrivska Hospital [2]. In 1920, he became the first rector of the newly established Kyiv Institute of Healthcare. In 1922, he headed the Faculty Surgical Clinic, where he actively introduced vascular surgery into practice and continued to work on experimental transplantation [1].

The beginning of independent professional activity and the first attempts at repression

In 1925, Yurii Voronyi began his career as an assistant at the Faculty Surgical Clinic of the Kyiv Medical Institute. However, in 1926, he unexpectedly moved to Kharkiv, where he took up a position as an assistant at the research department of the Faculty Surgery of the Kharkiv Medical Institute, under the leadership of Professor Volodymyr Shamov. Such an abrupt change in Yurii Voronyi's career seems strange, given the fact that in the mid-1920s, the Kyiv Faculty Surgical Clinic became the most powerful surgical institution in Kyiv, with professors Cherniakhivskyi, Volkovych, and Hedroyts working there [7]. The USSR KGB's declassified archives shed some light on this situation. The interrogation materials of Professor Oleksandr Cherniakhivskyi (brother of Yevhen Cherniakhivskyi) revealed the following:

«To spread our influence as an unorganised group, we used our acquaintance with the Kharkiv professors, who stood on the basis of recognising the needs of Ukrainian culture without introducing them to our political outlook, and at that time we sent young doctors to the Kharkiv Medical Institute. I remember Voronyi among them. However, I must admit that I do not know his political outlook and have never spoken to him about it... Thus, even at that time, we established ourselves as an illegal political organisation, uniting elements opposed to the Soviet government and forming cadres who could pose a threat to it in the event that it weakens... First of all, about myself: I had until then recognised an independent Ukraine

as the ideal of political existence, for which a purely socialist structure was not suitable».

This interrogation is part of the Union for the Liberation of Ukraine (ULU) case. The high-profile trial took place in 1929—1930 and marked the beginning of the methodical extermination of the Ukrainian intelligentsia. In this case, 474 people, including doctors and professors of the Kyiv Medical Institute, faced repression. The ULU case is a classic example of a completely fabricated and absurd persecution of the Ukrainian scientific and creative elite. The above text from the interrogation materials was dictated and signed under pressure, as evidenced by similar clichéd statements from other defendants in the case and the rehabilitation of those involved in the process in the 1950s. However, in these materials, the information about Yurii Voronyi is extremely valuable, which partially explains his spontaneous move to Kharkiv. We can assume that Professor Cherniakhivskyi sent his best student to Kharkiv to shield him from the punitive authorities in Kyiv. The ULU case marked the culmination of the Ukrainian professoriate's repression at the Kyiv Medical Institute, which began in the mid-1920s.

The city where the world's first transplantation was performed

In 1931, Professor Volodymyr Shamov initiated the establishment of the Institute of Haematology and Blood Transfusion (the All-Ukrainian Institute of Emergency Surgery and Blood Transfusion) in Kharkiv. This institution had offices in the Ukrainian SSR, including Kherson. From 1931 to 1936, Yurii Voronyi worked at the Kherson City Hospital and regularly travelled to Kharkiv on scientific trips. This fact from the prominent surgeon's biography sparked a controversy regarding kidney transplantation in 1933. During the 1930s, Yurii Voronyi continued to work on transplantation and blood transfusion issues. In addition to his scientific papers on kidney transplantation, he published extremely valuable and intriguing articles on organ transplantation in animals in experiments.

On March 31, 1933, a 26-year-old woman was brought to the hospital, where Yurii Voronyi was a surgeon on duty. She had taken a mercury solution to commit suicide due to personal life problems. The woman's kidney failure was progressing, and on April 3, Yurii Voronyi decided to transplant a kidney from her husband, who had died the day before from an incompatible with life brain injury. The kidney was connected to the woman's femoral vessels, and a ureteral fistula was created on the skin of the thigh area to drain urine. A few hours after the operation, some drops of urine were discharged from the fistula, indicating the viability and functioning of the kidney. The next day, the patient's condition gradually improved, but in the evening, doctors noted a clear negative dynamic. A day later, the patient died. The transplanted kidney showed signs of rejection. Despite a very progressive understanding of the principles of tissue compatibility at the time, which were based primarily on the blood group compatibility of the donor and recipient, the medicine of the time did not have modern capabilities to use immunosuppression, which led to the rejection of the transplanted organ.

In 1934, Yurii Voronyi was awarded the degree of Candidate of Medical Sciences «honoris causa», i.e., without defending his dissertation. This fact testifies to the wide recognition of his scientific and practical achievements. It is symbolic that the surgeon was awarded this honourable degree at his alma mater, the Kyiv Medical Institute.

Yurii Voronyi had an extremely difficult time during the Second World War. Prior to his capture, he lived with his family in occupied Kharkiv. During the war, Yurii Voronyi continued to practice surgery. In 1941, at Kharkiv Hospital No. 12, he performed an extremely complicated operation: the replantation of a young girl's partially severed (according to other sources, completely severed) right arm. In 1956, he received a letter from Nadiia Chyzhevska, which begins with the words «I am writing with your right hand...». Nadiia Chyzhevska was the patient for whom Yurii Voronyi performed the replantation in 1941. Unfortunately, to date, there is no reliable published medical documentation of this clinical case. Today, it is believed that the author of the world's first successful limb replantation was Ronald Malt, who performed a similar operation in 1964 in Boston, USA. Perhaps, in this case, the priority actually belongs to the outstanding Ukrainian surgeon, Yurii Voronyi [6].

Post-war life

After the war, Yurii Voronyi worked as a surgeon and urologist in Zhytomyr. Despite the fact that he held the position of chief urologist in the Zhytomyr region for some time, his potential was much greater. Unfortunately, certain facts from his biography (his «nationalist» past, his brother, who was serving a sentence on a political charge) did not allow him to make the most of his knowledge and skills. Despite the Soviet government's rejection of him, Yurii Voronyi continued to work on transplantation issues. By 1950, he had performed about 10 kidney transplantations in the Zhytomyr hospital. Unfortunately, there are no publications about these clinical cases in international journals because even the

transplantations performed by Voronyi in the second half of the 1940s were performed earlier than the transplantation performed by Joseph Murray in 1954 [5].

In 1950, Yurii Voronyi was able to return to Kyiv, where he worked at the Institute of Experimental Biology, in the basement of which he lived. He got a decent place to live after operating on a party leader who, out of gratitude, asked for an apartment for the surgeon. Until 1961, he worked in Kyiv, where he died. Yurii Voronyi was buried at the Baikove cemetery.

The repressive system

Unfortunately, throughout his life, Yurii Voronyi constantly faced the work of the destructive and demonic Soviet repressive machine. Thus, his Kyiv teacher, Professor Yevhen Cherniakhivskyi, was arrested in 1929. The Kyiv Medical Institute dismissed him in 1930, denying him the right to teach or practice medicine. Another of Voronyi's teachers, Professor Adam Belts, director of the clinic of the All-Ukrainian Institute of Emergency Surgery and Blood Transfusion, was arrested in 1937. He was accused of «spying for Poland». In 1938, Professor Belts was shot for «allowing inhumane operations», and in 1959, he was posthumously rehabilitated. In 1938, Yurii Voronyi's brother Oleksandr was arrested on trumped-up charges of «counter-revolutionary activity». He died under mysterious circumstances while serving his sentence in the camps [3].

Yurii Voronyi lived through extremely difficult times: the First and Second World Wars, the revolutionary events of 1917—1921, and the period of Stalin's repressions. His extraordinary surgical talent and aptitude for scientific work added to the world's treasure trove of medicine, but the country in which he lived failed to fully appreciate his capabilities.

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Юрій Вороний — хірург, який випередив час

Описано історичні віхи біографії видатного українського хірурга професора Юрія Вороного — учня професора Євгена Черняхівського. Стаття є компіляцією історичних документів, архівних матеріалів та фотографічних ілюстрацій різних етапів його життя. Висвітлено професійну та громадську діяльність Юрія Вороного, зокрема його участь у боротьбі за незалежність України в 1917—1921 роках.

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Postoperative complications and hernia recurrence after the use of various ventral hernia repair techniques

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Prosthetic hernioplasty (HP) for ventral hernias (VH) has a complication rate of up to 27 % and a hernia recurrence rate up of to 37 %, depending on the chosen technique. The use of laparoscopic HP techniques allows for a shorter hospital stay and a lower risk of wound infection. There is a wide range of data on the superiority of laparoscopy over the open technique in terms of recurrence rates and various types of complications. The results of comparing HP with and without suturing of the hernia defect are controversial.

Objective — to study the structure and incidence of postoperative complications, as well as the frequency of hernia recurrences after the use of open and laparoscopic HP for VH.

Materials and methods. A multicenter prospective study, which included 482 patients diagnosed with VH, was conducted at the clinical base of the Department of General Surgery No. 2 at Bogomolets National Medical University. A total of 279 (57.9 %) patients had primary VH, while 203 (42.1 %) had incisional VH. The patients were divided into two groups, comparable in terms of age, sex, and hernia size distribution. Group 1 included 250 (51.9 %) patients who underwent open HP with suturing of the hernia defect: subgroup 1a — open sublay (n = 243; 50.4 %), and subgroup 1b — open intraperitoneal onlay mesh technique (IPOM) (n = 7; 1.5 %). Group 2 included 232 (48.1 %) patients who underwent laparoscopic HP using the IPOM technique: subgroup 2a — IPOM without suturing of the aponeurosis defect (n = 81; 16.8 %), subgroup 2b — IPOM with suturing of the aponeurosis defect (n = 108; 22.4 %), and subgroup 2c — IPOM+ with open aponeurosis defect suturing (n = 43; 8.9 %). Follow-up evaluations were carried out at intervals of 2 weeks, 1 month, 6 months, and 1 year to assess the presence of complications, recurrence, and satisfaction with the cosmetic effect of the operation.

Results. The overall frequency of complications after HP was 15.6 %, while after open sublay it was 21.2 %, and after laparoscopic IPOM it was 9.9 %. All cases of complications belonged to Grades I—IIIb according to the Clavien-Dindo classification. In both groups, there were no fatalities. In group 1, the frequency of seroma was 11.6 % and hematoma was 5.6 %, and in group 2, it was 7.3 % and 0.9 %, respectively. A statistically significant increase in the frequency of hematoma development was observed after open HP techniques compared to laparoscopic ones ($p = 0.004$), while the frequency of seroma detection was comparable ($p = 0.148$). Non-suturing of the aponeurosis defect after laparoscopic IPOM in patients with VH did not result in an increase in the total number of complications or the percentage of recurrence ($p > 0.05$). Laparoscopic IPOM with hernia suturing demonstrated significantly higher patient satisfaction with the appearance of the anterior abdominal wall compared to other HP techniques ($p < 0.05$).

Conclusions. The open sublay and laparoscopic IPOM HP procedures have a comparable recurrence rate of VH ($p > 0.05$). The incidence of infectious complications and hematomas is significantly higher after open operations compared to laparoscopic ones ($p = 0.041$ and $p = 0.004$, respectively).

Keywords
ventral hernia, incisional hernia, hernia repair, mesh.

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Surgical treatment of ventral hernia (VH) occupies a leading place in planned abdominal surgery. More than 300,000 hernia repair procedures are performed each year in Europe [1], while the overall frequency of complications on average reaches 17.2 % [2]. Data on the frequency of complications and recurrences of hernias of the anterior abdominal wall after the use of open and laparoscopic methods of prosthetic hernioplasty (HP) vary widely and depend on the expertise of the centre where the operations were performed, the size of the studied sample, and the chosen technique of plastic hernia repair, and features driving patients in the postoperative ward period [3, 9, 14].

Using synthetic prostheses (various types of mesh) instead of merely suturing the defect leads to a notable reduction in the rate of hernia recurrences [11], regardless of where the mesh is placed. Mesh is recommended for all types of planned hernioplasty in the treatment of midline VH [23]. The most common of the open HP procedures is a retromuscular sublay technique for VH repair. The most studied laparoscopic technique is surgery with intraperitoneal mesh placement (IPOM) [12]. Laparoscopic HP for VH shows a shorter hospital stay compared to open surgery and a lower risk of wound infection, but the duration of complete patient recovery and long-term quality of life indicators are comparable [19, 24, 25]. At the same time, laparoscopic HP has advantages over open surgery in terms of quality of life in the early postoperative period [3].

However, it remains unclear how suture or non-suture repair of an aponeurosis defect influences the structure and frequency of postoperative complications, as well as hernia recurrence rate after laparoscopic and open HP. Three randomised controlled studies [8, 18, 22] involving 488 patients with postoperative VH demonstrated a slightly higher recurrence rate after IPOM without hernia suturing (10 %) than after open sublay (6 %). However, no statistically significant difference was found. There is also no data on patient satisfaction with the cosmetic result of the operation or the functional capabilities of the anterior abdominal wall [23]. It is unknown how the proportion of postoperative complications, such as seromas and hematomas, varies with the method of diagnosis in the early postoperative period.

Objective — to study the structure and incidence of postoperative complications, as well as the frequency of hernia recurrences after the use of open and laparoscopic HP for VH.

Materials and methods

General characteristics of patients

A prospective multicenter study was conducted with the participation of 482 patients with VH (primary ventral and incisional) who underwent various types of elective HP. The study was conducted at the clinical base of the Department of General Surgery No. 2 of Bogomolets National Medical University, in the Kyiv City Clinical Hospital No. 3 and the «Leleka» Medical Centre, from September 2011 to June 2024. The average age was 56.84 ± 14.32 years. There were 275 (57.0 %) women and 207 (43.0 %) men.

The criteria for inclusion in the study were as follows: the age of patients from 18 to 90 years, referral for the treatment of an uncomplicated VH, compensated concomitant somatic pathology, performing the operation in the elective order, consent to the possible performance of laparoscopic HP with intraperitoneal placement of the mesh, with and without suturing of the hernia defect.

The exclusion criteria from the study were as follows: age of patients under 18 or over 90 years, referral for treatment of complicated VH, including pinched VH, decompensated concomitant somatic pathology, performing the operation in an urgent order, categorical refusal to perform a possible laparoscopic HP with intraperitoneal placement of the mesh, with and without suturing of the hernia defect, subxiphoid or suprapubic location of the hernia defect.

Patients were divided into two groups, comparable in terms of age, sex, and hernia size distribution. Group 1 included 250 (51.9 %) patients who underwent open HP and was divided into 2 subgroups: subgroup 1a — open HP using the sublay technique (n = 243; 50.4 %), and subgroup 1b — open HP using the IPOM technique (n = 7; 1.5 %). All patients in Group 1 underwent suturing of the hernia defect before the mesh placement.

Group 2 included 232 (48.1 %) patients who underwent laparoscopic HP according to the IPOM technique. They were also divided into subgroups: subgroup 2a — laparoscopic IPOM without suturing the hernia defect (n = 81; 16.8 %), subgroup 2b — laparoscopic IPOM with suturing the hernia defect (n = 108; 22.4 %), and subgroup 2c — laparoscopic IPOM+ with open suturing of the hernia defect (n = 43; 8.9 %). Detailed patient characteristics are presented in Table 1.

The operation technique

All patients underwent HP and mesh placement. In all cases, the size of the mesh was chosen based on the calculation that the edge of the hernial defect should be covered by the mesh by at least 5 cm. The operations were performed under general combined anesthesia.

In subgroup 1a, patients underwent open HP using the sublay method, where a light macroporous polypropylene mesh was placed retromuscularly

Table 1. **Demographic and pre-operative data**

Characteristics	n = 482
Women Men	275 (57.0 %) 207 (43.0 %)
Age, years	56.84 ± 14.32
Body mass index, kg/m^2	31.12 ± 4.70
ASA score I II III IV	 135 (28.0 %) 330 (68.5 %) 17 (3.5 %) 0
Obesity	201 (41.7 %)
Smokers	105 (21.7 %)
Type of hernia Primary ventral Incisional	 279 (57.9 %) 203 (42.1 %)

Note. Categorical variables are presented as the absolute number and percentage, while quantitative indicators are presented as M ± SD.
ASA — American Association of Anesthesiologists

preperitoneally, and the hernial defect was sutured with separate nodal sutures. If necessary, the wound was drained, according to Redon.

In subgroup 1b, herniotomy, mobilisation of the edges of the hernial defect, and viscerolysis, if necessary, were performed. After that, a composite mesh with an anti-adhesive coating was placed intraperitoneally, with fixation in at least 8 points by separate transaponeurotic sutures, followed by suturing of the aponeurosis defect with a continuous suture with non-absorbable double monofilament thread 1—0.

In Group 2, after installing trocars and creating a pneumoperitoneum, the abdominal cavity was revised, and viscerolysis, if necessary, was performed. The location of the hernial defect and the presence of other aponeurosis defects were determined, and the area for mesh placement was prepared. In subgroup 2a, the hernia defect was not sutured; a composite mesh with an anti-adhesive coating was placed intraperitoneally. The mesh was fixed to the anterior abdominal wall with transaponeurotic sutures at 4 points, then with tackers using the «double crown» technique. In subgroup 2b, the hernia defect was sutured with separate knotted transaponeurotic sutures before the mesh was placed. Then, the installation and fixation of the mesh were carried out similarly to subgroup 2a. In subgroup 2c, after viscerolysis, deflation of the pneumoperitoneum was performed. If necessary, excision of excess skin and an old postoperative scar was carried out. It was followed by open suturing of the aponeurosis defect with a continuous suture and a non-dissolving double thread 1—0. Then, the laparoscopic stage was continued with the placement and fixation of the mesh, similarly to subgroup 2a.

Control of the patient's discharge from the hospital and postoperative follow-up

In order to prevent the development of complications and provide a standardised assessment of the patient's condition and the possibility of discharge from the hospital, we developed a control checklist (Table 2), which included the data of the patient's objective examination and their subjective feelings about the possibility of self-care for their needs. In order to assess satisfaction with the cosmetic effect of the operation and the functional capabilities of the anterior abdominal wall, we added separate sections to the above checklist. We also entered information about the patient's follow-up check-ups at intervals of 2 weeks, 1 month, 6 months, and 1 year after surgery. In addition to the objective examination of the postoperative wound, the patients underwent an ultrasound examination of the anterior abdominal wall and organs of the abdominal cavity during follow-up examinations.

Given the lack of a specialised standardised questionnaire for assessing patient satisfaction with the cosmetic result after hernia repair [4, 5], we used the Customer Satisfaction Research Index as a basis for a satisfaction score (CSAT), based on which the level of satisfaction was evaluated from 1 to 5, where 1 — very dissatisfied, 2 — not satisfied, 3 — neutral result, 4 — satisfied, 5 — very satisfied. During follow-up examinations starting 1 month after the operation, patients were additionally interviewed about their performance of their daily tasks, physical exercises, and work duties with or without restrictions.

The main criteria for discharging a patient from a hospital were as follows: absence of hyperthermia; self-service of one's needs without the help of medical personnel; lack of need for injectable forms of analgesics (pain level below 5 when moving according to a visual analogue scale); percutaneous oxygen saturation above 92 % without additional oxygen support; consent to hospital discharge.

Taking into account the risk of developing surgical infections in the wound, especially in the conditions of using a synthetic implant, before discharge from the hospital, all patients were instructed about the symptoms of inflammatory complications, in case of which it is necessary to urgently contact the attending physician. Such symptoms included an increase in body temperature above 37.5°C, pain in the area of the postoperative wound, swelling and/or redness of the skin, the appearance of

Table 2. **Checklist of patient discharge from the hospital and control follow-up**

No	Indicator	Possible assessment	Indicator for hospital discharge
	The patient's own assessment of their condition		
1	Pain level according to the VAS scale	0—10	< 5
2	Nausea and/or vomiting	Present/Absent	Absent
3	Abdominal bloating	Present/Absent	Absent
4	Feeling hungry	0—10	0—10
5	Feeling thirsty	0—10	0—10
6	Departure gases	Present/Absent	Present
7	Defecation (stool)	Present/Absent	Present
8	General weakness	0—10	< 5
9	Satisfaction with the effect of cosmetic surgery	1—5	1—5
10	Do you want to go home?	Yes/No	Yes
11	The need to wear a postoperative bandage	Yes/No	Yes/No
	The doctor's objective assessment of the patient's condition		
12	The objective patient's condition during the physical examination is satisfactory	Yes/No	Yes
13	Percutaneous oxygen saturation in the blood without additional oxygen support	0—100 %	> 92 %
14	Body temperature	35.5—41 °C	35.5—37.5 °C
15	Availability of drainage	Yes/No	No
16	The need to use narcotic analgesics	Yes/No	No
17	The need for injectable forms of analgesics	Yes/No	No
	Assessment of the patient's condition during control follow-up		
18	Postoperative complication (if detected, detail)	Present/Absent	Present/Absent
19	Recurrence of hernia	Present/Absent	Present/Absent
20	Satisfaction with the effect of cosmetic surgery	1—5	1—5
21	Carrying out daily tasks, physical exercises, work duties	With restrictions/ Without restrictions	With restrictions/ Without restrictions

Note. VAS — visual analogue scale. The numbers represent the intensity of the subjective patient's feelings, where 0 is the lowest intensity and 10 is the highest intensity.

secretions from the wound, and seepage of the bandage on the wound during the day with the need for its urgent replacement. All patients were instructed on the rules of post-operative wound care at home, methods of treating the wound with an antiseptic, and changing bandages.

During the patient's follow-up check-ups, in addition to the physical examination, an ultrasound examination of the anterior abdominal wall was performed in order to collect data on the development of local complications and hernia recurrence. If complications were detected, they were evaluated according to the Clavien-Dindo classification [7] and seromas according to the Morales-Conde classification [16].

Statistical analysis

The 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 ($p > 0,05$).

Results and discussion

At the time of discharge from the hospital, all patients from both groups met the requirements specified in the checklist (see Table 2). The overall incidence of complications after prosthetic ventral hernia hernioplasty was 15.6 %. In Group 1, complications occurred in 76 (21.2 %) patients after open hernioplasty. In Group 2, after laparoscopic hernioplasty with intraperitoneal mesh placement, complications were observed in 23 (9.9 %) patients. The detailed structure and frequency of complications for each of the subgroups are presented in Table 3.

All the complications we noted were related to Grades I—III b according to the Clavien-Dindo classification. In both groups, there were no fatalities. In subgroup 1a, 2 (0.8 %) patients experienced suppuration of the mesh (deep SSI) during the first 2 months after open hernioplasty sublay, which was classified as Grade III b. In both cases, the first stage of treatment involved attempting to preserve the mesh using VAC therapy, but due to its failure, the patients underwent a re-operation icluding mesh excision. In subgroup 1a, 4 (1.6 %) patients with hematomas in the early postoperative period required partial wound revision, and hematoma drainage, therefore we assigned these cases to Grade IIIa. We assigned Grade II to patients who underwent a puncture of the liquid formations (seroma and hematoma) under ultrasound control and received antibacterial drugs. We classified patients who underwent only a puncture into Grade I.

We did not observe any complications during HP, including intra-abdominal bleeding, intestinal wall damage, etc., in both groups. In Group 2, there were no conversion cases, which we explain by the individualised approach in the selection of candidates for laparoscopic HP, especially with large hernia defects.

All patients were advised to limit physical activity on the abdominal muscles for 1 month after surgery. All patients in Group 1, subgroups 2a and 2c were recommended to wear a postoperative bandage for at least 1 month from the moment of surgery. Bandage compression of the anterior abdominal wall in the area of the previous location of the hernial defect reduces the risk of seroma development [27]. 76 % of patients in Group 1 and 42 % in Group 2 expressed a desire to wear a postoperative bandage at the time of discharge, explaining this by reducing the severity of the pain syndrome.

In the early postoperative period, before discharge from the hospital, all patients underwent a control ultrasound examination. At discharge,

Table 3. **Structure and incidence of complications, recurrence of ventral hernia after open and laparoscopic hernioplasty**

Postoperative complications	Group 1		Group 2			Statistics according to publications
	1a (n = 243)	1b (n = 7)	2a (n = 81)	2b (n = 108)	2c (n = 43)	
Clavien — Dindo classification						
Grade I	22 (9.0 %)	1 (14.3 %)	7 (8.7 %)	9 (8.3 %)	2 (4.6 %)	
Grade II	24 (9.9 %)	0	0	4 (3.7 %)	1 (2.3 %)	
Grade IIIa	4 (1.6 %)	0	0	0	0	
Grade IIIb	2 (0.8 %)	0	0	0	0	
Grade IVa/b	0	0	0	0	0	
Seroma	28 (11.5 %)	1 (14.3)	5 (6.2 %)	12 (11.1 %)	0	0.5—78 %
Hematoma	14 (5.7 %)	0	0	0	2 (4.6 %)	0—4.8 %
Superficial SSI	6 (2.5 %)	0	0	0	1 (2.3 %)	3.1—10.8 %
Deep SSI	2 (0.8 %)	0	0	0	0	1.5 %
Urinary infection	2 (0.8 %)	0	0	1 (0.9 %)	0	0—2.1 %
Intestinal paresis	0	0	0	0	0	0—16 %
Intestinal obstruction	0	0	0	0	0	0.5—1 %
Postoperative bulging	0	0	2 (2.5 %)	0	0	1.3—21.5 %
Intraoperative complications	0	0	0	0	0	2—8 %
Recurrence	3 (1.2 %)	0	1 (1.2 %)	1 (0.9 %)	0	

Note. SSI — surgical site infection.

both groups showed no signs of fluid accumulation in the thickness of the anterior abdominal wall, which could be subject to puncture. 2 weeks after the operation, 43 (17.2 %) patients with fluid formations in the mesh area and in the thickness of the anterior abdominal wall were found in Group 1 — 43 (17.2 %) and in Group 2 — 19 (8.2 %) patients (p = 0.004). Simultaneously, Group 1 experienced a frequency of seroma of 11.6 % and hematoma of 5.6 %, while Group 2 experienced a frequency of 7.3 % and 0.9 %, respectively. A statistically significant increase in the frequency of hematoma development was observed after open HP techniques in comparison to laparoscopic ones (p = 0.004). The frequency of seroma detection was comparable (p = 0.148), which is consistent with the results of most publications comparing these methods [3]. In all cases, the formations were punctuated and evacuated under ultrasound control, of which in Group 1, eight (3.2 %) patients and in Group 2, three (1.3 %) patients required a repeated puncture one month after the operation. In Group 1, the maximum volume of evacuated fluid was 100 ml, while in Group 2, it was 50 ml.

According to the Morales-Conde classification, we should assign all cases of observation of punctured seromas under ultrasound control to type IV — large seromas that require puncture — in order to reduce symptoms (pain, discomfort). However, in only one case, a patient from subgroup 1a experienced minor discomfort in the area of the postoperative wound. In all other cases, the patients had no complaints; seromas were visualised during ultrasound examination of the anterior abdominal wall and were not observed longer than 3 months after the operation. In Group 1, the purpose of the puncture was to avoid suppuration of the wound, taking into account the open technique of performing HP, whereas in Group 2, it was to prevent possible protrusion and detachment of the mesh by free fluid that accumulated between the mesh and the parietal peritoneum. Therefore, we consider these cases not as complications but as incidents, classifying them into types I (n = 52) and II (n = 11). The issue of defining seroma as a complication of surgery and delineating the terms and feasibility of their puncture remains debatable [6, 15].

In the first 5 years of our study, 5 (2.2 %) patients underwent laparoscopic hernioplasty, a composite mesh was used for intra-abdominal placement with an anti-adhesive coating on both sides. In 2 out of 5 patients, we observed the development of seroma in the early postoperative period. Later, in connection with the withdrawal of this mesh from production, we used only mesh with a one-sided anti-adhesive barrier.

The frequency of infectious complications was significantly higher in Group 1 after open operations (3.2 %) compared to laparoscopic ones (0.4 %) (p = 0.041). Based on the results of the analysis of 5 randomised controlled trials, a similar trend was observed in the prevalence of SSI after open operations (10.8 %) over laparoscopic operations (3.1 %), but the difference in indicators did not reach statistical significance [23]. In the period of up to 14 days after the operation, local redness and swelling of the wound edges were observed in 6 patients after HP sublay in Group 1 and in 1 patient after IPOM+ hernioplasty in Group 2. The patient in Group 2 had obesity and type II diabetes. In all cases, after ultrasound examination of the wound area, the situation was considered a superficial infection without mesh involvement. There was no need for re-hospitalisation. Against the background of oral administration of broad-spectrum antibiotics for 5—10 days and local treatment with antiseptics, the signs of inflammation regressed and the wounds healed by primary tension.

The frequency of urinary tract infection after surgery was comparable in both groups (p = 0.952), with 0.8 % after open surgery and 0.4 % after laparoscopic HP, and did not exceed the frequency of 0—2.1 % according to the literature [20, 21].

Prolapse or postoperative bulging was detected in 2 (2.25 %) patients in subgroup 2a after laparoscopic IPOM without mesh suturing. According to Liang et al., postoperative bulging occurs in 21.5 % of patients after laparoscopic surgery and in 1.3 % after open VH repair [13]. The development of postoperative bulging did not require repeated surgical intervention. An ultrasound examination of the anterior abdominal wall ruled out a possible hidden recurrence of the hernia.

During the entire observation period, we found 5 (1.04 %) patients with hernia recurrences, 3 (1.2 %) after open hernioplasty and 2 (0.9 %) after laparoscopic, with no statistically significant difference between groups (p = 0.936). In all cases, when interviewing the patient, there were episodes of sharp physical exertion in the anamnesis. In Group 1, after open suturing of the hernia using the sublay technique, out of 3 cases of recurrence, in one case, superficial infection of the wound occurred in the early postoperative period. In Group 2, in one case, a relapse developed 11 months after the operation against the background of excessive physical exertion in a 65-year-old woman with a postoperative ventral hernia L 3- L 4 of more than 10 cm who was initially treated with IPOM and transcutaneous suturing of the hernia defect. During the repeat operation, the capacity of the applied sutures of the aponeurosis was diagnosed, but the edge of the

aponeurosis of the oblique muscles of the abdomen was torn off, resulting in the formation of a hernial defect near and below the eliminated previous one, with the migration of the lower edge of the mesh into the hernial sac. Therefore, a partial resection of the mesh that migrated into the hernia sac was performed. It was followed by open suturing of the aponeurosis with the placement of an additional mesh laparoscopically using the IPOM+ technique. In the second case, the relapse developed after laparoscopic IPOM without suturing of the hernial defect above the upper edge of the mesh. Consequently, relaparoscopy was performed. The procedure included suturing of the aponeurosis defect and prosthetic hernioplasty of IPOM with a larger mesh.

According to S. Olmi et al., independent risk factors for hernia recurrence are mesh coverage of a defect of less than 4 cm, use of resorbable fixation devices, mesh bulge, and infection, as well as patient-related factors such as advanced age and type of lateral iliac hernia L3 [17]. In our study, after laparoscopic operations, the first case of relapse exhibited three of the factors listed above, while the second case had 2.

We did not observe a statistically significant increase in the recurrence rate in subgroup 2a after IPOM without suturing of the hernia defect (1.2 %) compared to subgroup 2b with suturing (0.9 %) ($p = 0.59$). It is worth noting that 51 (63 %) patients in this subgroup were over 65 years old. According to the surveys conducted during follow-up examinations one year after IPOM without suturing the aponeurosis defect, the rate of performing daily tasks, physical exercises, and work duties without restrictions was 93.9 %, with restrictions 6.1 %, and was comparable to the similar indicator in patients in subgroups 2b and 2c, who underwent IPOM with suturing the aponeurosis defect. According to the data from separate randomised controlled trials, suturing of a hernia defect shows advantages over the technique of IPOM without suturing of a hernia. But the result of the meta-analysis by S. Jeong et al. testifies to the effect of the closure of fascial defects only on the level of seroma formation [10]. While the meta-analysis of A. Tandon et al. demonstrates significantly fewer adverse hernia-site events [26]. Therefore, we consider it a priority to perform hernia defect suturing in patients of working age when the benefits of restoring the function of the anterior abdominal wall outweigh the prolongation of the duration of the surgical intervention and the increase in anesthetic risk.

Satisfaction with the cosmetic effect of the operation during the entire observation period was 5 % higher in Group 2 after laparoscopic hernioplasty than in Group 1 after open hernioplasty. 97.9 % of patients were interviewed one month after the operation, 69.5 % after 6 months, and 29.2 % after one year. Detailed indicators of the level of satisfaction with the appearance of the anterior abdominal wall are presented in Table 4.

In Group 1, satisfaction with the cosmetic effect after open HP did not statistically differ between subgroups when performing the operation using the sublay technique and open IPOM in all observation periods (2 weeks — $p = 0.881$; 1 month — $p = 0.675$; 6 months — $p = 0.69$; 1 year — $p = 0.913$). In subgroup 1a, there were 2 cases where patients rated the cosmetic effect as «2 points — unsatisfied». In both of these cases, the patients were diagnosed with mesh suppuration and the postoperative wound was healing by secondary tension. Similarly, during the entire observation period, the highest satisfaction with the cosmetic effect in Group 2 was recorded in subgroup 2b after laparoscopic IPOM with suturing of the hernia defect ($p < 0.05$). The indicators for subgroups 2a and 2c after IPOM without suturing the defect and IPOM+ were lower than for subgroup 2b ($p < 0.01$), but comparable to each other ($p = 0.10$).

Table 4. **The level of patient satisfaction with the cosmetic effect of surgery after open and laparoscopic ventral hernia repair (M ± SD)**

Period after surgery	Group 1		Group 2		
	1a (n = 243)	1b (n = 7)	2a (n = 81)	2b (n = 108)	2c (n = 43)
2 weeks	4.39 ± 0.64 n = 243	4.43 ± 0.54 n = 7	4.69 ± 0.52 n = 81	4.96 ± 0.19 n = 108	4.54 ± 0.63 n = 43
1 month	4.33 ± 0.65 n = 240	4.43 ± 0.54 n = 7	4.69 ± 0.52 n = 81	4.96 ± 0.19 n = 108	4.54 ± 0.63 n = 43
6 months	4.48 ± 0.56 n = 153	4.57 ± 0.54 n = 7	4.46 ± 0.50 n = 69	4.97 ± 0.17 n = 70	4.67 ± 0.48 n = 36
1 year	4.53 ± 0.50 n = 61	4.50 ± 0.55 n = 6	4.38 ± 0.49 n = 34	5, 0 ± 0 n = 23	4.65 ± 0.49 n = 17

Summarising the results of our study, it is worth noting that the frequency of wound infection can be reduced by using laparoscopic HP techniques. Open surgical interventions can lead to a higher frequency of inflammatory complications from the wound and hematomas. The frequency of reccurence after open and laparoscopic HP is comparable.

In our study, there is a limitation regarding the duration of follow-up for most patients at one year. The longest follow-up time was 4 years in 6 patients who underwent laparoscopic surgery (IPOM). In 3 out of 4 patients, the aponeurosis defect was not sutured. In all 6 cases, mesh migration, hernia recurrence, or other complications were not observed in the late postoperative period.

Given the low rate of hernia recurrence and complications, as well as the limited sample of patients, we did not take into account the effect of different types of tackers on the treatment outcome. Moreover, the indicators of complications depending on the size of the hernial defect were not considered separately. In order to study the influence of certain factors related to the HP technique on the structure and frequency of complications and the level of relapses, it is advisable to continue research on a larger sample of patients with a follow-up period of more than one year.

Conclusions

The open sublay and laparoscopic IPOM HP procedures have a comparable recurrence rate of VH ($p > 0.05$). Non-suturing of the aponeurosis defect after laparoscopic IPOM in patients with VH did not result in an increase in the total number of complications or the percentage of recurrence ($p > 0.05$). Laparoscopic IPOM+ hernioplasty allows for reliable elimination of the hernia defect and demonstrates high patient satisfaction with the cosmetic effect of the operation. Laparoscopic IPOM with hernia suturing shows significantly higher patient satisfaction with the appearance of the anterior abdominal wall compared to other laparoscopic HP techniques. The use of ultrasound diagnostics during planned postoperative examinations allows for more accurate diagnosis of complications and hernia recurrence and increases the detection rate of such complications as seromas and hematomas, including clinically insignificant ones, thus increasing the number of punctures. An individual-personalised approach to choosing a method of surgical treatment, taking into account the risk factors for the development of complications, and conducting planned examinations after surgery using ultrasound diagnostics is promising for further research.

Declaration of interests

The authors have no conflicts of interest to declare.

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Ethics approval and written informed consent statements

All procedures performed in this study were in accordance with the ethical standards of the current Ukrainian regulations and with the 1964 Helsinki Declaration and its later amendments.

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.

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Післяопераційні ускладнення та рецидив грижі після застосування різних методів хірургічного ушивання вентральних гриж

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Протезувальна герніопластика (ГП) вентральних гриж (ВГ) асоціюється із 27 % ускладнень та з 37 % рецидиву грижі залежно від методики виконання. Використання лапароскопічних методів ГП дає змогу скоротити тривалість перебування пацієнта в стаціонарі та знизити ризик ранової інфекції. Дані щодо переваги лапароскопії над відкритою методикою за показниками рецидиву та інших видів ускладнень значно відрізняються. Контраверсійними є результати порівняння результатів ГП з/без ушивання грижового дефекту.

Мета — вивчити структуру та частоту післяопераційних ускладнень, частоту рецидивів грижі після застосування відкритої та лапароскопічної ГП гриж передньої черевної стінки.

Матеріали та методи. Проведено мультицентрове проспективне дослідження на клінічних базах кафедри загальної хірургії № 2 Національного медичного університету ім. О. О. Богомольця із залученням 482 пацієнтів із ВГ. Первинні ВГ були у 279 (57,9 %) пацієнтів, післяопераційні ВГ — у 203 (42,1 %). Пацієнтів розділили на дві групи, порівнянні за віком, співвідношенням статей та розподілом за розміром грижі. Група 1 — 250 (51,9 %) пацієнтів, яким застосовували відкриті методи ГП з ушиванням дефекту апоневрозу: підгрупа 1а — відкрита sublay (243 (50,4 %)), підгрупа 1в — відкрита IPOM (7 (1,5 %)), група 2—232 (48,1 %) пацієнти, яким проводили лапароскопічну ГП за методикою IPOM: підгрупа 2а — IPOM без ушивання дефекту апоневрозу (81 (16,8 %)), підгрупа 2в — IPOM з ушиванням дефекту апоневрозу (108 (22,4 %)), підргупа 2с — IPOM+ з ушиванням дефекту апоневрозу відкрито (43 (8,9 %)). Контрольні огляди пацієнтів, оцінку наявності ускладнень, рецидиву та оцінку задоволеності косметичним ефектом операції проводили через 2 тиж, 1 та 6 міс, 1 рік.

Результати. Загальна частота розвитку ускладнень після виконання ГП ВГ становила 15,6 %, після відкритої sublay — 21,2 %, після лапароскопічної IPOM — 9,9 %. Усі випадки ускладнень належали до I — IIIb ступеня за класифікацією Клав'є-Діндо. Летальних наслідків в обох групах не було. У групі 1 частота сером становила 11,6 %, гематом — 5,6 %, у групі 2 — 7,3 та 0,9 % відповідно. Виявлено статистично значуще підвищення частоти розвитку гематом після відкритих методів ГП порівняно з лапароскопічними ($p = 0,004$), тоді як частота виявлення сером була порівнянною ($p = 0,148$). Неушивання дефекту апоневрозу порівняно з ушиванням у пацієнтів з ВГ при лапароскопічній методиці IPOM не призводило до зростання загальної кількості ускладнень та частоти розвитку рецидиву ($p > 0,05$). Лапароскопічний IPOM з ушиванням грижі асоціювався із статистично значущо ($p < 0,05$) більшою задоволеністю пацієнтом вигляду передньої черевної стінки порівняно з іншими методами ГП.

Висновки. Виконання відкритої sublay та лапароскопічної IPOM ГП показало порівнянну частоту розвитку рецидиву ВГ ($p > 0,05$). Частота розвитку інфекційних ускладнень та гематом статистично значущо вища після відкритих операцій порівняно з лапароскопічними ($p = 0,041$ та $p = 0,004$ відповідно).

Ключові слова: вентральна грижа, післяопераційна грижа, ушивання грижі, сітка.

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Quality of life in patients with chronic slow-transit constipation according to the PAC-QOL questionnaire and the effectiveness of conservative therapy

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Objective — to assess the quality of life (QOL) of patients with chronic slow-transit constipation (CTC) according to the PAC-QOL (Patient Assessment of Constipation Quality of Life) questionnaire, as well as the effectiveness of conservative therapy.

Materials and methods. The study included 246 patients with chronic (more than 5 years) slow-transit constipation (CSTC group) and 70 patients without CSTC (reference group). These individuals were examined and treated in the clinics of Bogomolets National Medical University from 2014 to 2023. The onset of chronic slow-transit constipation often occurred at an average age of 22.2 ± 0.8 years (from 1 year to 67 years) and lasted 20.2 ± 0.7 years (from 5 to 53 years). The average duration of the delayed passage of stool was 9.4 ± 0.3 days (from 3 to 22 days). All patients received an adjusted course of conservative treatment according to the Rome guidelines. The nosospecific PAC-QOL questionnaire was used to evaluate the patients' quality of life on their initial visit and 6—8 months after conservative therapy.

Results. During the initial assessment, the CSTC group had a mean score of 3.03 ± 0.56 on the «Physical Discomfort» subscale, while the reference group had a mean score of 1.19 ± 0.29. On the «Psychosocial Discomfort» subscale, the CSTC group had a mean score of 2.21 ± 0.52 compared to 0.84 ± 0.18 in the reference group. The mean score for the «Worries and Concerns» subscale was 2.49 ± 0.41 in the CSTC group and 0.77 ± 0.24 in the reference group. The mean score for the «Satisfaction» subscale was 3.31 ± 0.43 in the CSTC group and 0.86 ± 0.28 in the reference group. The PAC-QOL questionnaire total score was 2.63 ± 0.26 in the CSTC group and 0.87 ± 0.12 in the reference group ($p < 0.001$ for all). After conservative treatment, the PAC-QOL scores improved by an average of 40.4 ± 20.0 % (to 0.68—2.71 points). The cluster analysis revealed that after the course of conservative therapy, the PAC-QOL questionnaire scores formed three distinct clusters: Cluster I—0.68—1.39 points (49.2 % of patients), Cluster II—1.40—1.99 points (17.5 % of patients), and Cluster III—2.0—2.8 points (33.3 % of patients). These clusters represent good, satisfactory, and unsatisfactory results.

Conclusions. The PAC-QOL questionnaire revealed a statistically significant decline in QOL in patients with CSTC (2.63 ± 0.26 points compared to 0.87 ± 0.12 points in the reference group). Modern conservative treatment improved quality of life in 49.2 % of cases. 17.5 % of cases showed a satisfactory result, while the remaining ones exhibited insignificant or no improvement. Other treatment options, including surgery, should be considered for patients who do not respond to conservative therapy.

Keywords
chronic slow-transit constipation, quality of life, PAC-QOL questionnaire, conservative therapy, results.

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Chronic constipation affects approximately 10—15 % of the population and is one of the most common gastrointestinal diseases that are treated in primary and secondary care [12]. It negatively affects quality of life (QOL) and is associated with a significant healthcare burden [16].

The term «constipation» is used to describe symptoms associated with difficulties in defecation. These include infrequent bowel movements, hard or lumpy stools, excessive straining, a feeling of incomplete evacuation or blockage, and, in some cases, the use of manual manoeuvres to facilitate evacuation [11]. Symptoms can be acute when they typically last less than a week and are caused by dietary and/or lifestyle changes (e.g., reduced fibre intake, reduced physical activity, stress, toileting in unfamiliar surroundings) [15]. In contrast, chronic constipation is usually characterised by symptoms that persist for at least 3 months [3].

The Rome criteria of the fourth revision classify chronic constipation disorders into four subtypes: (a) functional constipation (FC), (b) irritable bowel syndrome with constipation (IBS-C), (c) opioid-induced constipation (OIC), (d) functional bowel movements, including inadequate defecation propulsion and dyssynergic bowel movements [18].

The initial approach to the treatment of these disorders is the same, consisting of diet, lifestyle changes, and the use of standard over-the-counter laxatives. If the treatment is ineffective, additional therapy is prescribed based on the subtype [1, 2, 6—10, 13, 22].

According to a large meta-analysis of 45 population-based surveys covering 261,040 adults, the global prevalence of chronic constipation is estimated at 14 % (95 % confidence interval, 12—17 %) [21]. Chronic constipation is more common in women, the elderly, and people with lower socioeconomic status [5]. However, it can be argued that due to considerable heterogeneity between studies, caused by differences in sample size, duration of symptoms, definition criteria, and methods used to collect symptom data, the prevalence of chronic constipation worldwide is uncertain. Large studies, including large multinational collaborative studies with a common research methodology, are needed to clarify this. Recent data from a cross-population survey in three countries using a modern diagnostic questionnaire according to the Rome IV criteria showed that the prevalence of chronic constipation is approximately 9 %, with ~6 % being FC and the remaining cases being IBS-C and OIC, which occur with equal frequency [17]. A global epidemiological study of functional gastrointestinal disorders is ongoing. The prevalence of functional bowel movement disorders in the population is not known, as the diagnosis requires laboratory tests. In tertiary care centres, half of the cases of chronic constipation are not registered due to the absence of clear statistical information [3].

Patients usually have a long history of CSTC, most of it dating back to childhood. The disease is progressive in nature. It is characterised by numerous courses of conservative therapy with ambiguous (variable, unpredictable) effectiveness. CSTC negatively affects the QOL of patients, but there is a lack of research on this issue. The studies mainly used The Short Form-36 (SF-6) questionnaire, which is not nosospecific [19]. Only a few studies have been devoted to the assessment of QOL in patients with chronic constipation using the nosospecific PAC-QOL (Patient Assessment of Constipation Quality of Life) questionnaire, without focusing on the problem of CSTC. There is also a lack of information on the impact of conservative therapy on the QOL of people with CSTC, according to the PAC-QOL scale.

Objective — to assess the quality of life (QOL) of patients with chronic slow-transit constipation (CTC) according to the PAC-QOL (Patient Assessment of Constipation Quality of Life) questionnaire, as well as the effectiveness of conservative therapy.

Materials and methods

The study included 246 patients with chronic (more than 5 years) slow-transit constipation (CSTC group) and 70 patients without CSTC (reference group). These individuals were examined and treated according to the Rome criteria in the clinics of Bogomolets National Medical University from 2014 to 2023 [3, 19].

The study groups did not differ statistically significantly in terms of sex ratio, mean age, and body mass index. Women predominated in both groups: 233 (94.7 %) in the CSTC group and 65 (92.9 %) in the reference group ($p = 0.554$). The mean age was 42.8 and 41.5 years, respectively ($p = 0.458$). The body mass index was 22.7 ± 4.2 and 22.2 ± 2.0 kg/m^2, respectively ($p = 0.424$).

According to the anamnestic data, constipation occurred at different ages, on average at 22.2 ± 0.8 years (from 1 to 67 years), the duration of the disease before the visit to the clinic was on average 20.2 ± 0.7 years (from 5 to 53 years), and the delayed passage of stool before admission to the clinic was 9.4 ± 0.3 days (from 3 to 22 days). Stool consistency according to the Bristol Stool Form Scale corresponded to type I in 152 (61.8 %) patients, type 2 in 63 (25.6 %), type 3 in 21 (8.5 %), type 4 in 7 (2.8 %), and type 5 in 3 (1.2 %).

Before seeking medical assistance in our clinic, all patients received permanent conservative therapy, which gradually lost its effectiveness. 236 (95.9 %) patients used a high-fibre diet, 237 (96.3 %) used pharmacological agents, and 183 (74.4 %) used cleansing enemas.

The nosospecific PAC-QOL questionnaire was used to evaluate the patients' quality of life on their initial visit and 6—8 months after an adjusted course of conservative therapy.

The original English version of the Patient Assessment of Constipation Quality of Life (PAC-QOL, © PAC-QOL, 2005 Mapi Research Trust, all rights reserved) is a questionnaire that is often used to assess the impact of chronic constipation on QOL and daily activities using a simple structure and scoring system. It was developed and validated by R. Marquis et al. in 2005 [14]. The PAC-QOL questionnaire has been translated into different languages and validated in many countries. We used the PAC-QOL questionnaire to improve the clinical assessment of constipation in patients.

The PAC-QOL questionnaire contains 28 items grouped into 4 subscales: worries and concerns (11 items), physical discomfort (4 items), psychosocial discomfort (8 items), and treatment satisfaction (5 items). A five-point Likert response scale ranging from 0 (not at all/never) to 4 (strongly/all the time) is used over a 2-week period (a higher score indicates a worsening of QOL due to constipation). The total score and scores for each subscale were calculated according to the original PAC-QOL document. The test took 10—14 minutes to complete [14].

All patients received conservative treatment according to the Rome criteria [3, 13], taking into account drugs licensed in Ukraine.

Statistical analysis was performed using IBM SPSS Statistics, V 22. Discriminant statistics were calculated. The data were assessed for normality using the Shapiro-Wilk test. Mean values are presented as M ± SD. Categorical data were expressed as numbers (%). Comparison of mean values of quantitative variables was performed using the Student's t-test for data whose distribution does not differ from normal; for data whose distribution differs from normal, comparison of variables was performed using the Wilcoxon-Mann-Whitney U-test. To identify groups of similar objects, a two-stage cluster analysis was performed. A comparison of relative values was performed using Pearson's χ^2 test. The null hypothesis of equality of variables was rejected at $p < 0.05$.

Results

Despite the fact that patients with CSTC had a long history of conservative treatment, when they came to the clinic, they had unsatisfactory QOL indicators for all subscales of the PAC-QOL questionnaire, which significantly exceeded the reference ones. Thus, according to the Physical Discomfort subscale (Fig. 1), the mean score in the CSTC group was 3.03 ± 0.56 (from 1.5 to 4.0 points), while in the reference group it was 1.19 ± 0.29 (from 0.25 to 1.75 points, $p < 0.001$).

According to the Psychosocial Discomfort subscale (Fig. 2), the mean score in the CSTC group was 2.21 ± 0.52 (from 1.13 to 3.38 points), while in the reference group it was 0.84 ± 0.18 (from 0.5 to 1.38 points, $p < 0.001$).

According to the Worries and Concerns subscale (Fig. 3), the mean score in the CSTC group was 2.49 ± 0.41 (from 1.55 to 3.45 points), while in the

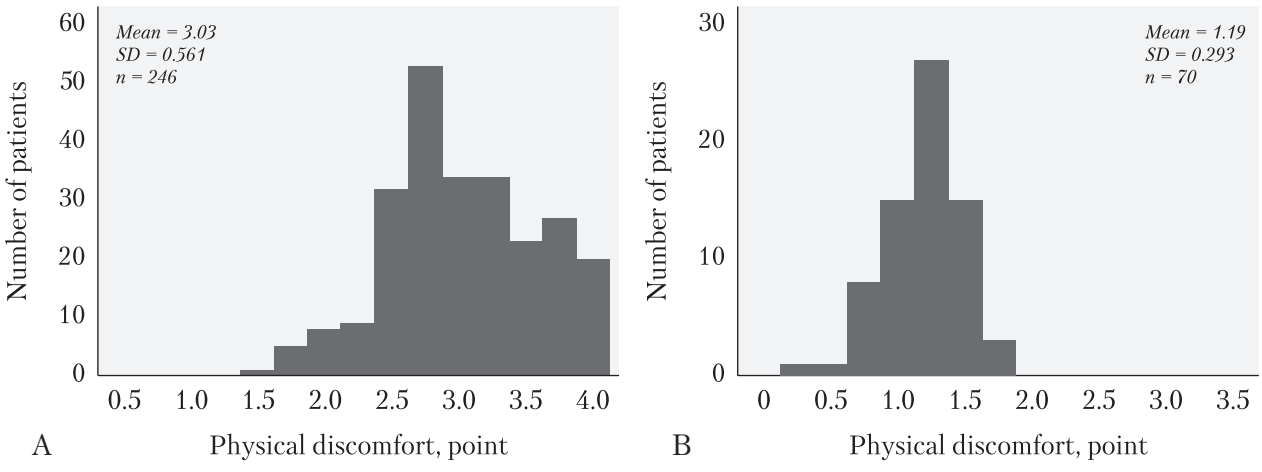

Figure 1. **Distribution by the mean score of the Physical Discomfort subscale in the CSTC group (A) and the reference group (B) before the course of conservative therapy**

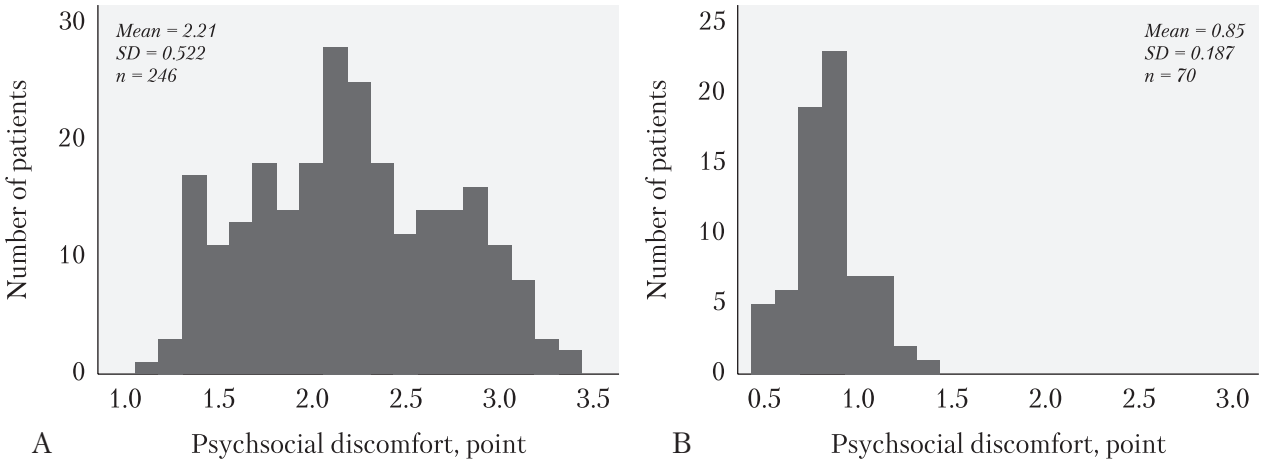

Figure 2. **Distribution by the mean score of the Psychosocial Discomfort subscale in the CSTC group (A) and the reference group (B) before the course of conservative therapy**

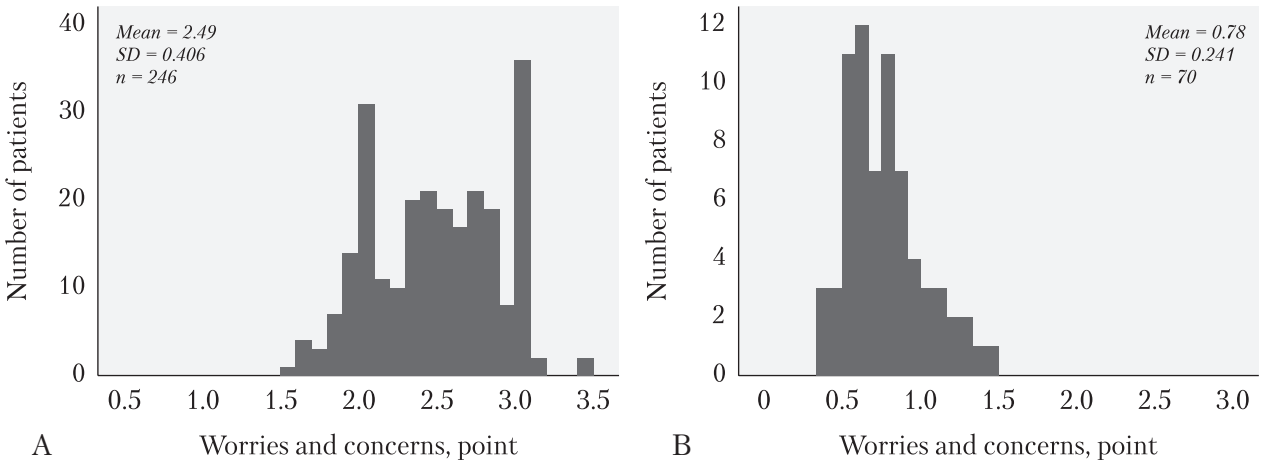

Figure 3. **Distribution by the mean score of the Worries and Concerns subscale in the CSTC group (A) and the reference group (B) before conservative therapy**

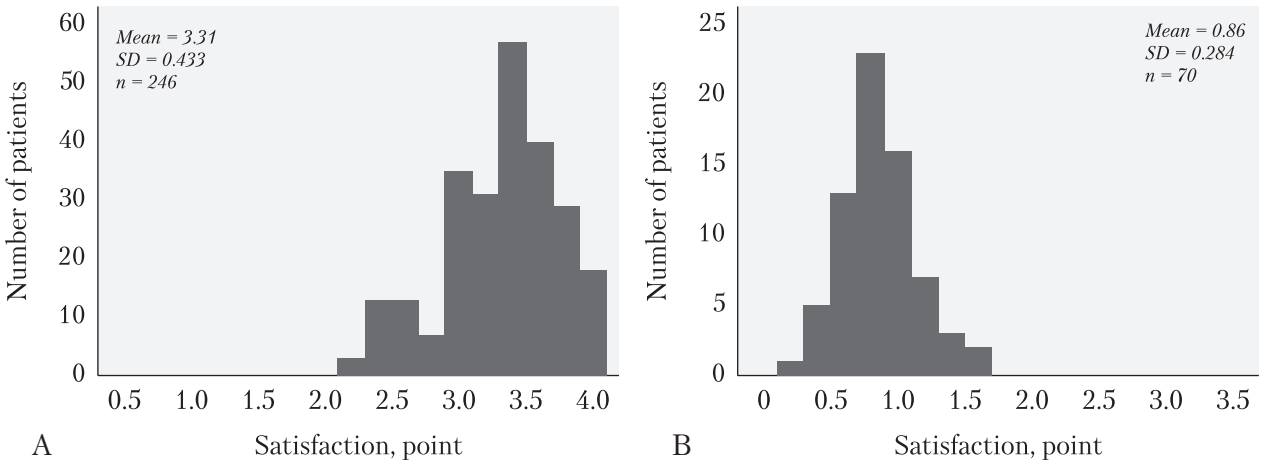

Figure 4. **Distribution by the mean score of the Satisfaction subscale in the CSTC group (A) and the reference group (B) before conservative therapy**

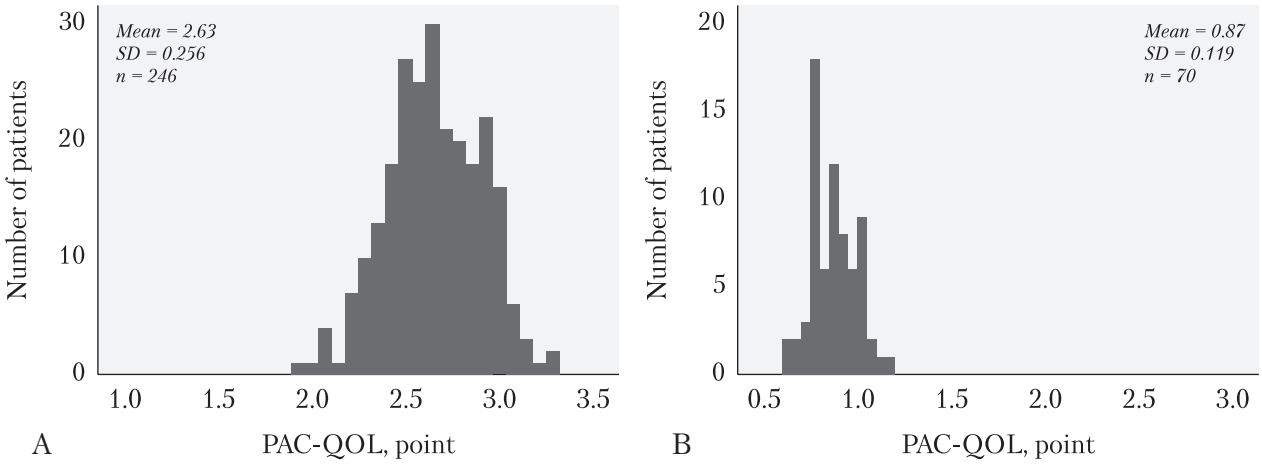

Figure 5. **Distribution by the total PAC-QOL questionnaire score in the CSTC group (A) and the reference group (B) before conservative therapy**

reference group it was 0.77 ± 0.24 (from 0.36 to 1.45 points, $p < 0.001$).

According to the Satisfaction subscale (Fig. 4), the mean score in the CSTC group was 3.31 ± 0.43 (from 2.20 to 4 points), while in the reference group it was 0.86 ± 0.28 (from 0.20 to 1.60 points, $p < 0.001$).

The total PAC-QOL questionnaire score (Fig. 5) averaged 2.63 ± 0.26 in the CSTC group (from 1.93 to 3.29 points) and 0.87 ± 0.12 in the reference group (from 0.61 to 1.18 points, $p < 0.001$).

After conservative treatment, a decrease in the PAC-QOL questionnaire score was noted in all patients by an average of 40.4 ± 20.0 % (Table 1, Fig. 6).

According to the PAC-QOL questionnaire and all its subscales, the mean values of QOL indicators after the course of conservative treatment were statistically significantly better than before treatment ($p < 0.001$ for all), but worse than the corresponding indicators in the reference group ($p < 0.001$ for all).

After conservative treatment, there was significant variability in the mean scores for all subscales

Table 1. **Score reduction on the PAC-QOL questionnaire and its subscales after conservative treatment**

Variable	Mean ± StD	Min—Max
Physical discomfort	29.0 ±20.9	0.0—88.9
Psychosocial discomfort	31.7 ±19.2	0.0—66.7
Worries and concerns	45.9 ±28.0	–31.6 ... +96.2
Satisfaction	47.8 ±22.2	14.3—94.7
PAC-QOL	40.4 ±20.1	3.7—69.9

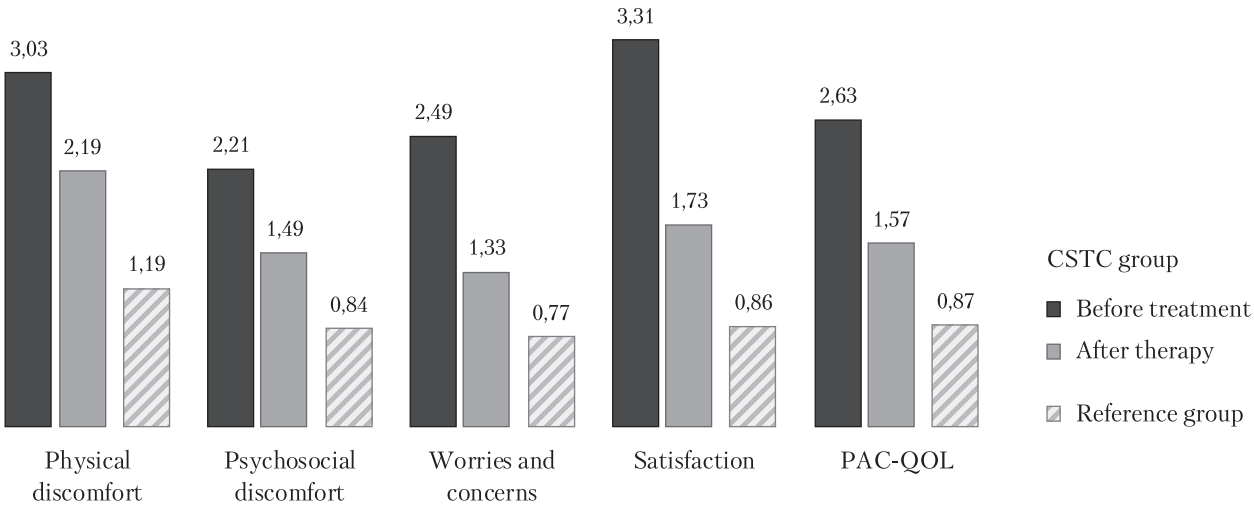

Figure 6. **Average scores of quality of life indicators before and after treatment in the CSTC group and in the reference group**

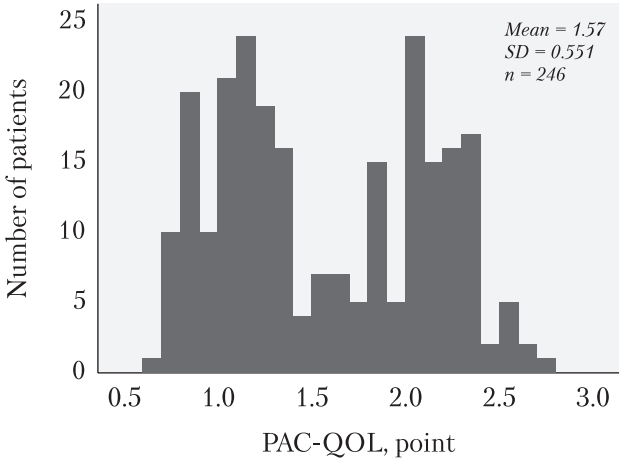

Figure 7. **Distribution of the average score on the PAC-QOL questionnaire in patients in the CSTC group after a course of conservative therapy**

and the PAC-QOL questionnaire. In particular, the total score on the PAC-QOL questionnaire ranged from 0.68 to 2.71 (Fig. 7).

It is noteworthy that only 86 (35 %) patients had mean values of the total PAC-QOL score within the reference values (from 0.61 to 1.18).

The cluster analysis revealed that after conservative therapy, the PAC-QOL questionnaire scores formed three distinct clusters with a good silhouette measure of connectivity and cluster separation: Cluster I — 0.68—1.39 points; Cluster II — 1.40—1.99 points; and Cluster III — 2.0—2.8 points. This indicates that conservative treatment has a different impact on QOL. In 121 (49.2 %) patients, the total score on the PAC-QOL questionnaire belonged to the first cluster, in 43 (17.5 %) to the second cluster, in 82 (33.3 %) to the third cluster, which may correspond to good, satisfactory, and unsatisfactory results.

This variability in the results of conservative treatment was recorded for all subscales of the PAC-QOL questionnaire (Table 2).

Thus, the PAC-QOL questionnaire revealed that modern conservative treatment improved quality of life in 49.2 % of cases. 17.5 % of cases showed a satisfactory result, while the remaining ones exhibited insignificant or no improvement.

Discussion

Conservative treatment of patients with FC should alleviate certain symptoms and improve QOL, but for some patients with CSTC who already have extensive experience with conservative treatment and still seek help, modern conservative treatment regimens do not always have the desired effect.

Using the PAC-QOL questionnaire, we analysed the QOL of patients with CSTC before and after conservative treatment. We did not find information on the use of this questionnaire in patients with CSTC to compare the results of conservative treatment with baseline.

The authors used various questionnaires to assess the severity of constipation [20, 23]. In particular, in 2015, an article was published in which the authors used the PAC-QOL and SF-36 questionnaires to analyse patients with chronic FC and IBS-C according to the Rome III criteria. The PAC-QOL questionnaire was filled out by 43 patients (14 % with IBS-C, 37 % with FC, and 49 % with unclassified constipation) and the SF-36 questionnaire was filled out by 93 patients (23 % with IBS-C, 27 % with FC, and 51 % with unclassified constipation) [19].

The SF-36 questionnaire showed that patients with IBS-C had a worse quality of life compared to the groups of people with functional and

Table 2. **Results of cluster analysis of the PAC-QOL questionnaire after a course of conservative treatment (Min—Max)**

Variable	Cluster I	Cluster II	Cluster III
Physical Discomfort	0.25—1.75 n = 85 (34.6 %)	2.00—2.75 n = 112 (45.5 %)	3.00—3.75 n = 49 (19.9 %)
Psychosocial Discomfort	0.75—1.38 n = 128 (52.0 %)	1.50—2.00 n = 83 (37.7 %)	2.13—2.88 n = 35 (14.2 %)
Worries and Concerns	0.90—1.09 n = 124 (50.4 %)	1.27—1.82 n = 44 (17.9 %)	1.91—2.64 n = 78 (31.7 %)
Satisfaction	0.2—1.4 n = 104 (42.3 %)	1.6—2.2 n = 76 (30.9 %)	2.4—3.4 n = 66 (26.8 %)
Total	0.68—1.39 n = 121 (49.2 %)	1.40—1.99 n = 43 (17.5 %)	2.0—2.8 n = 82 (33.3 %)

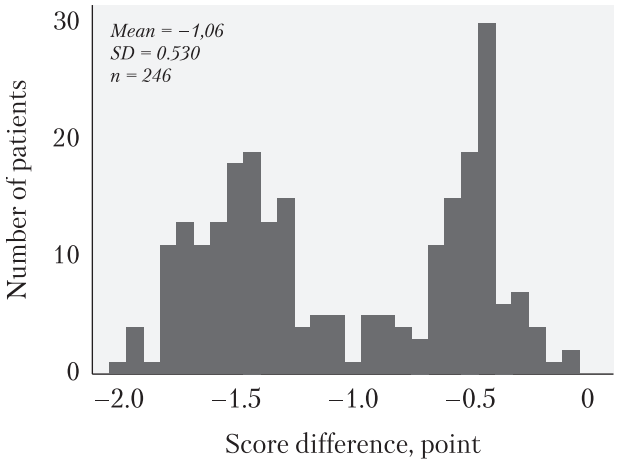

Figure 8. **Distribution of patients by absolute decrease in the total score on the PAC-QOL questionnaire after a course of conservative therapy**

unclassified constipation. Statistically significant differences were found on the fatigue/energy scale between patients with IBS-C and patients with functional constipation in favour of the latter (41.67 ± 3.386 vs. 55.20 ± 4.383; p = 0.0221) and on the pain scale between patients with IBS-C and patients with unclassified constipation (49.64 ± 5.290 vs. 63.62 ± 3.673; p = 0.0362).

The PAC-QOL questionnaire also showed worse results in patients with IBS-C than in patients with FC in terms of the physical component (10.00 ± 1.125 vs. 4.938 ± 0.8086; p = 0.0029), psychosocial component (14.33 ± 2.704 vs. 7.438 ± 1. 469; p = 0.0278), concerns and worries score (17.33 ± 4.410 vs. 9.375 ± 1.494; p = 0.0379), treatment satisfaction (16.50 ± 0.4282 vs. 10.31 ± 1.440; p = 0.0180), and overall PAC-QOL score (2.077 ± 0.2704 vs. 1.146 ± 0.1391; p = 0.0034) [19].

In 2017, Italian gastroenterologists provided data on patients with FC, IBS-C, and unclassified constipation who received various conservative therapies using the Bristol Scale, the Patient Assessment of Constipation Symptoms (PAC-SYM), and the PAC-QOL questionnaires. The authors concluded that patients with IBS-C had worse QOL than those with FC and unclassified constipation, according to all questionnaires [4].

Unfortunately, we have not found any articles in the literature that provide data on QOL determination by the PAC-QOL questionnaire in patients with CSTC before and after conservative treatment.

According to our data, QOL in patients with CSTC is significantly impaired. During the initial assessment, the CSTC group had a mean score of 3.03 ± 0.56 on the «Physical Discomfort» subscale, while the reference group had a mean score of 1.19 ± 0.29. On the «Psychosocial Discomfort» subscale, the CSTC group had a mean score of 2.21 ± 0.52 compared to 0.84 ± 0.18 in the reference group. The mean score for the «Worries and Concerns» subscale was 2.49 ± 0.41 in the CSTC group and 0.77 ± 0.24 in the reference group. The mean score for the «Satisfaction» subscale was 3.31 ± 0.43 in the CSTC group and 0.86 ± 0.28 in the reference group. The PAC-QOL questionnaire total score was 2.63 ± 0.26 in the CSTC group and 0.87 ± 0.12 in the reference group ($p < 0.001$ for all). After adjusted conservative therapy, only 86 (35 %) patients registered a total score on the PAC-QOL questionnaire that reached the limits of reference values (from 0.61 to 1.18). If the QOL of all patients is assessed using cluster analysis, the proportion of patients with relatively good results is 49.2 %, with insignificant or no improvement — 33.3 %. The original article [14] suggests that the effect of conservative treatment should be assessed by a reduction in the PAC-QOL score, with a decrease of 0.5 in the total score considered a minimally significant improvement. According to this assessment, 69 (28.0 %) patients had insignificant or no improvement (Fig. 8).

Assessment of the outcome by the value of the change in the indicator has a disadvantage, since even with a significant change, the absolute value of the indicator may remain high and indicate poor QOL. A comparison of QOL indicators in patients with CSTC with reference values, in our opinion, more clearly assesses their condition, but this requires additional research.

The fact that after prolonged pretreatment, patients came to the clinic with unsatisfactory PAC-QOL scores compared to the reference group, and in 33.3 % of them, they remained at this level after therapy adjusted according to the Rome guidelines, indicates the complexity of the problem and the heterogeneous nature of the disease. Other treatment options, including surgery, should be considered for patients who do not respond to conservative therapy.

Conclusions

The PAC-QOL questionnaire revealed a statistically significant decline in QOL in patients with CSTC (2.63 ± 0.26 points compared to 0.87 ± 0.12 points in the reference group).

Modern conservative treatment improved quality of life in 49.2 % of cases. 17.5 % of cases showed a satisfactory result, while the remaining ones exhibited insignificant or no improvement.

Other treatment options, including surgery, should be considered for patients who do not respond to conservative therapy.

Declaration of interests

The authors declare that they have no conflicts of interest.

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Authors contributions

Conception and design of the study, statistical analysis — I. M. Leshchyshyn, L. Y. Markulan; collection and analysis of data — I. M. Leshchyshyn, P. L. Byk; writing the manuscript — I. M. Leshchyshyn; critical revision — I. M. Leshchyshyn, O. I. Okhotska.

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Якість життя хворих із тривалими повільнотранзитними запорами за опитувальником PAC-QOL та ефективність консервативної терапії

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Мета — визначити якість життя (ЯЖ) хворих із хронічними повільнотранзитними запорами (ХПТЗ) за опитувальником PAC-QOL (Patient Assessment of Constipation Quality of Life Questionnaire) та ефективність консервативної терапії.

Матеріали та методи. У дослідження було залучено 246 хворих із тривало існуючими (понад 5 років) повільнотранзитними запорами (група ХПТЗ) та 70 пацієнтів без ХПТЗ (референтна група), обстежених і пролікованих на базах клінік Національного медичного університету імені О. О. Богомольця в період з 2014 до 2023 р. Хронічні повільнотранзитні запори виникали в середньому в (22,2 ± 0,8) року (від 1 року до 67 років), та існували (20,2 ± 0,7) року (від 5 до 53 років). Затримка випорожнення становила в середньому (9,4 ± 0,3) доби (від 3 до 22 діб). Усі хворі отримали відкориговане консервативне лікування згідно з Римськими рекомендаціями. Якість життя хворих оцінювали за нозоспецифічним опитувальником PAC-QOL під час першого візиту та після курсу консервативної терапії через 6—8 міс.

Результати. Під час першого візиту середній бал у групі ХПТЗ за субшкалою «Фізичний дискомфорт» становив (3,03 ± 0,56), у референтній групі — (1,19 ± 0,29), за субшкалою «Психологічний дискомфорт» — відповідно (2,21 ± 0,52) та (0,84 ± 0,18), за субшкалою «Тривожність та занепокоєння» — (2,49 ± 0,41) і (0,77 ± 0,24), за субшкалою «Задоволеність» — (3,31 ± 0,43) та (0,86 ± 0,28), загальний бал за опитувальником PAC-QOL — (2,63 ± 0,26) і (0,87 ± 0,12) (усі $p < 0,001$). Після консервативного лікування показники опитувальника PAC-QOL поліпшилися в середньому на (40,4 ± 20,0) % (до 0,68—2,71 бала). Згідно з кластерним аналізом показники опитувальника PAC-QOL після курсу консервативної терапії мали три кластери: перший — 0,68—1,39 бала (49,2 % хворих), другий — 1,40—1,99 бала (17,5 % хворих), третій — 2,0—2,8 бала (33,3 хворих), що може відповідати добрим, задовільним і незадовільним результатам.

Висновки. У хворих із ХПТЗ згідно з показниками опитувальника PAC-QOL статистично значущо погіршилася ЯЖ ((2,63 ± 0,26) бала порівняно з (0,87 ± 0,12) бала в референтній групі). Сучасне консервативне лікування суттєво поліпшило ЯЖ у 49,2 % випадків. Задовільний результат досягнуто в 17,5 % випадків, тоді як у решті випадків зареєстровано слабкий ефект або відсутність поліпшення. У хворих із резистентністю до консервативної терапії слід розглянути інші методи лікування, зокрема оперативне втручання.

Ключові слова: хронічний повільно-транзитний запор, якість життя хворих, опитувальник PAC-QOL, консервативна терапія, результати.

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The significance of clinical and morphological characteristics of spinal cord astrocytomas in the choice of surgical tactics

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Objective — to determine the factors affecting the dynamics of the neurological status in the postoperative period in patients with intramedullary spinal cord astrocytomas (SCA) in order to improve the results of their surgical treatment.

Materials and methods. Between 2010 and 2019, we conducted a retrospective study on the surgical treatment outcomes of 39 SCA patients operated on at the SI "Romodanov Neurosurgery Institute of the National Academy of Medical Sciences of Ukraine". The age of the patients ranged from 19 to 67 years, with an average age of 41.4 years. Out of the total, 25 patients (64 %) were men and 14 patients (36 %) were women. We observed cervical localization in 11 (28 %) clinical cases, thoracic localization in 25 (64 %), and conus medullaris in 3 (8 %). All patients underwent a comprehensive clinical and instrumental examination using magnetic resonance imaging with intravenous enhancement, computed tomography, and spondylography. The dynamics of neurological symptoms were evaluated using the modified McCormick before surgery, at the time of the patient's hospital discharge, and during follow-up examinations.

Results. Total removal of SCA was performed in 7 (18 %) patients, subtotal in 25 (64 %), and partial in 7 (18 %). Pilocytic astrocytoma (PA) (World Health Organisation (WHO) grade I) was detected in 19 (49 %) patients, diffuse astrocytoma (DA) (WHO grade II) in 17 (43 %), and anaplastic astrocytoma (AA) (WHO grade III) in 3 (7 %). Partial regression of neurological symptoms was noted in 29 (74 %) patients, the neurological status remained at the preoperative level in 6 (15 %) patients, and a slight increase in the neurological deficit was noted in 4 (10 %) patients. Age < 60 years is significantly more frequently associated with the growth of PA, while age > 60 years is significantly more frequently associated with the growth of AA. The duration of anamnesis (< 1 year and > 1 year) and the degree of radicality of the operation were identified as significant factors that can influence the neurological status in the late postoperative period, mainly in patients with PA and DA. However, such factors as tumour location and the degree of infiltration of nearby structures are not statistically significant. AA is associated with an unfavourable prognosis across all important criteria.

Conclusions. The most important determinants of SCA prognosis are preoperative and postoperative neurological condition, resection extent, and histological grade. Patients with minor neurological damage at the time of surgery, those under the age of 60, and those with highly differentiated SCA had the greatest surgical treatment outcomes. Assessment of the preoperative neurological status and determination of the histological type of the tumour are important factors in choosing the optimal surgical tactics, which can improve treatment outcomes and the quality of life in SCA patients.

Keywords
intramedullary spinal cord astrocytomas, surgical treatment, neurological symptoms.

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Primary spinal cord tumours overage about 4—8 % of all central nervous system tumours [1, 2, 5, 29]. Depending on the location, they are divided into extradural, intradural extramedullary, and intramedullary [2, 7, 8]. The share of intramedullary spinal cord tumours (IMSCT) does not exceed 20 % among all primary spinal cord tumours, while in children, IMSCT occurs two times more commonly than in adults. Spinal cord gliomas in adults account for 90 % of all IMSCT, and their histology is mainly represented in 60 % of cases by ependymomas and in 30 % of cases by astrocytomas [2, 5, 7, 8, 13]. Less common types of IMSCT are hemangioblastomas (3—8 %), primary lymphomas of the Central Nervous System (CNS) (0.5—2.0 %) etc. [5, 7—10].

Intramedullary spinal cord astrocytomas (SCA) account for approximately 30 % of all primary IMSCT in adults, and up to 60 % of all IMSCT in children [1, 8]. The prevalence of SCA in the population is about 0.045—0.22 per 100,000. For example, in the USA, approximately 136 SCAs are diagnosed annually [3, 8, 10, 11, 28]. A predominant localization of SCA is in the cervical and thoracic parts of the spinal cord. Unlike brain astrocytomas, most intramedullary SCAs are highly differentiated histological variant pilocytic astrocytomas (PA) (World Health Organisation (WHO) grade I) and fibrillary diffuse astrocytomas (DA) (WHO grade II) [16]. PA has a prevalence in all age groups but is significantly more commonly diagnosed in children and somewhat more often in young and middle-aged adults, while DA is most commonly found in adults (5). In elderly and senile patients ≥ 65 years, anaplastic astrocytomas (AA) (WHO grade III) and not otherwise specified (NOS) astrocytoma have significantly higher levels than in more younger groups (5) [1, 5, 9].

The past decades have seen an increasing interest in identifying the genomic profile of SCA [12, 13, 28]. Detection of target genes or biomarkers can improve the prognosis of the disease and treatment strategies and may represent novel targets for individual or genetic therapy. The WHO classification of CNS (2016, 2021) included molecular markers and defined new subtypes of IMSCT based on genetics [16, 17, 28, 35].

The choice of optimal tactics for surgical treatment of intramedullary SCA is an urgent problem in modern neurosurgery, given the small prevalence of this pathology and its unsatisfactory functional consequences in the postoperative period [1, 2, 13, 23, 24, 26]. The effectiveness of radio- and chemotherapy for the treatment of SCA is limited [1, 4, 14]. But new investigations in the sphere of gene mutations in IMSCT can open new opportunities in targeted therapy. The diagnosis of IMSCT, mainly SCA, includes a detailed clinical and neurological examination, magnetic resonance imaging of the spine and spinal cord (MRI) with intravenous enhancement, computed tomography (CT), less often spondylography, and neurophysiological examination [4, 14, 20]. The further choice of treatment tactics depends on several factors: clinical picture, histogenesis of the tumour, anatomical localization, etc. Surgical removal is the primary method of SCA treatment, primarily for treating grade I—II astrocytomas [1, 9, 10, 23, 24, 26]. Adjuvant therapy in the postoperative period can improve the results of SCA treatment after partial removal of the tumour and in the case of recurrences and multifocal lesions, but its effectiveness needs clarification [12, 28].

Surgical tactics must be optimised, as the lack of generally accepted recommendations for the management of SCA patients, despite their low prevalence, leads to mostly unsatisfactory treatment outcomes.

Objective — to determine the factors affecting the dynamics of the neurological status in the postoperative period in patients with intramedullary spinal cord astrocytomas in order to improve the results of their surgical treatment.

Materials and methods

Between 2010 and 2019, we conducted a retrospective study on the surgical treatment outcomes of 39 SCA patients operated on at the SI «Romodanov Neurosurgery Institute of the National Academy of Medical Sciences of Ukraine». The age of the patients ranged from 19 to 67 years, with an average age of 41.4 years. Out of the total, 25 patients (64 %) were men and 14 patients (36 %) were women. Anamnesis ranged from 2 months to 3.3 years (average term — 18 months). We observed cervical localization in 11 (28 %) clinical cases, thoracic in 25 (64 %), and conus medullaris in 3 (8 %).

The dynamics of neurological symptoms were evaluated using the modified McCormick Scale (MMS) before surgery, at the time of the patient's hospital discharge, and during follow-up examinations (Table 1) [5].

Neurovisualization included MRI with intravenous enhancement (in all observations), CT in 7 (18 %) patients and spondylography in 7 (18 %) patients. Contrast was used in order to differentiate SCA from other types of ITSC and demyelinating diseases. The level of tumour extension was classified into less than three involved segments and three or more segments.

Gross total removal (GTR) of SCA was performed in 7 (18 %) patients, subtotal (SR) in 25 (64 %),

Table 1. **Modified McCormick scale for evaluation of neurological functions in spinal cord diseases**

Grade	Neurological status
I	Intact neurologically, normal ambulation, minimal dyesthesia
II	Mild motor or sensory deficit, functional independence
III	Moderate deficit, limitation of function, independent with external aid
IV	Severe motor or sensory deficit, limited function, dependent
V	Paraplegia or quadriplegia, even with flickering movement

and partial removal/biopsy (PR) in 7 (18 %). To prevent the damage to functionally important areas of the spinal cord, electrophysiological monitoring was performed — the recording of somatosensory evoked potentials (SEPs) and, in some cases, motor evoked potentials. Intraoperative ultrasonography was performed to clarify the boundaries and localization of SCA.

According to the WHO Classification (2016) [16] PA (WHO grade I) was detected in 19 (49 %) patients, fibrillary DA (WHO grade II) in 17 (43 %), and AA (WHO grade III) in 3 (8 %). According to the International Classification of Diseases for Oncology, 3rd edition (ICD-O-3), the following histological codes were detected: 9421/1 (pilocytic astrocytoma), 9420/3 (fibrillary diffuse asctocytoma), and 9401/3 (anaplastic astrocytoma). 18 (46 %) patients received adjuvant therapy (radiation and chemotherapy) according to the established protocols [28]. In all patients, catamnesis was present from 2 months to 2 years (M ± 9 months).

The exclusion criteria were defined as the age of patients < 18 years, non-intradural intramedullary astrocytomas, unknown clinical status before and after surgery, non-surgical treatment, unknown WHO grade, not a primary tumour, and no active follow-up.

Statistical analysis

Statistical analysis was carried out using the Fisher extract test to compare the factors of age, duration of anamnesis, location of the tumour, histology, extent of resection, MMS grades in pre- and postoperative periods and during late follow-up etc. We didn't analyse survival rates due to the small number of cases. Statistical analysis was performed using IBM SPSS Statistics 22 for Windows 10. Statistical significance was defined as $p < 0.05$.

Results

Neurological outcomes

The mean duration of symptoms was 18 months, with a range from 2 months to 3.5 years. 20 (51 %) patients were operated on during the first year from the appearance of the first symptoms of the disease; within 1 to 2 years, 13 (33 %) patients; within 2 to 3 years, 3 (8 %) patients, and with a disease history of more than three years, 3 (8 %) patients.

During the **preoperative** assessment of patients' neurological status using the MMS, it was established that 1 (2 %) patient could be assigned to the I grade of neurological status, 25 (64 %) to the II grade, 9 (24 %) to the III grade, 3 (8 %) to the IV grade, and 1 (2 %) to the V grade. During the preoperative examination, the median MMS score was 2.4. Patients with IV and V grades were > 60 years old.

A complex neurological examination of SCA patients revealed that local pain was the most common symptom in 34 (87 %) patients of different age groups. Sensory disorders were observed in 30 (77 %) patients and were manifested mainly by paresthesias, hypoesthesias, and dysesthesias of the conductive and segmental types in the early stages of the disease. Movement disorders in the form of limb paresis of varying severity were diagnosed in 35 (87 %) patients. Functional disorders of the pelvic organs in combination with urinary frequency or incontinence were detected in 26 (67 %) patients and observed, mainly in the late stages of the disease, except for tumours of conus medullaris.

Postoperatively, we classified neurological outcomes as good in patients with grades I—III and poor in patients with grades IV and V. A 1—2 point regression of neurological symptoms was considered an improvement, and changes of more than 2 points compared to the initial status were considered statistically significant. The more objective dynamics of neurological symptoms were observed at the time of discharge from the hospital. 29 (74 %) patients showed partial regression of neurological symptoms, with grade I in 2 (5 %) and grade II in 27 (69 %). 6 (15 %) patients maintained their neurological status at the preoperative level (grade III), while 4 (10 %) patients experienced a slight worsening of their neurological deficit (grade III in 2 and grade IV in 2). There were no fatal cases. The median MMS postoperative period was 2.3. At the late follow-up, 33 (87 %) patients improved their neurological status: up to grade I — 6 (15 %), up to grade II — 24 (62 %), and up to grade III — 3 (8 %). 6 (15 %) patients showed no changes (4 patients — grade III, and 2 patients- grade IV). Persistent motor and sensory disturbances, particularly pelvic organ dysfunction, are unfavourable prognostic factors for functional recovery even with

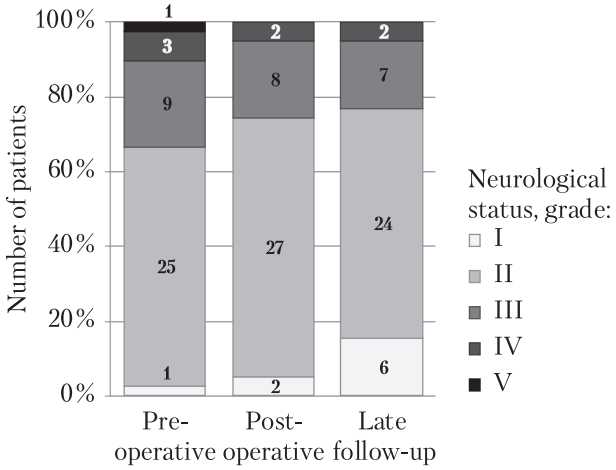

Figure 1. **The dynamics of the neurological status of SCA patients in pre- and postoperative periods according to the MMS**

successful SCA removal. The median MMS at the late follow-up was 2.1 (Fig. 1).

Minimal changes in the median MMS grades of the neurological status in the pre-postoperative periods and during late follow-up (2.4; 2.3; 2.1 respectively) are due to the severity of the pathology and changes within the groups, for example, an increase in the number of patients who can be attributed to grade I according to MMC in the late follow-up.

An interesting trend emerged during the evaluation of the dynamics of neurological symptoms according to the MMS scale in patients with SCA of different histological types in the pre- and postoperative periods. Thus, statistically significant improvement of the neurological status was detected in patients with PA in the late follow-up period in comparison with the preoperative period: increasing the number of patients with grade I according to MMS and decreasing the number of patients with grade II MMS (from 5 % to 25 % vs. from 90 % to 70 %; Fisher test: p = 0.00009). And statistically significant improvement of the neurological status was detected in patients with DA in the late follow-up period in comparison with the preoperative period: increasing the number of patients with grade II according to MMS and decreasing the number of patients with grade III MMS (from 47 % to 65 % vs. from 41 % to 29 %; Fisher test: p = 0.0334) (Table 2).

Radiological findings

Neurovisualization included: MRI with intravenous enhancement (in all observations), CT in 7 (18 %) patients, and spondylography in 7 (18 %) patients. Contrast was used in order to differentiate SCA from other types of IMSCT and demyelinating diseases. The level of tumour extension was

Table 2. **Dynamics of the neurological status of patients with different histological types of spinal cord astrocytomas**

Period	MMS Grade					Fisher's exact test
	I	II	III	IV	V	
Pilocytis astrocytoma (Grade I; n = 19)						
Preoperative	1 (5.3 %)*	17 (89.4 %)	1 (5.3 %)	0	0	p = 0.00009
Postoperative	2 (10.5 %)	17 (89.4 %)	0	0	0	
Late follow- up	5 (26.3 %)	13 (68.4 %)	1 (5.3 %)	0	0	
Diffuse astrocytoma (n = 17)						
Preoperative	0	8 (47.1 %)	7 (41.2 %)	2 (11.8 %)	0	p = 0.0334
Postoperative	0	10 (58.8 %)	7 (41.2 %)	0	0	
Late follow- up	1 (5.8 %)	11 (64.7 %)	5 (29.4 %)**	0	0	
Anaplastic astrocytoma (n = 3) ***						
Preoperative	0	0	1 (33.3 %)	1 (33.3 %)	1 (33.3 %)	
Postoperative	0	0	1 (33.3 %)	2 (66.7 %)	0	
Late follow- up	0	0	1 (33.3 %)	1 (33.3 %)	1 (33 .3%)	

Note. * Comparing the cases with PA of MMS grade I and MMS grade II in preoperative and late follow-up periods.
**Comparing the cases with DA of MMS grade II and MMS grade III in preoperative and late follow-up periods.
*** Because of the small number of cases with anaplastic astrocytoma, they were excluded from the statistical analyses.

classified into less than three involved segments and three or more segments.

All patients underwent MRI pre- and post-operatively. The MRI results revealed that all patients had spinal cord expansion due to SCA. According to the literature, astrocytoma and ependymoma are isointense or hypointense in T1 imaging and hyperintense in T2 imaging [4, 5, 25]. These tumours are well visualised after the introduction of a contrast agent, but a more intense accumulation of contrast is observed in astrocytoma. Unlike ependymoma, SCA is characterised by indistinct edges of the neoplasm, less heterogeneity, and a tendency towards eccentric growth.

Anatomo-topographical and morphological characteristics of SCA

Cervical localization was observed in 11 (28 %) clinical cases, thoracic in 25 (64 %), and conus medullaris in 3 (8 %). A poor preoperative MMS score was detected in 2 (5 %) patients with tumours at the cervical level, in 1 (2 %) patient with a thoracic tumour, and in 1 patient with a tumour in the area of conus medullaris. Post-operatively, the score was clinically but not statistically improved in 7 of all 11 cervical cases (64 %), 14 of all 25 thoracic cases (64 %), and 1 case with a tumour of the conus medullaris. The poor neurological status was in 1 patient with a tumour at the cervical level and 1 patient with a tumour in the area of conus medullaris.

In tumour extension, less than 3 segments were involved in 28 (70 %) cases, and 3 or more segments were involved in 11 (28 %) cases. Preoperatively, 25 (64 %) cases with less than 3 segments received a good score, while 3 (8 %) cases with more than 3 segments received a good score. Postoperatively, all 28 (70 %) patients with less than 3 involved segments improved, while 3 (8 %) patients with 3 or more involved segments received good scores.

Surgical outcomes

The goal of surgical treatment is the total, subtotal, or partial removal of intramedullary tumours, achieving internal decompression of the spinal cord, and creating favourable conditions for further radiation treatment or chemotherapy [16]. The operation must be performed before severe, irreversible symptoms of spinal cord damage have developed.

GTR was achieved in 7 (18 %) cases, ST in 25 (64 %) cases, and PR in 7 (18 %) patients. During operations, we followed the next surgical tactics.

Peculiarities of surgical technique. Surgical treatment of SCA aimed to remove the spinal cord tumour, establish the histogenesis of the tumour, and improve the neurological status of the patients. Electrophysiological monitoring was used to prevent damage to functionally essential areas of the spinal cord — the registration of SEPs and, in some cases, motor-evoked potentials. Intraoperative ultrasonography ensured the identification of neoplasm boundaries and their localization. All patients underwent the procedure in the prone position under general anaesthesia. A microscope was used to examine the tissue, and an ultrasonic aspirator for maximally atraumatic tumour removal.

Before the operation, the limits of surgical access were determined according to the preoperative MRI data, taking into account the localization of the solid part of the tumour, the area of spinal cord edema, and cystic areas. Laminectomy was performed in the projection of the solid component of the neoplasm. The dura mater was dissected linearly along the solid part of the tumour and separated from the sides with sutures (Fig. 2*A*). Taking into account the displacement and rotation of the spinal cord in the presence of SCA, the posterior median sulcus was identified by determining the exit zones of the right and left posterior roots. Large vessels in the myelotomy projection were displaced laterally, and small vessels were coagulated. After dissection of the meninges, atraumatic 7/0 sutures were applied, and traction was performed using ligatures. Using a microscope, a posterior median myelotomy was conducted in the projection of the tumour (Fig. 2*B*). The length of the myelotomy was evaluated segment by segment. In 25 observations, it corresponded to 3—4 segments, in 8 to 1—2 segments, and in 6 to more than four spinal cord segments. In the presence of cysts at the poles of the tumour, they were drained, which subsequently greatly facilitated the removal of the solid part. At the same time, the cystic-solid variant was observed in 21 (54 %), and the solid variant was observed in 18 (46 %) patients. Cysts were located at the poles of the solid part in 15 patients. There were cysts above the solid part in 3 patients and below in 2 patients. Subsequently, the tumour was removed by fragmentation and aspiration using bipolar microcoagulation and an ultrasonic aspirator until the boundaries between the tumour tissue and intact parenchyma appeared in the spinal cord. In the case of infiltrative growth of the tumour and the absence of clear borders between the tumour and the substance of the spinal cord, the operation was limited to the removal of the central mass of the tumour. With a sharp decrease in the amplitude and an increase in the latency of the SEPs, the surgical intervention was stopped due to the threat of deepening the neurological deficit.

Hemostasis was achieved by washing the bed of the removed tumour with saline and H_2O_2 tapes and

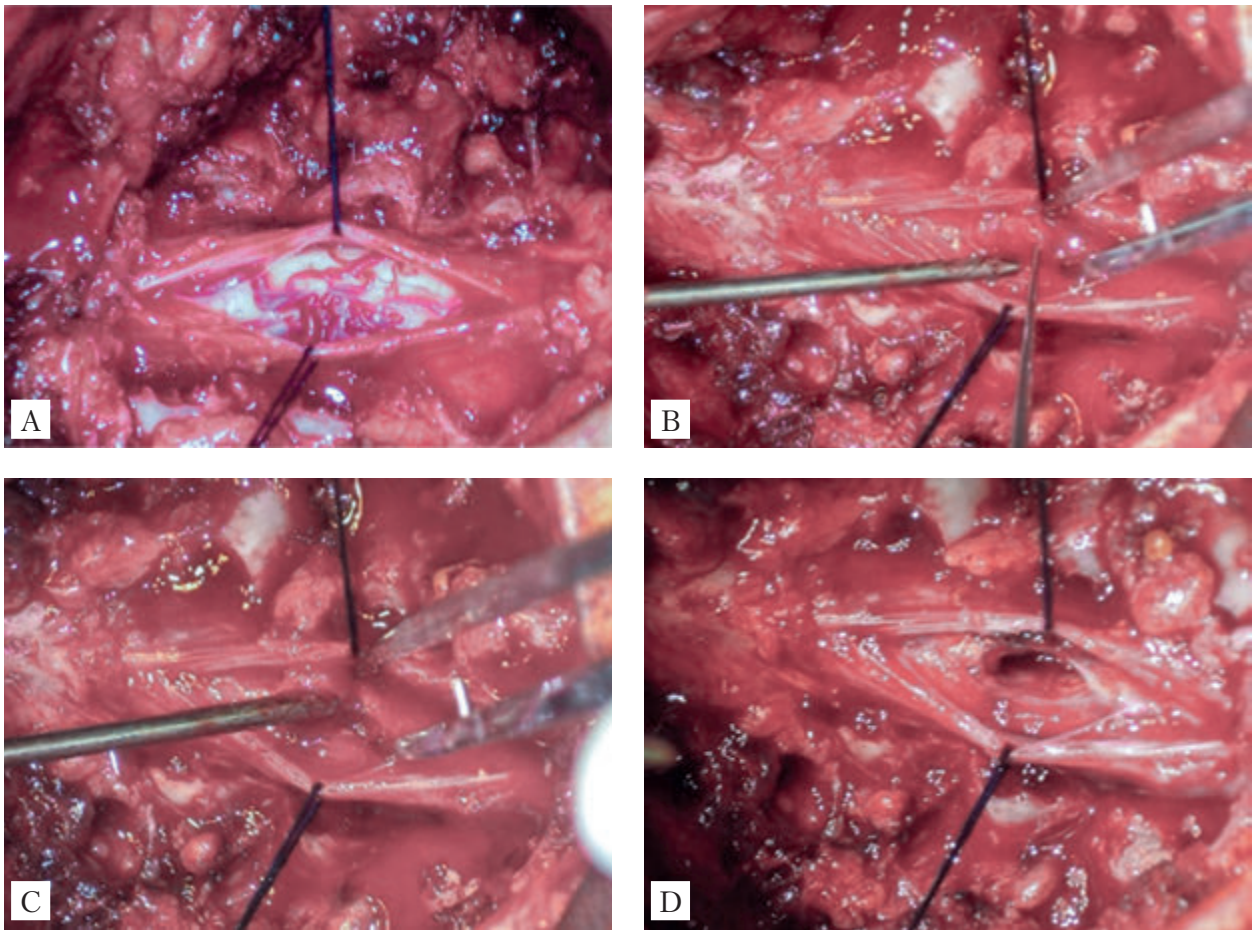

Figure 2. **Intraoperative photos of the stages of intramedullary anaplastic astrocytoma removal at the level of Th8-Th10 vertebrae in a 49-year-old male.** Explanation in the text

using Surgicel strips on the surface of the meninges. The soft meninges were sutured with knotted sutures with 9/0 atraumatic sutures, and the dura was mated with continuous sutures with 6/0 sutures. Soft tissues were hermetically sutured layer by layer (Fig. 2*C, D*).

For 24 (61.5 %) patients, intra-operative neuromonitoring was used, which included assessments of D-wave integrity, somatosensory responses, and motor evoked potentials. This monitoring is crucial for ensuring a safe tissue resection during surgery. Technical difficulties accounted for the absence of neuromonitoring in 15 (38.0 %) cases of the total.

Patients with acute neurological deterioration or those showing signs of surrounding spinal cord tissue involvement on spinal MRI typically received steroids preoperatively.

Early post-operative complications occurred in 4 (10 %) cases: 2 (5 %) cases experienced cerebrospinal fluid leak at the cervical level where dural grafts were used; 1 (2 %) case had a post-operative haematoma with a volume of up to 20 ml, which was treated conservatively; and 1 (2 %) case had *Escherichia* coli meningitis and a low Th10 level. The patients experiencing cerebrospinal fluid leaks were treated prophylactically with lumbar drains. The case of meningitis was managed with antibiotics and the re-insertion of a lumbar drain.

18 (46 %) patients who underwent partial and subtotal resection received adjuvant therapy (radiation (47.6 ± 3.3 Gy) and chemotherapy) according to the established protocols [2, 13].

Late outcomes

An objective prognostic criterion for the results of SCA treatment is the severity of the neurological status in the pre-and postoperative periods. Typically, the worsening of neurological symptoms is noted in the early postoperative period, and the recovery of functions continues for several months after surgery. Low-differentiated SCAs (grades III—IV) have an unfavourable prognosis. Usually, the neurological status does not improve after surgery, and the radicality of tumour resection does not affect the patients' quality of life or overall survival (Fig. 3, 4).

According to the literature, the overall survival rate after surgery for malignant anaplastic SCA

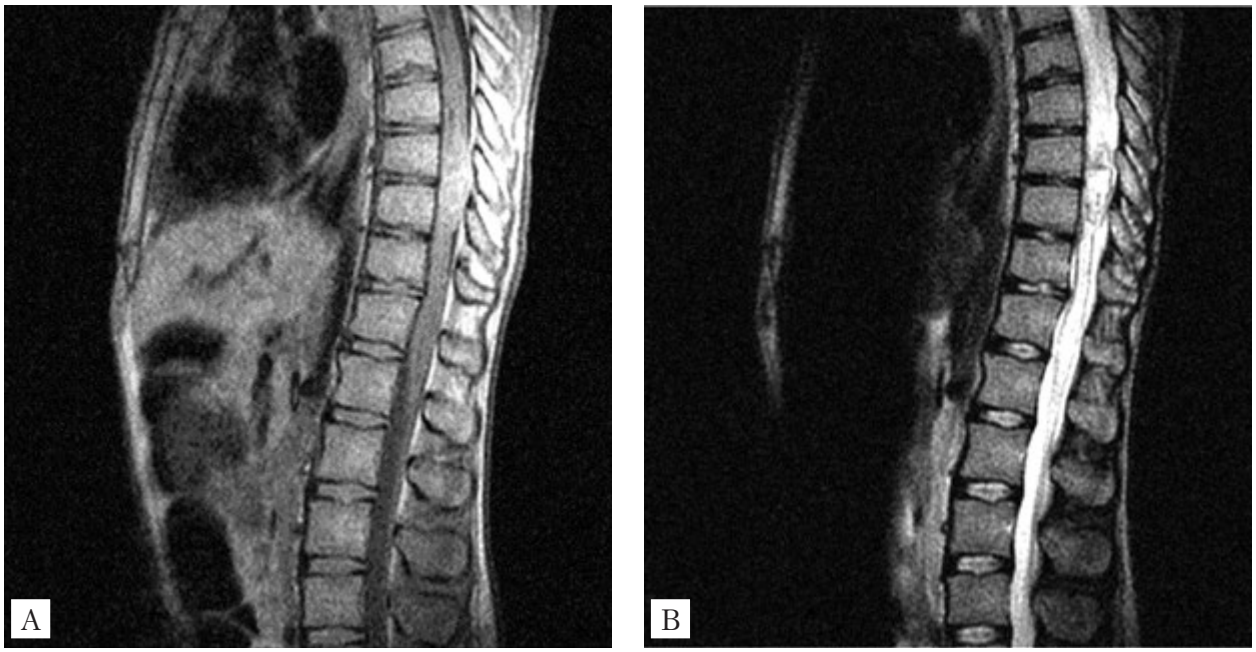

Figure 3. **Presurgical T1-weighted (A) and enhanced T2-weighted (B) MRI images of a spinal cord anaplastic astrocytoma (WHO grade III) on the Th8-Th10 level in a 49-year-old male with symptoms of numbness and weakness in both lower limbs**

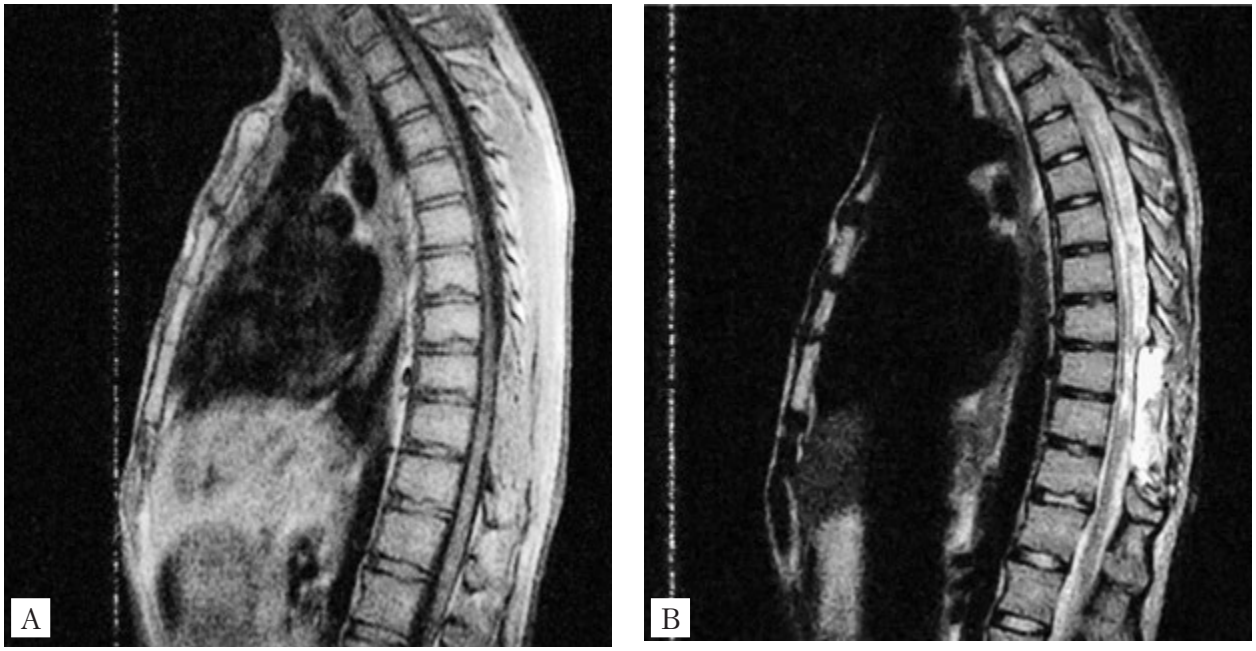

Figure 4. **Postsurgical T1-weighted (A) and enhanced T2-weighted (B) MRI images of a spinal cord anaplastic astrocytoma (WHO grade III) on the Th8-Th10 level in a 49-year-old male 3 weeks after subtotal removal. Clinical symptoms without improvement**

does not exceed 6—8 months in adults and 13 months in children. The overall survival of patients with PA was 22 months, with DA — 18 months, and with AA — 6 months. In patients who underwent combined treatment with radiation and chemotherapy, overall survival increased to 2—5 months [15, 18—23, 25]. In our study, catamnesis was present from 2 months to 2 years (± 9 months) in all patients. Tumour recurrence occurred in 4 (10 %) cases during the first 6 months after surgery. We didn't analyse the survival rate due to the small number of cases, but statistical analysis was carried out using the analysis of variables to compare the factors of age, duration of anamnesis, location of the tumour, extent of resection, MMS grades in pre- and postoperative periods and during late

Table 3. **Clinico-radiological features of 39 intramedullary spinal cord astrocytomas**

Variable	Pilocytis astrocytoma n = 19	Diffuse astrocytoma n = 17	Anaplastic astrocytoma n = 3*	Fisher's exact test
Age, years				
< 60 (n = 31)	19 (100 %)	12 (70.6 %)	0	p = 0.00000
> 60 (n = 8)	0	5 (29.4 %)	3 (100 %)	
Gender				
Male (n = 25)	9 (47.4 %)	13 (76.5 %)	3 (100 %)	p = 0.00003
Female (n = 14)	10 (52.6 %)	4 (23.5 %)	0	
Duration of anamnesis				
≤ 1 year (n = 20)	7 (36.8 %)	10 (58.8 %)**	3 (100 %)	
1—2 years (n = 13)	8 (42.1 %)	5 (29.4 %)	0	p = 0.00286
2—3 years (n = 3)	2 (10.5 %)	1 (5.8 %)	0	
> 3 years (n = 3)	2 (10.5 %)	1 (5.8 %)	0	
Tumour location				
Cervical	10 (52.6 %)	10 (58.8 %)	1 (33.3 %)	
Thoracic	7 (36.8 %)	7 (41.2 %)	1 (33.3 %)	
Conus medullaris	2 (10.5 %)	0	1 (33.3 %)	
Infiltration				
Well-delienated	7 (36.8 %)	5 (29.4 %)	0	p = 0.167
Infiltrative	10 (52.6 %)	11 (64.7 %)	3 (100 %)	
No data	2 (10.5 %)	1 (5.8 %)	0	
Extent of surgical resection				
Gross total resection	4 (21.1 %)	2 (11.8 %)	0	p = 0.00000
Subtotal resection	12 (63.2 %)	6 (35.3 %)	1 (33.3 %)	
Partial/biopsy	3 (15.8 %)***	9 (52.9 %)	2 (66.7 %)	

Note * Because of the small number of cases with anaplastic astrocytoma they were excluded from the statistical analyses both with the category «no data».
** Comparing anamnesis < 1 year and > 1 year in patients with piloctic astrocytoma and diffuse astrocytoma.
*** Comparing partial/biopsy and more radical surgical resection (gross total and subtotal resection) in patients with piloctic astrocytoma and diffuse astrocytoma.

follow-up, etc. in patients with different histological types.

In our study, age < 60 is significantly more frequently associated with the growth of PA, while age > 60 years is significantly more frequently associated with the growth of AA (Fisher test: p = 0.00000). We also observed a higher prevalence of DA in males compared to females, but there was no significant difference in the incidence of PA (76 % and 23 % vs. 47 % and 52 %; Fisher test: p = 0.00003). We also noted a significant difference between the duration of anamnesis < 1 year and > 1 year in patients with PA and DA (Fisher test: p = 0.00003). As for the degree of radicality of the operation, we revealed a significant difference between the number of patients who underwent partial removal / biopsy or more radical surgical resection (gross total and subtotal resection) in patients with PA and DA (85 % and 15 % vs. 47 % and 53 %; Fisher test: p = 0.00000). However, such factors as tumour location and degree of infiltration of nearby structures were not statisticaly significant (Table 3).

Disscussion

Summarising the data from the literature and our results, it should be noted that SCA is a complex pathology for early diagnosis and treatment tactics.

Patients' age has an essential prognostic value in SCA patients [3, 8, 13]. It is important to directly understand the age-adjusted incidence of SCA per 100,000 of people in the population. Thus, according to the comprehensive epidiological review of SCA in the USA, the peak incidence of SCA was observed in the 0—19-year-old age group, while the lowest level was observed in the 20—34-year-old age group for males and in the 35—44-year-old age group for females [28]. The second peak was observed in the 75—84-year-old age group without significant prevalence of sex, with the next decreasing level of incidence in the ≥85-year-old age group [28]. Multiple studies have shown that old age is associated with a worse prognosis, but we must analyse this tendency in the context of the prevalence of initially poor overall and recurrence-free survival in patients older than 65 years in whom AA is mainly diagnosed. So, the duration of the remission period is longer in young patients than in elderly patients due to the prevalence in <60-year-old patients with PA and DA, which are associated with a more favourable prognosis.

It was established that high-grade tumours had poor neurological outcomes. This finding may be due to the fact that high-grade tumours tend to infiltrate normal spinal cord tissue. High-grade tumours require pre- or post-operative radiotherapy, which could result in poor functional outcomes [28]. Preoperative radiotherapy may cause radiation-induced myelopathy and/or myelitis and compromise the spinal cord microvasculature, which leads to spinal cord ischaemia and severe neurological symptoms.

SCA can be well enhanced on contrast MRI of the spine, which improves distinction between more common solid and less common cystic types of the tumour, which are usually more malignant [31—34]. SCA characterised mainly by infiltrative growth, which limits the radicality of their removal and is a reason for possible recurrences, except for juvenile pilocytic SCA [3, 12, 34].

The surgical management protocol for SCA is not absolutely clear [15, 18, 19, 31]. Surgery for low-grade astrocytomas should be aimed at total resection to preserve neurological function and improve ealy and late outcomes. The correlations between the resection volume and the risk of recurrence still need to be studied [26, 27, 30, 31]. To determine the radicality of the surgical intervention, an MRI is performed in the early postoperative period since intraoperative visual control of tumour removal is often not full. Taking into account the peculiarities of the growth of SCA, it should be noted that residual tumour elements may also be present in cases of absence of the tumour according to the MRI data and visual total removal of SCA during surgery [2, 4, 31].

Modern microsurgical techniques, intraoperative electrophysiological monitoring, and ultrasonography increase the volume of plan resection and ensure atraumatic removal of the tumor. Differentiated surgical tactics in SCA consist of the following positions: adequate operative access depending on the location of the tumour, limiting the resection zone in the absence of clear boundaries between the SCA tissue and the intact parenchyma of the spinal cord, and changes in the SEP indicators. In the case of infiltrative growth of the tumour, surgical intervention was limited to the partial removal of SCA.

Thus, our study established that the results of surgical intervention in patients with SCA are directly related to the preoperative neurological condition, the patient's age, and the tumour's histological structure. Preoperative neurological status, persistent motor and sensory disturbances, and pelvic organ dysfunction are the determining predictors of postoperative functional outcomes in SCA. The best results of the surgical treatment were observed in patients with SCA with minimal neurological deficit at the time of surgery, in patients younger than 60 years old, and with highly differentiated SCA. In patients with pronounced clinical symptoms, surgery should be performed as early as possible (just after the tumour is detected).

Conclusions

The most important outcome predictors of SCA are the preoperative and postoperative neurological condition, extent of resection, and histological grade. The best surgical treatment results were observed in patients with minimal neurological deficit at the time of surgery, in patients younger than 60 years, and with highly differentiated SCA.

Age < 60 years is significantly more frequently associated with the growth of PA, while age > 60 years is significantly more frequently associated with the growth of AA. The duration of anamnesis (< 1 year and > 1 year) and the degree of radicality of the operation were identified as significant factors that can influence the neurological status in the late postoperative period, mainly in patients with PA and DA. However, such factors as tumour location and the degree of infiltration of nearby structures are not statistically significant. AA is associated with an unfavourable prognosis across all important criteria.

Therefore, in patients with pronounced clinical symptoms of any histological type of SCA, surgery

should be performed as early as possible after the tumour is detected.

Assessment of the preoperative neurological status and determination of the histological type of the tumour are important factors in choosing the optimal surgical tactics, which can improve treatment outcomes and the quality of life in SCA patients.

Declaration of interests

The authors declare that they have no financial, personal, authorship, or other conflicts of interest that could influence the research and results presented in this article.

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Ethics approval and written informed consent statements

The Commission on Bioethical Expertise and Ethics of Scientific Research at Bogomolets National Medical University concluded that the mentioned research does not contain an increased risk for the research subjects and was planned according to existing bioethical norms and scientific standards regarding the conduct of clinical research involving patients.

Authors contributions

O. I. Troyan: research concept and design; analysis and interpretation of data; A. V. Muravsky: acquisition of data; M. O. Marushchenko: analysis and interpretation of data; M. V. Khyzhnyak: drafting the manuscript.

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Значення клініко-морфологічних особливостей астроцитом спинного мозку у виборі хірургічної тактики

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Мета — визначити чинники, що впливають на динаміку неврологічного статусу в післяопераційний період у пацієнтів з інтрамедулярними астроцитомами спинного мозку (АСМ) для поліпшення результатів їх хірургічного лікування.

Матеріали та методи. Проведено ретроспективне дослідження результатів хірургічного лікування 39 хворих з АСМ, прооперованих у ДУ «Інститут нейрохірургії імені акад. А. П. Ромоданова НАМН України» у 2010—2019 рр. Вік пацієнтів — від 19 до 67 років (середній вік — 41,4 року). Серед пацієнтів переважали чоловіки (64 %). Ріст пухлини в шийному відділі спинного мозку спостерігався в 11 (28 %) випадках, у грудному — у 25 (64 %), у ділянці мозкового конуса — у 3 (8 %). Усім пацієнтам проведено комплексне клініко-інструментальне обстеження з використанням магнітно-резонансної томографії з внутрішньовенним підсиленням, комп'ютерної томографії, спондилографії. Динаміку неврологічної симптоматики оцінювали за модифікованою шкалою McCormick Scale до операції, при виписуванні хворого зі стаціонару та під час контрольних оглядів.

Результати. Тотальне видалення АСМ виконано у 7 (18 %) хворих, субтотальне — у 25 (64 %), часткове — у 7 (18 %). Пілоцитарна астроцитома (ВООЗ grade I) виявлена в 19 (49 %) хворих, дифузна астроцитома (ВООЗ grade II) — у 17 (43 %), анапластична астроцитома (ВООЗ grade III) — у 3 (8 %). У 29 (74 %) хворих зареєстрували частковий регрес неврологічної симптоматики, у 6 (15 %) — неврологічний статус залишився на дооперацийному рівні, у 4 (10 %) — незначне підсилення неврологічного дефіциту. Пілоцитарні астроцитоми статистично значуще частіше формуються у пацієнтів віком < 60 років, тоді як анапластичні астроцитоми — у пацієнтів віком > 60 років. Статистично значущими чинниками, які можуть впливати на неврологічний статус у віддалений післяопераційний період, переважно в пацієнтів із пілоцитарними та дифузними астроцитомами є: тривалість анамнезу (< 1 року та > 1 року) і ступінь радикальності операції, а такі чинники, як розташування пухлини та ступінь інфільтрації прилеглих структур, статистично незначущі. Анапластична астроцитома асоціюється з поганим прогнозом за всіма ключовими чинниками.

Висновки. Найважливішими предикторами наслідків АСМ є дооперацийний і післяопераційний неврологічний статус, ступінь радикальності операції та гістологічний тип. Найкращі результати хірургічного лікування спостерігали в пацієнтів із мінімальним неврологічним дефіцитом на момент операції, в осіб віком до 60 років та хворих із високодиференційованими інтрамедулярними астроцитомами. Оцінка дооперацийного неврологічного статусу та визначення гістологічного типу пухлини є важливими чинниками для вибору оптимальної хірургічної тактики, урахування яких дасть змогу поліпшити результати лікування та якість життя хворих з АСМ.

Ключові слова: інтрамедулярні астроцитоми спинного мозку, хірургічне лікування, неврологічна симптоматика.

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Differentiated approach to hernioplasty of paraesophageal hernias

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The results of surgical treatment of paraesophageal hernias indicate a high recurrence rate, from 15 % to 66 %, with an average follow-up period of 12 to 40 months. The main options for repairing the defect of the esophageal hiatus in the presence of paraesophageal hernia are crurorraphy and mesh-reinforced crurorraphy. Both methods have their own advantages and disadvantages. The criteria for choosing a method have not been specified.

Objective — to develop a differentiated approach to the surgical treatment of paraesophageal hernias, taking into account the size of the esophageal hiatus, and to determine its effectiveness.

Materials and methods. The study included 157 patients who were operated on for paraesophageal hernias. They were divided into two groups. The patients in both groups did not exhibit any statistically significant differences in terms of mean age, body mass index, sex ratio, type, frequency of complaints, or results of the endoscopic and radiological examination.

In Group I, hiatoplasty was performed using crurorraphy (61 (38.9 %) patients). In this group, the threshold values of the esophageal hiatus dimensions were calculated using the developed device and methodology, which allowed predicting hernia recurrence during the follow-up period of up to 18 months. In Group II (96 (61.1 %) patients), the hernioplasty technique (crurorraphy or mesh-reinforced crurorraphy) was chosen on the basis of the obtained threshold values.

Results. In Group I, the mean hiatal surface area was 86.8 ± 18.2 mm^2 (53 to 161 mm^2) and the width of the esophageal hiatus was 29.3 ± 3.3 mm (24 to 38 mm). In Group II, they were 95.6 ± 23.2 mm^2 (51 to 212 mm^2) and 31.1 ± 3.7 mm (24 to 43 mm), respectively. The threshold hiatal surface area, at which the probability of recurrence after crurorraphy was > 50 %, was 90 mm^2 (AUC — 0.926 (95 % confidence interval — 0.827—1.000), with a sensitivity and specificity of 87.5 % and 97.8 %, respectively. The width of the esophageal hiatus was measured at a cut-off point of 32 mm (AUC — 0.864 (95 % confidence interval — 0.733—0.995), with a sensitivity and specificity of 75.0 % and 78.0 %. In Group II, posterior crurorraphy was performed in the case of a hiatal surface area < 90 mm^2 and a distance between the crura diaphragmatis < 32 mm. In other cases, mesh-reinforced crurorraphy was conducted. The recurrence rate in Groups I and II was 26.2 % and 7.3 % (p = 0.001).

Conclusions. The device and methodology that have been developed are capable of measuring the dimensions (length, width, and area) of the esophageal hiatus intraoperatively. These measurements can be taken for the entire area within the esophageal hiatus contour, independent of its shape, even when using laparoscopic methods. The study found that there was a probability of recurrence after crurorraphy > 50 % when the threshold hiatal surface area was 90 mm^2, and the width of the esophageal hiatus was 32 mm. A differentiated approach to hiatoplasty involves using crurorraphy for hiatal surface areas < 90 mm^2 or distances between the crura diaphragmatis < 32 mm. For larger hiatal surface areas or widths, mesh-reinforced crurorraphy is indicated. This approach has resulted in a significant reduction in the recurrence rate from 26.2 % to 7.3 % (p = 0.001) and has prevented complications associated with the use of implants for up to 18 months after surgery.

Keywords
paraesophageal hernia, hiatal surface area, crurorraphy, allohernioplasty, recurrence, prediction, surgical tactics.

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In 1954, N.R. Barrett published a fundamental work in which he proposed to classify acquired hiatal hernias into 4 types according to their anatomical characteristics [8]:

- Type I hernias are sliding hiatal hernias in which the gastroesophageal junction (GEJ) migrates over the diaphragm. The stomach remains in its normal longitudinal position, with the fundus located below the gastroesophageal junction.
- Type II hernias are true paraesophageal hernias. The gastroesophageal junction remains in the normal anatomical position, while part of the gastric fundus is adjacent to the esophagus through the diaphragmatic hiatus.
- Type III hernias are a combination of types I and II, with both the esophagus and the gastric fundus bulging through the hiatus. The gastric fundus lies above the gastroesophageal junction.
- Type IV hernias are distinguished by the presence of a structure inside the hernial sac other than the stomach, such as the omentum, colon, or small intestine.

It is believed that more than 95 % of diagnosed hiatal hernias are type I. More than 90 % of type II—IV hernias are type III, and the least common is type II [24].

Regardless of the access method (laparotomy, laparoscopy, or thoracotomy), surgical treatment for paraesophageal hernias entails opening the hernial sac, reducing the hernia contents back into the abdominal cavity, and excising the sac [44] without exposing the crura diaphragmatis [2, 14]. It also involves complete mobilisation of the oesophagus 360° to the level of the lower pulmonary veins, hiatoplasty, fundoplication, or the Collis gastroplasty [38].

The results of surgical treatment of paraesophageal hernias indicate a high recurrence rate due to failure of hiatoplasty, from 15 % to 66 %, with an average follow-up period of 12 to 40 months [6, 16, 23, 29, 31, 35]. The main options for repairing the defect of the esophageal hiatus are crurorraphy and mesh-reinforced crurorraphy. Both methods have their own advantages and disadvantages. The criteria for choosing a method have not been specified.

Objective — to develop a differentiated approach to the surgical treatment of paraesophageal hernias, taking into account the size of the esophageal hiatus, and to determine its effectiveness.

Materials and methods

The study included 157 patients who were operated on for paraesophageal hernias. The research consisted of two stages. The first stage involved evaluating the impact of the size of the esophageal hiatus on the incidence of hernia recurrence over an extended period after crurorraphy, as well as the justification for using allografts. We measured the width of the esophageal hiatus (the maximum distance between the crura diaphragmatis), the length (from the crural adhesion at the bottom to the upper border of the hernia defect), and the hiatal surface area.

The second stage included the study of the long-term results of hernioplasty using a differentiated approach to cruroplasty, developed on the basis of the data obtained during the first stage of surgical treatment.

Group I included 61 (38.9 %) patients who received treatment at the first stage, while Group II included 96 (61.1 %) patients who underwent treatment according to a differentiated approach.

The long-term results of the operations were monitored for up to 18 months. Radiological esophagogastrography with barium sulphate was used.

The dimensions of the esophageal hiatus were measured after the contents of the hernial sac were reduced into the abdominal cavity and the esophagus was mobilised. In open operations, we used the modified method presented by H.F. Batirel et al. [9]. The esophageal hiatus was photographed against a 10 mm long standard, and the image was transferred to a computer screen with a millimetre grid scaled to the standard. The hiatal surface area was calculated in square millimetres, and the length and width of the esophageal hiatus were measured in millimetres.

During laparoscopic interventions, intraoperative measurement of the dimensions of the esophageal hiatus was performed using a designed device [42] and the corresponding software (Fig. 1).

All patients in both groups underwent endoscopic and radiological examinations.

The endoscopic examination was performed using a Fujinon EG 760-R fibrogastroduodenoscope under intravenous sedation (propofol) in the patient's left side position. The endoscope measured 0.92 cm in diameter. The cardinal sign of a hiatal hernia was the presence of gastric mucosa above the crural impression by more than 2 cm.

The X-ray examination was performed using the Winscope Plessart EX8 universal X-ray system with remote control (Toshiba). The examination included a polypositional examination of the direct, lateral, and oblique anterior and posterior projections in the upright position and Trendelenburg position, followed by an examination of the initial upright position with normal breathing, deep breathing, and the Valsalva manoeuvre.

The study was conducted in compliance with the Declaration of Helsinki [46]. The study protocol was approved by the ethics committee of

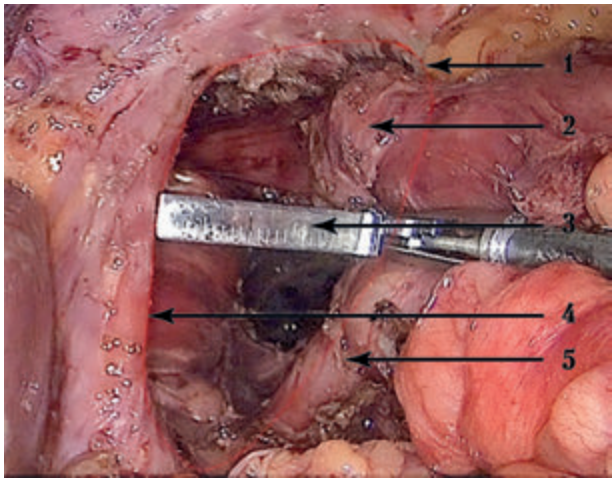

Figure 1. **Location of the laparoscopic instrument scale in the hiatal area (the hiatal surface area — 9.43 mm², the length of the esophageal hiatus — 48 mm, and the width of the esophageal hiatus — 27 mm):** 1 — esophageal hiatus contour; 2 — esophagus; 3 — instrument scale; 4 — right crura diaphragmatis; 5 — left crura diaphragmatis

Table 1. **Group characteristics**

Variable	Group I (n = 61)	Group II (n = 96)
Age, years	52.3 ± 10.9	54.1 ± 10.1
Male Female	25 (41.0 %) 36 (59.0 %)	34 (35.4 %) 62 (64.6 %)
Body mass index, kg/m²	26.8 ± 2.5	27.4 ± 2.7
Disease duration, months	58.6 ± 49.5	59.3 ± 53.7
Heartburn	35 (57.4 %)	51 (53.1 %)
Chest pain	20 (32.8 %)	40 (41.7 %)
Belching	27 (44.3 %)	41 (42.7 %)
Nausea	38 (62.3 %)	55 (57.3 %)
Hoarseness	26 (42.6 %)	45 (46.9 %)
Cough	12 (19.7 %)	24 (25.0 %)
Dysphagia	21 (34.4 %)	32 (33.3 %)
Hiccups	11 (18.0 %)	21 (21.9 %)
Odynophagia	11 (18.0 %)	13 (13.5 %)
Vomiting	10 (16.4 %)	19 (19.8 %)
Feeling of fullness after meal	21 (34.4 %)	36 (37.5 %)
Weight loss	15 (24.6 %)	25(26.0 %)
Arrythmia	19 (31.1 %)	34 (35.4 %)
Dyspnea	20 (32.8 %)	28 (29.2 %)

All $p > 0.05$.

Bogomolets National Medical University (protocol No. 160 of September 26, 2022).

According to the X-ray examination, hernia recurrence (anatomical recurrence) was defined as the migration of the gastroesophageal junction above the diaphragm. We distinguished the displacement of the gastroesophageal junction as < 2 cm and ≥ 2 cm.

At the first stage, laparotomy was used in 27 (44.3 %) patients, laparoscopy in 18 (29.5 %), and thoracotomy in 16 (26.2 %). At the second stage, the operation was performed using a laparoscopic approach.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics. Discriminant statistics were calculated. The mean values are presented as the arithmetic mean and standard deviation (M ± SD). A comparison of the mean values of quantitative variables was performed using the Mann-Whitney U-test or Student's t-test, depending on the distribution of the variable. Relative values were compared using Pearson's χ^2 test.

Binary logistic regression analysis was performed to determine the probability of an event occurring depending on the values of the variable. ROC analysis was used to assess the quality of classification models.

The null hypothesis of equality of variables was rejected at $p < 0.05$.

Results

The patients in both groups did not exhibit any statistically significant differences in terms of mean age, body mass index, sex ratio, type, or frequency of complaints (Table 1).

There was also no statistically significant difference between the groups in terms of instrumental research indicators (Table 2).

In Group I, the average length of the esophageal hiatus was 54.8 ± 5.4 mm (46—65 mm), the width of the esophageal hiatus was 29.3 ± 3.3 mm (24—38 mm), and the hiatal surface area was 86.8 ± 18.2 mm² (53—161 mm²).

Within 18 months, anatomical recurrence was recorded in 16 (26.2 %) patients, including 10 (16.4 %) patients with a gastroesophageal junction > 2 cm above the diaphragm and 6 (9.8 %) patients with a gastroesophageal junction from 1 to 2 cm.

The recurrence rate did not depend on the surgical approach ($p = 0.703$) (Table 3).

Univariate bivariate logistic regression analysis showed a statistically significant dependence of recurrence rate on the area and width of the esophageal hiatus.

Table 2. **Results of the endoscopic and radiological examination**

Variable	Group I (n = 61)	Group II (n = 96)
Endoscopic examination		
Esophagitis	40 (65.6 %)	58 (60.4 %)
Erosive esophagitis, stage*	36 (59.0 %)	53 (55.2 %)
A	6 (16.7 %)	6 (11.3 %)
B	16 (44.4 %)	21 (36.9 %)
C	10 (27.8 %)	20 (37.7 %)
D	4 (11.1 %)	6 (11.3 %)
Erosive gastritis	10 (16.4 %)	19 (19.8 %)
Peptic ulcer	6 (9.8 %)	8 (8.3 %)
Cameron's ulcer	2 (3.3 %)	6 (6.3 %)
Radiological examination		
Reducibility		
Non-reducible hernia	48 (78.7 %)	80 (83.3 %).
Partially reducible hernia	13 (21.3 %)	16 (16.7 %)
Hernia size		
Cardiofundal hernia	34 (55.7 %)	66 (68.8 %)
Subtotal hiatal hernia	26 (42,6 %)	27 (28,1)
Total hiatal hernia	1 (1,6 %)	3 (3,1 %)

All p > 0.05.

* According to the LA Classification System.

Table 3. **Hernia recurrence rate depending on the access method**

Surgical access method	Total number	Recurrence
Laparotomy	27	6 (22.2 %)
Laparoscopy	18	6 (33.3 %)
Thoracotomy	16	4 (25.0 %)
Total	61	16 (26.2 %)

The cut-off point at which an increased probability of recurrence was predicted depending on the hiatal surface area (> 0.5) was 90 mm^2 (Fig. 2).

The test proved to be effective, as evidenced by the area under the ROC curve (AUC) of 0.926 (95 % confidence interval (CI) — 0.827—1.0) (Fig. 3). The sensitivity was 87.5 % and the specificity was 97.8 %.

The cut-off point for predicting an increased probability of recurrence based on the width of the esophageal hiatus (> 0.5) was 32 mm (Fig. 4).

The test was effective (AUC — 0.864 (95 % CI—0.733—0.995) (Fig. 5). The sensitivity was 75.0 % and the specificity was 78.0 %.

According to the logistic regression analysis, the length of the esophageal hiatus did not statistically significantly affect the recurrence rate.

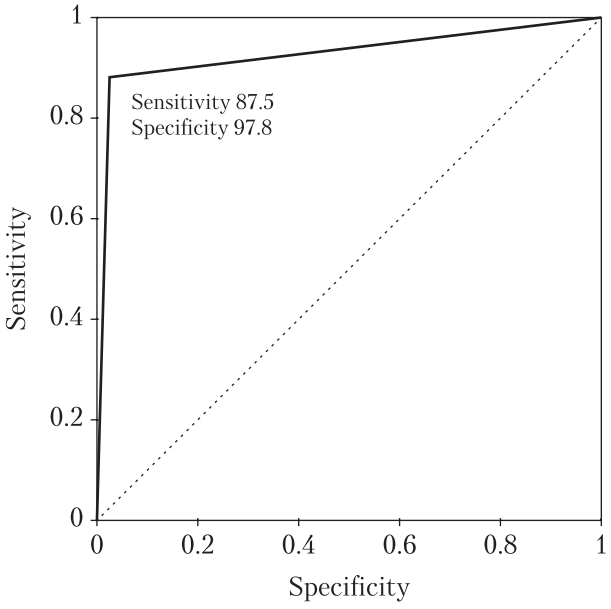

Figure 3. **ROC curve for predicting the probability of recurrence at a hiatal surface area of 90 mm^2**

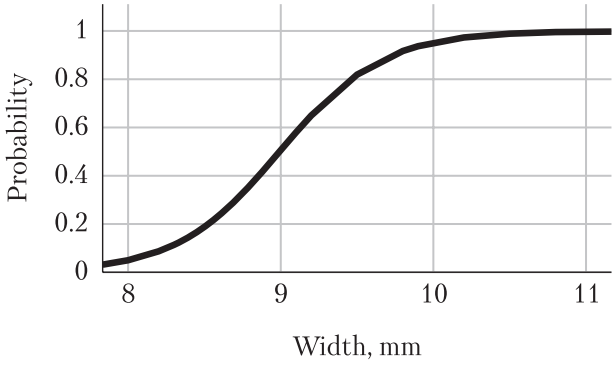

Figure 2. **Probability of hernia recurrence depending on the hiatal surface area**

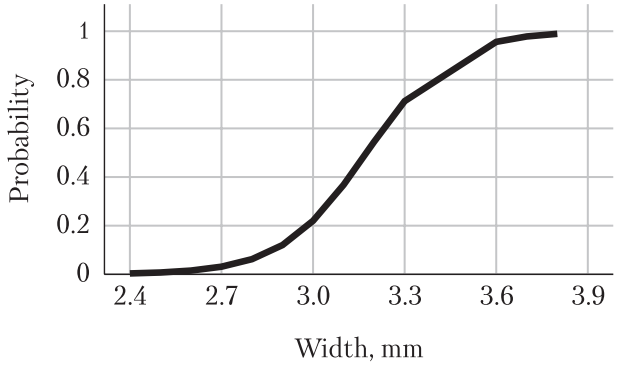

Figure 4. **Probability of hernia recurrence depending on the width of the esophageal hiatus**

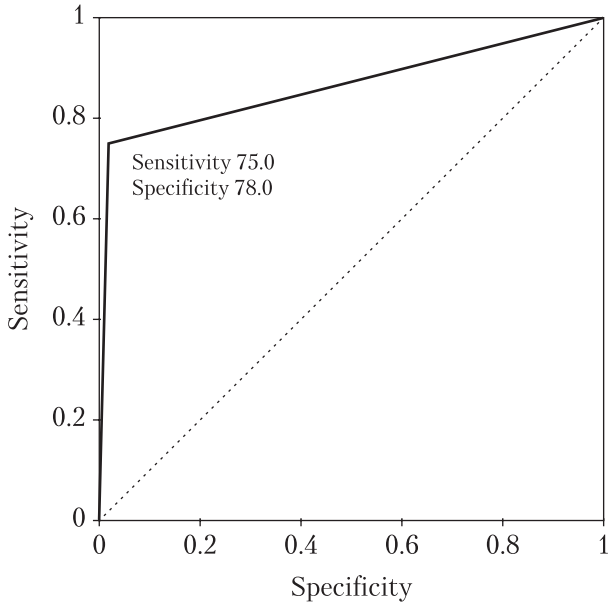

Figure 5. **ROC curve for predicting the probability of recurrence at a width of 32 mm**

In the regression logistic binary analysis of the two variables «the hiatal surface area» and «the width of the esophageal hiatus», only «the hiatal surface area» was an independent prognostic factor for the occurrence of hernia recurrence. The null hypothesis's error concerning the coefficient for the indicator «the width of the esophageal hiatus» is $p = 0.07$.

Taking into account the data obtained from the analysis of results in Group 1, we used a differentiated approach to hernioplasty in Group II. It consisted of reducing the hernia into the abdominal cavity, mobilising the esophagus at least 3 cm below the diaphragm, and intraoperatively determining the dimensions of the esophageal hiatus according to the developed methodology. In the case of a hiatal surface area < 90 mm^2 and a distance between the crura diaphragmatis < 32 mm, posterior crurorraphy was performed. In the case of a hiatal surface area ≥ 90 mm^2 and/or a distance between the crura diaphragmatic ≥ 32 mm, posterior crurorraphy was reinforced with a U-shaped mesh (Parietex Composite Mesh, Polyester with Absorbable Collagen Film, Covidien) with dimensions of 90×80 mm. The mesh was fixed to the crura diaphragmatis using a stapler (Endo Universal 65 Auto Suture (Universal Hernia Stapler) 12.0×4.0 mm, Covidien). All patients underwent a Nissen fundoplication.

For the required indications, 40 (41.7 %) patients underwent posterior crurorraphy, whereas 56 (58.3 %) received mesh-reinforced crurorraphy.

Although the area and width of the esophageal hiatus in Group II were larger than in Group I: 95.6 ± 23.2 mm^2 (51 mm^2 to 212 mm^2) versus 86.8 ± 18.2 mm^2 (53 mm^2 to 161 mm^2) and 31.1 ± 3.7 mm (24 mm to 43 mm) versus 29.3 ± 3.3 mm (24 mm to 38 mm), the number of recurrences within 18 months was significantly lower (7 (7.3 %) versus 16 (26.2 %), $p = 0.001$). At the same time, in patients who received crurorraphy, recurrence occurred in 2 (5.0 %) instances versus 5 (8.9 %) cases with mesh ($p = 0.465$).

In Group II, the gastroesophageal junction was located > 2 cm above the diaphragm in only 2 (2.1 %) patients and at a distance of 1 to 2 cm in 5 (5.2 %).

During the 18-month follow-up, no mesh-related complications were detected.

Thus, a differentiated approach to selecting the cruroplasty method for paraesophageal hernia treatment, which is based on the dimensions of the esophageal hiatus and the personalised use of implants, dramatically reduced the recurrence rate 12—18 months after surgery.

Discussion

Cruroplasty is an integral part of the surgical treatment of paraesophageal hernias and the main preventive measure against recurrence. Various options for closing the defect of the esophageal hiatus have been described, including the reduction of the crura diaphragmatis with sutures, which are mainly placed behind the esophagus (posterior crurorrhaphy), mesh implantation (absorbable or non-absorbable), and combinations of crurorraphy with mesh implantation [1, 4, 32, 39, 43].

The use of crurorraphy was associated with a high recurrence rate. Thus, according to P.A. Le Page et al., after 455 operations for paraesophageal hernias, mainly using crurorrhaphy (in 94 %), the rate of anatomical recurrence (< 2 cm and ≥ 2 cm) in the period up to 1 year was 13.7 %, in 5—10 years — 40.1 %, over 10 years — 50.0 %, and the recurrence rate (≥ 2 cm) was 3.4 %, 9.5 %, 13.8 % and 25.0 %, respectively [28].

Many studies have reported a decrease in the hernia recurrence rate after hernioplasty with implants compared to crurorraphy in short-term follow-up [19, 20, 25, 37].

Subsequently, it was shown that the additional use of mesh compared to crurorraphy reduces the recurrence rate at different times of the postoperative period to 0.8—9 % versus 22.2—26 % without mesh [7], to 12.1 % versus 20.5 % [34], to 3.7 % versus 6 % [41], and in the case of giant hernias, to 35 % versus 77 % [33].

At the same time, implantation of a foreign body in the area of the esophageal hiatus, along with enhancing the stability of hernia defect closure, can have

negative consequences (wrinkling, mesh migration, infection (abscesses, fistulas), cardiac tamponade, erosion of the aorta, esophagus or stomach, esophageal stenosis, severe dysphagia, fibrous reaction that can complicate a new esophageal surgery), so some surgeons refrain from using mesh even in giant paraesophageal hernias [10, 15, 18, 17, 25, 34, 37, 40].

Recently, a number of multicentre prospective studies and meta-analyses have been conducted that have not found statistically significant differences in the recurrence rate after crurorraphy compared with mesh-reinforced crurorraphy, although in most of them the recurrence rate was lower in the case of mesh, but the difference was not statistically significant [5, 13, 36, 45]. For example, a meta-analysis in 2024, which included 34 studies (6 randomised clinical trials, 25 retrospective studies and 3 prospective cohort studies) and included 2170 patients after laparoscopic treatment of hiatal hernia, found the following recurrence rates: after crurorrhaphy — 20.8 %, after absorbable mesh reinforcement — 20.6 %, after non-absorbable mesh reinforcement — 13.7 %. The average follow-up period was 25.8 ± 16.4 months, 28.1 ± 13.8 months and 30.8 ± 15.3 months, respectively [27]. The Brazilian Society for Abdominal Wall Hernias notes in its guidelines for the management of patients with large paraesophageal hernias that the use of non-absorbable prostheses effectively prevents anatomical recurrence in the short-term follow-up, but long-term evidence is still lacking [11].

Thus, the question of indications for the use of mesh in paraesophageal hernias remains open and requires further research.

F. A. Granderath et al. first implemented the idea of performing mesh-reinforced crurorraphy at specific sizes of the hiatal surface area [21]. They developed an intraoperative method for calculating the hiatal surface area, which in hiatal hernias was on average 50.92 mm^2, and divided patients into three categories. The authors suggested crurorraphy for patients with a hiatal surface area up to 40 mm^2, from 40 to 80 mm^2 — reinforcement with 1—3 cm mesh, > 80 mm^2 — tension-free cruroplasty using the in-lay technique with ePTFE mesh.

O. O. Koch et al. also determined the average hiatal surface area in patients undergoing laparoscopic hiatoplasty (according to the method of F. A. Granderath et al.), which was higher than in the previous study — 81.9 mm^2 (from 56.1 to 160.9 mm^2). According to the authors, the esophageal hiatus with an area of at least 56.0 mm^2 should be indicated for mesh hiatoplasty [25].

V. V. Grubnik et al. [22] used ANOVA analysis of variance to determine the threshold hiatal surface area for mesh-reinforced crurorraphy. The area was measured using the method developed by F. A. Granderath et al. The authors divided hernias into three categories: < 100 mm^2 (small hernias), 100 to 200 mm^2 (large hernias), and > 200 mm^2 (giant hernias). For additional mesh applications, the threshold area was > 100 mm^2. In the case of a hiatal surface area of 100—200 mm^2, a light, partially absorbable mesh was suggested, and in the case of a hiatal surface area > 200 mm^2, a non-absorbable mesh was used according to the original method [22]. Dispersion analysis does not directly allow determining the threshold values (in this case, the hiatal surface area) for a particular situation (in this case, the probability of recurrence), but it does allow confirming the correctness of the selected threshold levels, which the researchers determined based on their own experience.

To determine the impact of the measurements of the esophageal hiatus on the incidence of paraesophageal hernia recurrence and to justify the indications for mesh use, we developed a device and method for calculating the size (length, width, and surface area), including in the case of laparoscopic access. This method is more accurate than other intraoperative methods (the method developed by F. A. Granderath et al. and the estimation of the hiatal surface area by the size of a rhombus [11]) because it considers the entire area within the esophageal hiatus contour, regardless of shape. Binary logistic regression analysis was used to calculate the thresholds, which allows us to estimate the probability of recurrence at any size of the hiatal surface area available in the study. The test was evaluated for its sensitivity and specificity using the ROC curve. In the examination of 61 patients who underwent crurorraphy for esophageal hernia, the mean value of the hiatal surface area was 86.8 ± 18.2 mm^2 (from 53 mm^2 to 161 mm^2), which approximately corresponds to the findings presented by O. O. Koch et al. [25]. In the period up to 18 months after surgery, anatomical recurrence was recorded in 16 (26.2 %) patients, including 10 (16.4 %) patients with a gastroesophageal junction ≥ 2 cm above the diaphragm and 6 (9.8 %) patients with a gastroesophageal junction from 1 to 2 cm above the diaphragm.

The cut-off point at which an increased probability of recurrence was predicted depending on the hiatal surface area was 90 mm^2 (AUC 0.926 (95 % CI 0.827—1.0); sensitivity and specificity were 87.5 % and 97.8 %, respectively). This hiatal surface area value is larger than that reported by F. A. Granderath et al. [21] and O. O. Koch and et al. [25], but smaller than that found by V. V. Grubnik et al. [22]. Another important factor in recurrence was the width of the esophageal hiatus, with a cut-off point

of 32 mm (AUC — 0.864 (95 % CI: 0.733—0.995), the sensitivity and specificity were 75.0 % and 78.0 %, respectively.

In a prospective group (96 patients), we evaluated a differentiated approach to hiatoplasty for up to 18 months. In the case of a hiatal surface area > 90 mm^2 or a distance between the crura diaphragmatis > 32 mm, the posterior crurorraphy was reinforced with a U-shaped mesh (Parietex Composite Mesh, Polyester with absorbable Collagen Film, Covidien) with dimensions of 90 × 80 mm. In other cases, posterior crurorraphy was performed. In this group, the recurrence rate was statistically significantly lower (7.3 % vs. 26.2 % in the crurorraphy group, p = 0.001). No complications associated with the use of implants were recorded in any case.

Thus, the acquired data suggest that this type of mesh can be effectively used in hiatoplasty procedures for patients with paraesophageal hernias with a hiatal surface area > 90 mm^2 or a distance between the crura diaphragmatis > 32 mm. In other cases, crurorraphy is appropriate.

Conclusions

The device and method that have been developed are capable of measuring the dimensions (length, width, and area) of the esophageal hiatus intraoperatively. These measurements can be taken for the entire area within the esophageal hiatus contour, independent of shape, even when using laparoscopic methods.

Among patients with paraesophageal hernias who underwent crurorraphy, the recurrence rate within 18 months was 26.2 %. In 10 cases (16.4 %), the gastroesophageal junction was located more than 2 cm above the diaphragm, while in 6 cases (9.8 %), it was positioned 1 to 2 cm above.

The study found that there was a probability of recurrence after crurorraphy > 50 % when the threshold hiatal surface area was 90 mm^2 (AUC 0.926 (95 % CI 0.827—1.0), with a sensitivity and specificity of 87.5 % and 97.8 %, respectively. The cut-off point based on the width of the esophageal hiatus was 32 mm (AUC 0.864 (95 % CI 0.733—0.995), with a sensitivity and specificity of 75.0 % and 78.0 %, respectively.

A differentiated approach to hiatoplasty involves using crurorraphy for hiatal surface areas < 90 mm^2 or distances between the crura diaphragmatis < 32 mm. For larger hiatal surface areas or widths, mesh-reinforced crurorraphy is indicated. This approach has resulted in a significant reduction in the recurrence rate from 26.2 % to 7.3 % (p = 0.001) and has prevented complications associated with the use of implants for up to 18 months after surgery.

Declaration of interests

The authors declare that they have no conflicts of interest.

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Authors contributions

Conception and design of the study — O. Y. Ioffe, T. A. Tarasov; collection and analysis of data — T. A. Tarasov, M. M. Bagirov, statistical analysis — T. A. Tarasov, L. Y. Markulan; writing the manuscript — T. A. Tarasov; critical revision — O. Y. Ioffe, T. A. Tarasov, L. Y. Markulan.

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Хірургічне лікування параезофагеальних гриж із використанням диференційованого підходу до герніопластики

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Результати хірургічного лікування параезофагеальних гриж (ПЕГ) асоціюються з високою частотою рецидивів (від 15 % до 66 %) при середньому періоді спостереження від 12 до 40 міс. Основні методики усунення дефекту стравохідного отвору діафрагми (СОД) при ПЕГ — шовна крурорафія (ШК) та ШК з армуванням швів сітчастим імплантатом мають переваги та недоліки. Критеріїв вибору методу не розроблено.

Мета — розробити диференційований підхід до хірургічного лікування параезофагеальних гриж з урахуванням параметрів стравохідного отвору діафрагми та визначити його ефективність.

Матеріали та методи. Прооперовано 157 хворих із ПЕГ, яких розподілили на дві групи. Хворі обох груп статистично значущо не відрізнялися за середнім віком, індексом маси тіла, співвідношенням статей, характером і частотою скарг, показниками ендоскопічного та рентгенологічного дослідження. У групі I пластику СОД здійснювали за допомогою ШК (61 (38,9 %) хворий). У цій групі розраховували з використанням розробленого пристрою і методики порогові значення параметрів СОД, які давали змогу спрогнозувати рецидив грижі за період спостереження до 18 міс. У групі II (96 (61,1 %) хворих) методику герніопластики (ШК або армування ШК сіткою) обирали на підставі отриманих порогових значень.

Результати. Середня площа СОД у групі I становила (86,8 ± 18,2) мм^2 (від 53 до 161 мм^2), ширина СОД — (29,3 ± 3,3) мм (від 24 до 38 мм), у групі II — відповідно (95,6 ± 23,2) мм^2 (від 51 до 212 мм^2) та (31,1 ± 3,7) мм (від 24 до 43 мм) відповідно. Порогова площа СОД, за якої ймовірність рецидиву після ШК > 50 %, — 90 мм^2 (AUC — 0,926 (95 % довірчий інтервал — 0,827—1,000), чутливість і специфічність тесту — відповідно 87,5 та 97,8 %), та ширина СОД із точкою відсічення 32 мм (AUC — 0,864 (95 % довірчий інтервал — 0,733—0,995), чутливість і специфічність тесту — 75,0 та 78,0 %). У групі II у разі площі СОД < 90 мм^2 та відстані між ніжками діафрагми < 32 мм виконували задню ШК, в інших випадках ШК армували сітчастим імплантатом. Частота рецидивів у групах I та II становила 26,2 і 7,3 % (p = 0,001).

Висновки. Розроблений пристрій і методика розрахунку параметрів СОД, зокрема в разі лапароскопічного доступу, дає змогу інтраопераційно врахувати площу в межах контуру СОД незалежно від його форми, а також довжину і ширину СОД. Порогова площа СОД, за якої ймовірність рецидиву після ШК перевищує 50 % — 90 мм^2, ширина СОД — 32 мм. Диференційований підхід до пластики СОД передбачає виконання лише ШК у разі площі СОД < 90 мм^2 або відстані між ніжками діафрагми < 32 мм, а також армування ШК сіткою у випадку розмірів площі СОД або його ширини, що перевищують зазначені. Цей підхід дав змогу зменшити частоту рецидивів із 26,2 до 7,3 % (p = 0,001) та уникнути ускладнень, пов'язаних із використанням імплантатів, протягом 18 міс після операції.

Ключові слова: параезофагеальна грижа, площа стравохідного отвору діафрагми, шовна крурорафія, алогерніопластика, рецидив, прогнозування, хірургічна тактика.

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Sarcopenic obesity and severity of chronic venous disease in postmenopausal women

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Sarcopenic obesity (SO) is a functional and clinical condition that is characterised by the simultaneous existence of sarcopenia and excess adipose tissue. This condition may be one of the pathogenetic factors for chronic venous disease (CVD) of the lower extremities and chronic venous insufficiency (CVI), due to impaired muscle venous pump function. Furthermore, obesity is considered a risk factor for these conditions.

Objective — to investigate the association of sarcopenia and sarcopenic obesity with the severity of chronic venous disease in postmenopausal women.

Materials and methods. The study included 117 postmenopausal women who were divided into two groups: Group I — 87 (74.4 %) women with CVD, and Group II — 30 (25.6 %) women without any signs of CVD. Within Group I, two subgroups were distinguished based on the class of CVD as defined by the CEAP classification system. Subgroup IA consisted of 45 women (51.7 %) with CVD classes 1 and 2, which correspond to compensated chronic venous insufficiency (CVI). Subgroup IB included 42 women (48.3 %) with CVD classes 3, 4, and 5, indicating subcompensated or decompensated CVI. The measurement of fat and lean mass was conducted using dual-energy X-ray absorptiometry with the Hologic device (Discovery WI, USA, 2015). The presence of sarcopenia was determined by the skeletal muscle assessment index ASM/height2, where ASM is the total appendicular skeletal muscle mass of the legs and arms. Sarcopenia was diagnosed when the value of ASM/height2 was < 6.0 kg/m^2. The diagnosis of SO was made in patients with sarcopenia and a body mass index > 25 kg/m^2.

Results. The mean age of women was 67.32 ± 9.12 years (46—86 years), the mean body mass index was 29.1 ± 6.0 kg/m^2 (18.4—50.1 kg/m^2), and BMI/height2 was 6.72 ± 0.864 kg/m^2. Women in Group I had lower values of BMI/height2 (6.63 ± 0.72 kg/m^2) than women in Group II (6.97 ± 1.0 kg/m^2, p = 0.056). Sarcopenia was detected in 27 (23.1 %) women, and SO in 17 (14.5 %). There was no statistically significant difference between the groups in the frequency of sarcopenia: in Group I, 5 (16.7 %) women had sarcopenia, in Group II — 22 (25.3 %), (p = 0.334). The proportion of patients with SO in Group I was statistically significantly larger compared to Group II — 18.4 and 3.3 % (p = 0.044). There was an increase in the proportion of women with sarcopenia and SO with increasing severity of CVI: 8 (17.8 %) patients in subgroup IA and 14 (33.3 %) in subgroup IB had sarcopenia (p = 0.095), and 4 (8.94 %) and 12 (28.6 %) had SO, respectively (p = 0.018).

Conclusions. Postmenopausal women with CVD were more likely to have SO (18.4 %) compared to patients without CVD (3.3 %, p = 0.044). Postmenopausal women with subcompensated and decompensated CVI were more likely to have SO (12 (28.6 %)) than women with compensated CVI (4 (8.94 %, p = 0.018, odds ratio 6.54, 95 % confidence interval 0.83—51.58). Menopausal women with CVD were more likely to have sarcopenia and had a higher incidence of subcompensated and decompensated CVI compared to women without sarcopenia, but the difference was not statistically significant.

Keywords
postmenopausal women, chronic venous disease, chronic venous insufficiency, sarcopenia, sarcopenic obesity.

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Sarcopenia is defined as a progressive and generalised loss of muscle mass and strength [22]. It is accompanied by physical inactivity, decreased mobility, a slow gait, poor physical endurance, falls, fractures, and mortality [3].

Sarcopenia more often affects the elderly, but a progressive decrease in muscle mass begins at the age of 40, and after 50 years, muscle mass decreases by 1—2 % annually [18].

At the same time, ageing and physical inactivity contribute to an increase in fat mass, in particular visceral fat [21].

Sarcopenic obesity (SO) is defined as a functional and clinical condition characterised by the simultaneous loss of skeletal muscle mass and function as well as excess adipose tissue [30]. The incidence of SO is growing rapidly, mainly due to the ageing of the population worldwide and the current obesity epidemic. The prevalence of SO in people aged 20 to 80 years is 0.8 % to 22.3 % in women and 1.3 % to 15.4 % in men [12], and increases with age [29, 10].

SO is a more severe condition than both obesity and sarcopenia alone, as it is associated with a higher risk of cardiovascular disease, decreased bone mineral density, and all-cause mortality [15, 23, 24, 32].

It is generally recognised that one of the causes of chronic venous disease (CVD) and chronic venous insufficiency (CVI) is a disruption of the so-called «venous pump», which functions through the contraction of the deep muscles of the lower extremities. It is logical to assume that sarcopenia and SO may be one of the pathogenetic factors of venous pump dysfunction and the occurrence of CVD and CVI, especially in older people. After all, it has been shown that women with CVD in the oldest group have higher values of body weight, BMI, total body fat, and lower body fat [13]. In addition, there is evidence that old age, obesity, and muscle weakness are independent factors in deep vein thrombosis [26]. However, the association of sarcopenia and SO with CVD has not yet been studied.

Objective — to investigate the association of sarcopenia and sarcopenic obesity with the severity of chronic venous disease in postmenopausal women.

Materials and methods

The study was performed at the Chebotarev Institute of Gerontology of the National Academy of Medical Sciences of Ukraine, NAMS of Ukraine. The study involved 117 postmenopausal women.

The patients were divided into two groups. Group I included 87 (74.4 %) women with CVD, and Group II included 30 (25.6 %) women without any signs of CVD.

Within Group I, two subgroups were distinguished based on the class of CVD as defined by the CEAP classification system.

Subgroup IA consisted of women with CVD classes 1 and 2 without CVI or with compensated CVI. Subgroup IB included women with CVD classes 3, 4, and 5, indicating subcompensated or decompensated CVI.

Subgroup IA included 45 (51.7 %) women, and subgroup IB included 42 (48.3 %), as presented in Table 1.

The diagnosis of CVD was made on the basis of symptoms and a clinical and ultrasound (if necessary) examination of the lower extremities. All patients were examined by vascular surgeons. Demographic (age and gender) and anthropometric (weight, height, body mass index — BMI) characteristics were collected.

To assess CVD, we used the CEAP classification [7]. The C0s category, according to the CEAP classification (no deficiency or obstruction), was determined after excluding other possible causes of the symptoms.

BMI was calculated as the ratio of body weight (kg) to height (m)^2 (WHO, 1998). Obesity was diagnosed when the BMI exceeded 30 kg/m^2. Women were divided into three categories based on their BMI: Category I — with normal body weight (BMI 18.5—24.9 kg/m^2); Category II — with overweight (BMI 25.0—29.9 kg/m^2); and Category III — with obesity (BMI over 30.0 kg/m^2).

The measurement of fat and lean mass was conducted using dual-energy X-ray absorptiometry with the Hologic device (Discovery WI, USA, 2015). [Dual-energy X-ray absorptiometry (DXA) with Hologic (Discovery WI, USA, 2015)].

The presence of sarcopenia was determined by the skeletal muscle assessment index — ASM/height^2 [1], where ASM is the total appendicular skeletal

Table 1. **Distribution of patients in subgroups based on the severity of CVD according to the CEAP scale [7]**

CVD class	Subgroup IA	Subgroup IB	Total
1	36 (41.4 %)	–	36 (41.4 %)
2	9 (10.3 %)	–	9 (10.3 %)
3	–	23 (26.4 %)	23 (26.4 %)
4	–	16 (18.4 %)	16 (18.4 %)
5	–	3 (3.4 %)	3 (3.4 %)
Total	45 (51.7 %)	42 (48.3 %)	87 (100 %)

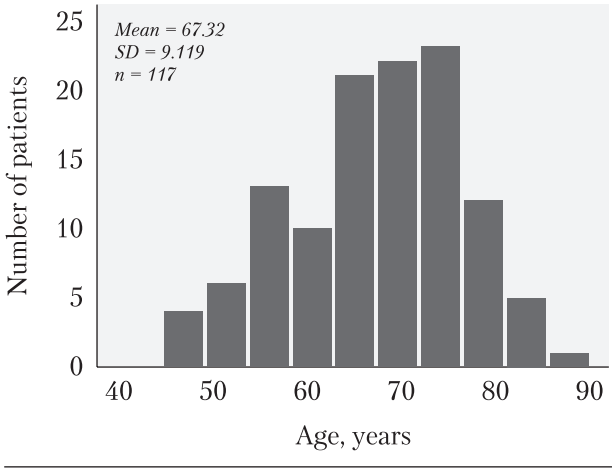

Figure 1. **Distribution of women by age**

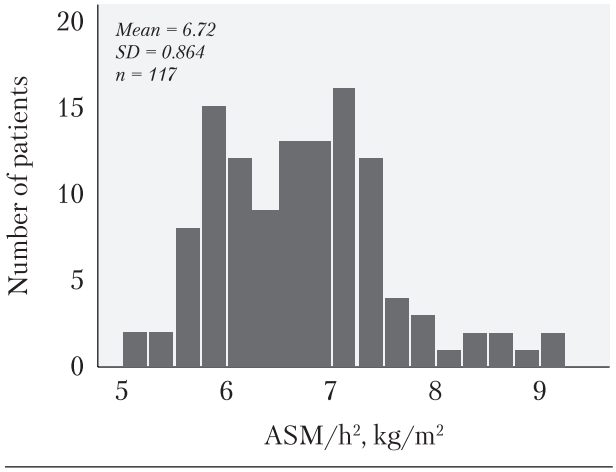

Figure 2. **Distribution of patients by ASM/ht²**

muscle mass of the legs and arms. Sarcopenia was diagnosed when the value of ASM/h^2 was less than 6.0 kg/m^2 [17]. The diagnosis of SO was made in patients with sarcopenia and a BMI of more than 25 kg/m^2 [14].

Statistical analysis was performed using IBM SPSS Statistics, V 22. Discriminant statistics were calculated. Mean values are presented as M ± SD. A comparison of the mean values of quantitative variables was performed using the Mann-Whitney U-test or Student's t-test, depending on the distribution of the variable. Relative values were compared using Pearson's chi-square test. Odds ratios (OR) with 95% confidence intervals (95% CI) were calculated to assess the association between factors and disease occurrence.

The null hypothesis of equality of variables was rejected at $p < 0.05$.

Results

The average age of menopausal women was 67.32 ± 9.12 years (from 46 to 86 years), as presented in Fig. 1.

Women in both groups did not differ in the mean age of 65.63 ± 8.17 years versus 67.91 ± 9.39 years in Group I and Group II, respectively, $p = 0.240$.

Table 2. **Distribution of patients by gerontological age categories in groups**

Age, years	Group I (n = 87)	Group II (n = 30)	Total (n = 117)
46—59	22 (25.3%)	11 (36.7%)	33 (28.2%)
60—74	37 (42.5%)	9 (30.0%)	46 (39.3%)
75—85	28 (32.2%)	10 (33.3%)	38 (32.5%)

There was also no difference between the groups in the distribution of age categories, $p = 0.382$, as presented in Table 2.

There were no differences in anthropometric data between the study groups (Table 3).

The groups did not differ in BMI categories, $p = 0.199$, as seen in Table 4.

The skeletal muscle assessment index averaged 6.72 ± 0.864 kg/m^2 (Fig. 2).

Table 3. **Anthropometric characteristics of women in the study groups**

Variable	Group I	Group II
Body weight, kg	75.5 ± 15.3 (45—125)	73.2 ± 15.4 (42—121)
Height, cm	159.7 ± 6.5 (146—176)	160.3 ± 8.3 (150—175)
BMI kg/m^2	29.6 ± 6.3 (18.4—50.1)	28.6 ± 6.3 (18.7—49.1)

Note. Variables are presented as M ± SD (min—max).
The difference between Group I and Group II is statistically insignificant ($p > 0.05$) for all variables.

Table 4. **Distribution of women by body mass index categories in groups**

BMI, kg/m^2	Group I (n = 87)	Group II (n = 30)	Total (n = 117)
Normal weight, 18.5—24.9	23 (26.4%)	6 (20.0%)	29 (24.8%)
Overweight, 25.0—29.9	25 (28.7%)	14 (46.7%)	39 (33.3%)
Obesity, over 30.0	39 (44.8%)	10 (33.3%)	49 (41.9%)

Women without CVD (Group I) had lower mean ASM/ht^2 values (6.63 ± 0.72 kg/m^2) than patients with CVD (Group II) (6.97 ± 1.0 kg/m^2), but this difference was not statistically significant (p = 0.056).

In general, sarcopenia was detected in 27 (23.1 %) women, and SO in 17 (14.5 %). There was no significant difference in sarcopenia frequency between the groups. Thus, in Group I, 5 (16.7 %) women had sarcopenia, and in Group II — 22 (25.3 %), p = 0.334. At the same time, a significantly larger proportion of patients with SO was observed in Group I (18.4 %) compared with Group II (3.3 %), p = 0.044, as presented in Table 5.

There was also an increase in the proportion of women with sarcopenia and sarcopenic obesity with increasing severity of CVI, as seen in Table 6.

Thus, out of 87 women with CVD, sarcopenia was diagnosed in 22 (25.3 %): 8 (17.8 %) with compensated CVI and 14 (33.3 %) with sub- and decompensated CVI, p = 0.095. Sarcopenic obesity was detected in 16 (18.4 %), including 4 (8.94 %) with compensated CVI and 12 (28.6 %) with sub- and decompensated CVI, p = 0.018.

Thus, in menopausal women, the risk of CVD is increased in the presence of sarcopenia and sarcopenic obesity compared with women without sarcopenia and SO: OR 1.69; CI 0.578—4.96 and OR 6.54; CI 0.828—51.58, respectively.

Table 5. **Frequency of sarcopenia and sarcopenic obesity in the study groups**

Variable	Group I (n = 87)	Group II (n = 30)	Total (n = 117)
Sarcopenia	22 (25.3 %)	5 (16.7 %)	27 (23.1 %)
Sarcopenic obesity	16 (18.4 %)	1 (3.3 %)*	17 (14.5 %)

Note. The difference from Group I is statistically significant (p < 0.05).

Table 6. **Incidence of sarcopenia and sarcopenic obesity in Group I depending on the severity of CVI**

Variable	Compensated (n = 45)	Subcompensated/ decompensated (n = 30)	Total (n = 87)
Sarcopenia	8 (17.8 %)	14 (33.3 %)	22 (25.3 %)
Sarcopenic obesity	4 (8.94 %)	12 (28.6 %)*	16 (18.4 %)

Note. The difference from the patients with compensated CVI is statistically significant (p < 0.05).

Women with CVD in the presence of sarcopenia and sarcopenic obesity have an increased risk of sub- and decompensated CVI compared with women without sarcopenia, and SO: OR 2.38; CI 0.877—6.433 and OR 4.20; CI 1.234—14.29.

Discussion

Chronic venous diseases of the lower extremities are one of the most discussed medical problems. In Western countries, approximately 3 % of total healthcare costs are associated with venous diseases, which occur in 25—30 % of women and 10—40 % of men [9, 20, 25]. Among the well-known risk factors for CVD are age, gender, genetic factors, sedentary lifestyle, sedentary work, nutritional aspects (consumption of large amounts of meat food), etc. [16, 28, 31]. Data on the link between obesity and CVD are still considered controversial. A number of studies have reported a significant correlation between BMI and clinical severity, according to the C-category of the Clinical, Anatomical and Pathophysiological (CEAP) classification [11]. Danielsson et al. found a significant association between clinical severity, according to CEAP category C, and BMI [4]. In a study of the San Diego population, increased waist circumference was associated with cardio-vascular diseases in men and women, and increased body weight was a risk factor for mild cardio-vascular diseases, although only in women.

According to Musil D et al., multiple linear regression showed that age (p < 0.0001) and BMI (p = 0.049) are independent predictors of the clinical grade of CVI and CEAP clinical grade of CVD (p < 0.0001) and are significant predictors of the degree of epiphasic venous reflux [19].

Eskici H et al. used multivariate logistic regression analysis to find that high levels of visceral obesity affect clinical complaints in patients with CVI (class C0-C3) [8].

A study of 1116 patients with CVD showed that CVD categories (CEAP C) were significantly associated with overweight and obesity [27],

In contrast, a French epidemiological study found no association between CEAP category C and obesity [1].

S. Demir et al. assessed the association between the severity of venous insufficiency and body mass index in patients referred for Doppler ultrasound and found no association of BMI with the severity of CVI [5].

In 2015, Iranian researchers investigated the incidence of CVD in 197 female hairdressers aged 18—68 years, which was 47.7 %. In this study, no significant association was found between CVD

and participants' body weight. However, CVD was significantly correlated with patient age (OR 1.08; 95 % CI 1.03, 1.13); family history of cardio-vascular diseases (OR 1.99; 95 % CI 1.03, 3.82), blood pressure (OR 4.41; 95 % CI 1.63, 11.90), and standing time (OR 2.34; 95 % CI 1.05, 5.22) [6].

In our study, we hypothesised that one of the risk factors for CVD and CVI may be not so much overweight or obesity, but rather so-called sarcopenic obesity. SO combines the negative effects of both excess weight and the weakness of the muscle venous pump due to sarcopenia. To our knowledge, no similar studies have been conducted. The cohort of patients included in the study was limited to postmenopausal women, which is a drawback. Also, in this study, we did not examine other risk factors for CVD, such as comorbidities, including osteoporosis, osteoarthritis and back pain, which were present in these women.

The results of the study showed that in menopausal women, SO increases the chance of developing CVD by 6.4 times compared to women without SO (OR 6.54; CI 0.828—51.58).

Women with CVD in the presence of SO have a 4.2-fold increased chance of developing sub- and decompensated CVI compared to women without SO: OR 4.20; CI 1.234—14.29.

Thus, in menopausal women, the risk of CVD is increased in the presence of sarcopenia and sarcopenic obesity compared to women without sarcopenia and SO: OR 1.69; CI 0.578—4.96 and OR 6.54; CI 0.828—51.58, respectively.

Women with CVD in the presence of sarcopenia and sarcopenic obesity have an increased risk of sub- and decompensated CVI compared with women without sarcopenia and SO: OR 2.38, CI 0.877—6.433 and OR 4.20, CI 1.234—14.29.

These findings may be important for improving CVD prevention by not only reducing body weight but also preventing muscle loss, especially in the lower extremities. At the same time, it is necessary to further investigate this aspect of the problem by including a more diverse sample of individuals across different age groups and genders.

Conclusions

Menopausal women with CVD were more likely to have SO (18.4 %) compared to those without CVD (3.3 %) (p = 0.044).

Menopausal women with CVI in the stages of sub- and decompensation were more likely to suffer from SO (12 (28.6 %)) than women with compensated CVI (4 (8.94 %)), p = 0.018; OR 6.54; CI 0.828—51.58.

Postmenopausal women with CVD were more likely to have sarcopenia and had a higher incidence of sub- and decompensated CVI compared with women without sarcopenia, but the difference was not statistically significant.

Declaration of interests

The authors declare that they have no conflicts of interest.

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Authors contributions

Conception and design — G. O. Kostromin, O. V. Balaban; data collection and analysis — G. O. Kostromin; statistical analysis — G. O. Kostromin, R. V. Gonza; critical revision of the manuscript — G. O. Kostromin, O. V. Balaban, R. V. Gonza.

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Саркопенічне ожиріння та тяжкість хронічного захворювання вен у жінок у постменопаузі

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Саркопенічне ожиріння (СПО) — функціональний і клінічний стан, що характеризується одночасним існуванням саркопенії (СП) та надлишком жирової тканини, може бути одним із патогенетичних чинників хронічного захворювання вен (ХЗВ) нижніх кінцівок і хронічної венозної недостатності (ХВН) через порушення діяльності м'язової венозної помпи та ожиріння, яке також вважають чинником ризику.

Мета — визначити зв'язок між саркопенією і саркопенічним ожирінням та тяжкістю хронічного захворювання вен у жінок у постменопаузальний період.

Матеріали та методи. У дослідження було залучено 117 жінок у постменопаузі, яких розподілили на дві групи: групу I — 87 (74,4 %) жінок з ХЗВ, групу II — 30 (25,6 %) жінок без ознак ХЗВ. У групі I виділили дві підгрупи за класом ХЗВ відповідно до класифікації CEAP: IA — 45 (51,7 %) жінок із ХЗВ 1 та 2 класу (компенсована ХВН), IB — 42 (48,3 %) жінки з класом ХЗВ 3, 4 та 5 (субкомпенсована або декомпенсована ХВН). Жирову та нежирову масу вимірювали методом двохенергетичної рентгенівської абсорбціометрії за допомогою Hologic (Discovery WI, США, 2015). Наявність СП визначали за індексом оцінки скелетних м'язів АММ/зріст^2, де АММ — це сумарна апендикулярна м'язова маса ніг та рук. Саркопенію діагностували при значенні показника АММ/зріст^2 <6,0 кг/м^2. Діагноз СПО установлювали в пацієнток із СП та індексом маси тіла > 25 кг/м^2.

Результати. Середній вік жінок становив (67,32 ± 9,12) року (46—86 років), середній індекс маси тіла — (29,1 ± 6,0) кг/м² (18,4—50,1 кг/м²), АММ/зріст² — (6,72 ± 0,864) кг/м². Жінки групи I мали менші значення АММ/зріст² ((6,63 ± 0,72) кг/м²), ніж жінки групи II ((6,97 ± 1,0) кг/м²; p = 0,056). Саркопенія виявлена у 27 (23,1 %) жінок, СПО — у 17 (14,5 %). Не було статистично значущої різниці між групами жінок за частотою СП: в групі I СП мали 5 (16,7 %) жінок, у групі II — 22 (25,3 %), (p = 0,334). Частка хворих із СПО в групі I була статистично значущо більшою порівняно із групою II — 18,4 та 3,3 % (p = 0,044). Відзначено збільшення частки жінок із СП і СПО зі збільшенням тяжкості ХВН: СП була у 8 (17,8 %) пацієнток у підгрупі IA та в 14 (33,3 %) у підгрупі IB (p = 0,095), СПО — у 4 (8,94 %) та 12 (28,6 %) відповідно (p = 0,018).

Висновки. Жінки в менопаузі з ХЗВ частіше мали СПО — (18,4 %) порівняно з пацієнтками без ХЗВ (3,3 %, p = 0,044). Жінки в менопаузі з ХВН в стадії субкомпенсації та декомпенсації частіше страждали на СПО (12 (28,6 %)), ніж жінки з компенсованою ХВН (4 (8,94 %, p = 0,018, відношення шансів — 6,54, 95 % довірчий інтервал — 0,83—51,58. Жінки в менопаузі з ХЗВ частіше хворіли на СП і мали більшу частоту субкомпенсованої та декомпенсованої ХВН порівняно із жінками без СП, але різниця була статистично незначущою.

Ключові слова: жінки після менопаузи, хронічні захворювання вен, хронічна венозна недостатність, саркопенія, саркопенічне ожиріння.

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Preclinical evaluation of the individualized approach for chronic non-healing wounds management

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Chronic non-healing wounds (CNHW) are very common and often incorrectly treated, the morbidity and associated costs of chronic wounds management highlight the need to implement wound prevention and treatment concepts.

Objective — to evaluate the possibility of different metal nanooxide polymer nanofilms use for CNHW' local treatment.

Materials and methods. The study design is based on evaluation of various types of dressing materials considering their option for use in CNHW local treatment. Samples of biodegradable polymer films (with an optimal composition of gelatin, polyvinyl alcohol, lactic acid, glycerin and distilled water) saturated with nanoparticles of several oxides with expected antibacterial and pro-regenerative feature — nZnO, nMgO in concentrations of 1 %, 5 %, and 10 % were used in the study of antimicrobial action and substance release profiling. Quarterly ammonium antiseptic decamethoxin 0.02 % was used for control.

Results. Obtained data shows that polymer based biodegradable films incorporating optimal component composition (gelatin, polyvinyl alcohol, lactic acid and glycerin) enriched with 5 % and 10 % zinc nanooxide have potent antimicrobial activity against both gram-positive and gram-negative microorganisms, the most common causative agents of CNHW's. The ion release capacity analysis showed that the Zinc impregnated wound-healing biodegradable polymer film gradually releases the active substance in a time dependent manner, and the nano-sized particles of nanoZinc oxide are released from the polymer composition faster than ordinary zinc oxide.

Conclusions. Complex natural biodegradable polymer based nanofilms are composite materials impregnated with metal nanooxides showing high potential in local treatment of chronic non-healing wounds. Polymer film with 5 % nanoZnO showed up to the 58 % higher antimicrobial activity, comparable or exceeding the one of quarterly ammonium compound decamethoxin. Furthermore, nanoZnO impregnated polymer films compared to standard ZnO impregnated polymer films showed up to 63.2 % faster substance release profile with rapid and more unified curve.

Keywords

chronic wound, ulcer, treatment, metal nanooxide, polymer nanofilm, antimicrobial activity, biofilms.

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Chronic non-healing wounds (CNHW) are those that do not progress through a normal, and timely sequence of repair, and one of the most common chronic conditions today impacting lifestyle and health status of millions worldwide [1]. They are very common and often incorrectly treated, the morbidity and associated costs of chronic wounds management highlight the need to implement wound prevention and treatment concepts [3]. The mainstay of CNHW treatment is the TIME concept, which includes Tissue debridement, Infection control, Moisture balance, and Edges of the chronic wound [2, 9]. Following these common approaches are addressed, treatment may be focused on specific to the ulcer type features [7, 19].

More than 70 % of patients with diabetes mellitus (DM) suffer from various complications of

diabetes, among which the most common is diabetic foot syndrome or diabetic foot syndrome (DFS), which is a complex of morpho-functional and pathogenetic changes in the tissues of the lower extremities against the background of diabetic micro- and macroangiopathy. neuropathy, osteoarthropathy [11]. In the majority of patients with DFS, CNHW of the foot and lower leg are registered, which in almost half of the cases ends in forced amputations [4, 10].

CNHW are commonly associated with metabolic, regulatory and vascular conditions. In addition to DFS, another important types of CNHW are venous, arterial and pressure ulcers, which are slightly less common but similarly poses a great risk for the respective patients in terms of morbidity, mortality and various complications. High levels of disability and mortality determine the medical and socio-economic significance of the disease [12, 19].

According to the existing recommendations, the general principles of treatment of patients with CNHW [1, 3] include compensation and normalization of metabolism, including carbohydrate and lipid violations, correction and compensation of organ dysfunctions, detoxification; rational systemic and local etiotropic antibacterial therapy; elimination/correction of angio- and neuropathy, unloading (immobilization) of a limb; reduction of oedema and ischemia; timely necessary and adequate surgical intervention; local treatment of a chronic wound (ulcers or other defects of covering and soft tissues), vascular resuscitation. The role of local CNHW's treatment is preserved throughout decades as majority of these patients have multiple comorbidities and high risk for development of complications, making high-scale surgical interventions dangerous and ineffective [2].

Hitherto, there are significant differences in the interpretation of many aspects of the treatment of patients with CNHW, especially regarding the choice and phasing of surgical interventions, selection of local therapies, debridement techniques and selection of remedies. At the current stage, opposing views on surgical activity in CNHW have been formed. On the one hand, the implementation of radical interventions already at the beginning of the development of purulent-necrotic processes, which is justified by the expected inevitability of further pathological changes progression, on the other hand, the maximum limitation of interventions, and selection of merely conservative approach, which is justified by the high risk of their complications [1, 2, 7]. As a result, there is a high risk of unjustified choice of methods and stages of surgical treatment in patients with CNHW, especially in terms of selecting the local procedures and measures [18].

The above determines the need to develop an individualized approach to local surgical treatment of patients with CNHW.

Objective — to evaluate the possibility of different metal nanooxide polymer nanofilms use for CNHW' local treatment.

Materials and methods

The study design is based on evaluation of various types of dressing materials considering their option for use in CNHW local treatment and was fully compliant with acting national and international legislation in bioethics. Following the study, it may act as a background for selecting the proper dressing materiel for individualized treatment of CNHWs.

Samples of biodegradable polymer films (with an optimal composition of gelatin, polyvinyl alcohol, lactic acid, glycerin and distilled water) saturated with nanoparticles of several oxides with expected antibacterial and pro-regenerative feature — nZnO, nMgO in concentrations of 1 %, 5 %, and 10 % were used in the study of antimicrobial action. Quarterly ammonium antiseptic decamethoxin 0.02 % samples (n = 5) were used for control. The study of antimicrobial activity was carried out by standard solid media disk diffuse method (by inoculating the surface of an agar plate with bacteria isolated from clinical material). The inhibition zone in mm was calculated after 24 hrs. of cultivation in thermostat at temperature 36 °C. Ninety clinical strains of microorganisms that are most often isolated in 98 patients' wounds content: *S. aureus* MSSA (n = 10), *S. aureus* MRSA (n = 10), *S. epidermidis* MSSE (n = 10), *S. haemolyticus* MRSH (n = 10), *S. pyogenes* (n = 10), *E. coli* (n = 10), *P. aeruginosa* (n = 10), *C. freundii* (n = 10), *Candida* spp. (n = 10). Five samples of each tested polymer films were used for obtaining more statistically valid results.

Study of the substance release capacity of biodegradable polymer films (n = 5, each type, respectively) was performed spectrophotometrically or using the colorimetric test system with a sensitivity of 0.1—5 mg/l [17].

The raw digital data obtained in the study was processed by the variation statistics method in MS Excel software. Student's t-test was used to test whether the difference between two groups is statistically significant or not. The frequency characteristics of the investigated indicators (n, %), the average values (mean — M) of the variability estimates of the quantitative indicators (mean square deviation) and the average error (m) were calculated.

Results and discussion

Testing the activity of polymer films saturated with antibacterial agents against clinical strains of microorganisms showed that the highest antimicrobial effect was observed in films impregnated with decamethoxin, as expected, taking into account its topical antimicrobial activity. The results of the study (Fig. 1) indicate the size of microorganism's suppression using the 5 % concentration of zinc nanooxide in a biodegradable film base. This type of film has the widest spectrum of antimicrobial activity and effectively suppressed the growth of all tested strains of microorganisms, especially emphasizing *S. pyogenes*, coagulase-negative cocci (including the methicillin-resistant strain of *S. haemolyticus*), as well as *Candidae* spp. The nano-sized zinc oxide films showed their acceptable antimicrobial potential in relation to all tested taxonomic group of opportunistic microorganisms. However, tested films with magnesium nanooxide introduced into the polymer base showed no significant antimicrobial activity (not shown in the diagram).

The overview of biofilm's antimicrobial efficacy is presented in the table. Zones of microorganisms' growth inhibition (mm) under the influence of films with zinc nanooxide to some extent increased in ratio to its concentration.

The best antimicrobial effect against resistant MSSE and MRSH was observed in 5 % ZnO films. Whereas, β-hemolytic *S. pyogenes* was found to be the most sensitive of all ZnO film samples, especially at concentrations of 1 % and 5 %. Regarding polyresistant *P. aeruginosa*, all studied nanofilms showed minor but only a bacteriostatic influence. The antimicrobial activity of the 5 % and 10 % ZnO nanofilms was comparable to decamethoxin. A 5 % ZnO impregnated nanofilm showed top activity against *E. coli*, whilst two times weaker antimicrobial effect was observed in films impregnated with 10 % magnesium nanooxide.

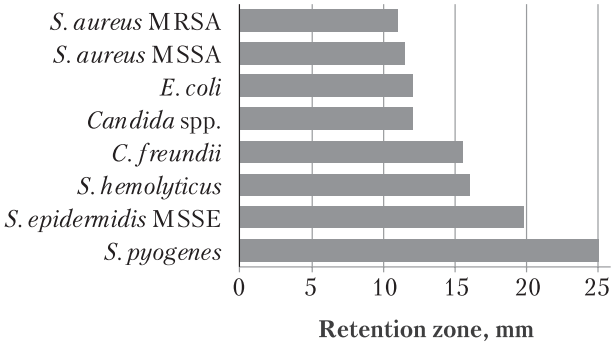

Figure 1. **Efficacy of 5 % ZnO antimicrobial action against most common CNHW pathogens.**
Data shows respective growth retention zone's sizes

Obtained data shows that polymer based biodegradable films incorporating selected component composition (gelatin, polyvinyl alcohol, lactic acid and glycerin) enriched with 5 % and 10 % zinc nanooxide have potent antimicrobial activity against both gram-positive and gram-negative microorganisms, the most common causative agents of CNHW's.

Expectedly, based on the literature data [4] the speed of Zn^{2+} ions release from the films significantly increased when using its nanoform. Only during first 5—15 minutes of test standard ZnO film showed comparable release of ions. The most remarkable difference between samples was observed during 30—1140 minutes of exposure (Fig. 2).

Table. **Comparison of antimicrobial action of tested biofilms**

Pathogen	DKT	1 % ZnO	5 % ZnO	10 % ZnO	1 % MgO	5 % MgO	10 % MgO
S. aureus MSSA	14.29 ± 0.21	9.78 ± 0.17*	11.49 ± 0.35*#	11.98 ± 0.33#	6.45 ± 0.63#&	6.32 ± 0.17#&	6.01 ± 0.31#
S. aureus MRSA	13.65 ± 0.25	11.47 ± 0.84*	10.90 ± 0.46*	10.53 ± 0.18	–	–	–
S. epidermidis MSSE	13.87 ± 1.10	15.39 ± 0.46*	17.90 ± 0.77*#	15.78 ± 0.60&	–	–	–
S. haemolyticus MRSH	15.81 ± 0.77	6.17 ± 0.37*	16.23 ± 0.32*#	15.43 ± 0.55#	–	–	–
Str. pyogenes	20.96 ± 0.68	23.08 ± 0.42*	24.60 ± 0.11*#	18.21 ± 0.63#&	–	–	–
E. coli	8.92 ± 0.47	8.88 ± 0.27	11.64 ± 0.16*#	9.40 ± 1.06	6.63 ± 0.64#&	6.83 ± 0.15#&	7.01 ± 0.42#&
P. aeruginosa	[10.20 ± 0.36]	–	[9.46 ± 0.18]	[9.83 ± 0.20]	–	–	–
Citrobacter freundii	4.82 ± 0.67	14.33 ± 0.79*	15.48 ± 0.23*	11.00 ± 0.43#&	–	–	–
Candida	11.69 ± 0.36	9.77 ± 0.34	12.13 ± 0.89*#	13.20 ± 0.67#	–	–	–

Note. DKT — decamethoxin (control). Values in square brackets mean presence of bacteriostatic effect only.
* The difference from the control (decamethoxin) is statistically significant ($p < 0.05$).
# The difference compared to 1 % ZnO film is statistically significant ($p < 0.05$).
& The difference compared to 5 % ZnO film is statistically significant ($p < 0.05$).

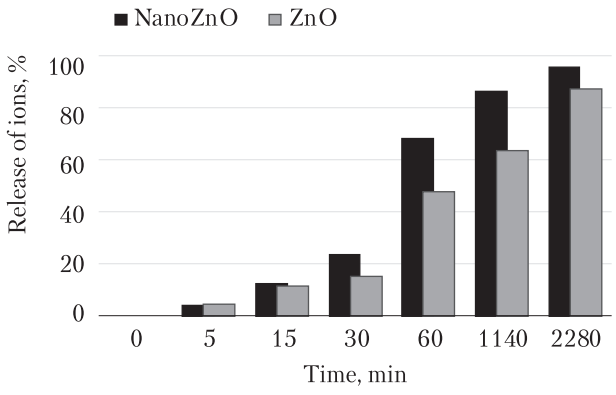

Figure 2. **Time-dependent comparison of 5 % ZnO and 5 % nanoZnO ions release from polymer films**

The ion-release capacity analysis showed that the Zinc impregnated wound-healing biodegradable polymer film gradually releases the active substance in a time dependent manner, and the nano-sized particles of nanoZinc oxide are released from the polymer composition faster than ordinary zinc oxide. This phenomenon may have both positive and negative interpretations as longer release may decrease the number and frequency of dressings, alleviating iatrogenic wound trauma, however, faster release of ions let achieving of higher drug concentration and better, and more reliable antimicrobial action.

Adequate management of chronic non-healing wounds remains challenging both in terms of prevalence and complexity [10]. In recent decades, considerable progress has been achieved in understanding the background of wound healing, and creating novel approaches for their treatment [1, 6].

Whereas explosive volumes of studies and related publications may be found, and the developments of hundreds of dressing and therapy options became available, the issue is far from being solved. Moreover, existing database sometimes cause confusions due to different research approaches used in different studies, making extrapolation and use of data problematic [5].

The efficacy of the complex gelatin-containing polymer films use as carriers of therapeutic agents has been previously mentioned in literature [2, 4, 15]. Available sources [16] indicate that on the basis of natural biodegradable polymers combined with active substances the composite materials with specified substance release properties can be created [12, 21], and metal nanooxides are well released from the polymer carrier, which significantly increases the effectiveness of CNHWs' local treatment applying a smaller dose of drug [17, 18].

In this study we have confirmed well established data concerning zinc containing [2, 13, 14, 20] polymer film efficacy. However, it remained unclear whether different zinc concentrations could have demonstrated significant variations in antimicrobial activity. Moreover, this is one of the first studies to introduce and explore nanoforms of polymer films dedicated to CNHW treatment. Therefore, it was shown that 5 % zinc as a nanoZnO is preferable emphasizing its higher antimicrobial effect and ion-releasing potential.

The limitations of the study include comparatively small dataset in terms of its size and *in vitro* character of the methodical approach. Further clinical studies of nanoZnO polymer films use may accurately accomplish this study.

Conclusions

Complex natural biodegradable polymer based nanofilms are composite materials impregnated with metal nanooxides showing high potential in local treatment of chronic non-healing wounds. Polymer film with 5 % nanoZnO showed up to the 58 % higher antimicrobial activity, comparable or exceeding the one of quarterly ammonium compound decamethoxin. Furthermore, nanoZnO impregnated polymer films compared to standard ZnO impregnated polymer films showed up to 63.2 % faster substance release profile with rapid and more unified curve.

Declaration of interests

The authors declare no conflicts of interest.

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Authors contributions

The authors have contributed equally to concept and design, acquisition and interpretation of data, drafting the article.

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Доклінічна оцінка індивідуального підходу до лікування хронічних тривало незагоюваних ран

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Хронічні незагоювані рани (ХНР) дуже поширені та часто неправильно лікуються, захворюваність і пов'язані з цим витрати на лікування хронічних ран підкреслюють необхідність впровадження концепцій профілактики та лікування ран.

Мета — оцінити можливості використання різних місцевих методик і засобів у лікуванні ХНР.

Матеріали та методи. Дизайн дослідження ґрунтується на оцінці різних типів перев'язувальних матеріалів з урахуванням їх можливості використання при місцевому лікуванні ХНР. Зразки біорозкладних полімерних плівок (з оптимальним складом желатину, полівінілового спирту, молочної кислоти, гліцерину та дистильованої води), насичених наночастинками кількох оксидів з очікуваною антибактеріальною та прорегенеративною властивістю — nZnO, nMgO у концентраціях 1 %, 5 % та 10 %, були використані для вивчення антимікробної дії та профілю вивільнення діючої речовини. Для контролю використовували четвертинно амоніевий антисептик декаметоксин 0,02 %.

Результати. Отримані дані свідчать, що біорозкладні плівки на полімерній основі з оптимальним компонентним складом (желатин, полівініловий спирт, молочна кислота та гліцерин), збагачені 5 % та 10 % нанооксидом цинку, демонструють потужну антимікробну дію як щодо грампозитивних, так і грамнегативних мікроорганізмів, найбільш поширених збудників ХНР. Аналіз здатності до вивільнення іонів показав, що просочена цинком ранозагоювальна біорозкладна полімерна плівка поступово вивільняє активну речовину залежно від часу, а нанорозмірні частинки нанооксиду цинку вивільняються з полімерної композиції швидше, ніж звичайний оксид цинку.

Висновки. Комплексні природні біорозкладані наноплівки на основі полімерів — це композиційні матеріали, просочені нанооксидами металів, які мають високий потенціал для місцевого лікування хронічних ран, що не загоюються. Полімерна плівка з 5 % наноZnO показала найвищу антимікробну активність, порівнянну або таку, що перевищує четвертинно амонієву сполуку — декаметоксин. Крім того, полімерні плівки, просочені наноZnO, порівняно зі стандартними полімерними плівками, просоченими ZnO, показали кращий профіль вивільнення речовини з швидшою та більш уніфікованою кривою.

Ключові слова: хронічна рана, виразка, лікування, нанооксид металу, полімерна наноплівка, антимікробна активність, біоплівка.

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Lemniscate intestinal loop through an internal hernia after Roux-en-Y gastric bypass cause of coecum mobile. A case report

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The internal hernia is a typical complication after laparoscopic Roux-en-Y gastric bypass surgery. In most cases, there are chronic symptoms that only lead to a diagnostic laparoscopy during the diagnostic exclusion procedure. Less common is acute internal hernia with devastating pain, ileus symptoms and even the development of intestinal gangrene. Although this case describes a typical constellation, it posed a particular challenge because it resulted in mesenteric lemniscate-like torsion through the Petersen pouch.

Case presentation. A 29-year-old patient presented to our emergency department with abdominal pain, complained of sudden epigastric pain that lasted overnight, and radiated into the back with a permanent belching every 10 seconds. Four weeks ago, the patient received an abdominoplasty, complaining of postprandial nausea, meterorism and constipation afterwards. 19 months ago, a Roux-en-Y gastric bypass with a weight of 109 kg and a body mass index of 42.6 kg/m^2 was done. The current body weight was 60 kg and the body mass index was 23.4 kg/m^2. After focused assessment with sonography for trauma and the detection of dilated intestinal loops, an abdominal computer tomography (CT) was performed. Radiologically, the suspicion of mesenteric malrotation was confirmed. The SWELL (CT-graphic swirl sign, excess weight loss > 95 %, liquid in abdomen CT scan) score was positive with a CT-graphic swirl sign and an excess weight loss of 108.9 % (> 95 %), no chylus or ascites. We discussed an immediate, necessary diagnostic laparoscopy. Based on the ileocoecalpol, it was not possible to establish a proper assignment of the detached gastrointestinal tract. The exploration of the sigmoid colon as the only fixed point revealed that this was a complete fixed twisting of the right intestinal part with a twist of the caecum into the right upper abdomen through the Petersen space. This necessitated a laparotomy to manually cancel Bernoulli's lemniscate-like loop and perform a mesenteric defect suture of the mesenteric space of Brolin and the Petersen space with a non-absorbable suture. The intestinal loops and patient recovered quickly. The dismission was on the 4th post-operative day.

Conclusions. The internal hernia after gastric bypass remains a diagnostic challenge despite advances in imaging. Due to the increasing number of patients undergoing bariatric surgery, this differential diagnosis must always be considered in the case of abdominal complaints. In addition to the excess weight loss of > 95 %, this case shows that a recent abdominoplasty can also provoke an internal hernia.

Keywords

internal hernia, Roux-en-Y gastric bypass, adipositas, bariatric surgery, mesenteric defect, mesenterial closure, Petersen pouch, Brolin pouch, coecum mobile, Lemniscate, Bernoulli.

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The proximal Roux-en-Y gastric bypass was first performed in 1966 by Edward E. Mason and Chikashi Ito, inspired by weight loss after gastrectomies [28]. Over the years, this process has been modified. One change that formed the basis for the procedure carried out today was the modification in 1991, according to Wittgrove and Clark [44]. He postulated the laparoscopic implementation and formation of a small gastric pouch. Nowadays, there are various techniques and variants that affect the essential components of this procedure and the rate of development of an internal hernia [19]. In eighth registry report of 2023 of International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO), with 24 participating countries and a total of 480,970 bariatric registered procedures, Roux-en-Y surgery for obesity continues to account for 30 % of all bariatric surgeries performed worldwide, making it the second most common procedure after sleeve gastrectomy [21]. As a rule, an antecolic alimentary and a biliopancreatic loop are formed, which pass into the common channel via a footpoint anastomosis [42].

The internal hernia is defined by a passage from an intestinal loop through a hernia gap or space, the so-called Petersen space formed by the antecolic alimentary loop and transverse colon and mesenteric Brolin space by jejunojejunostomy [22, 34]. It continues to be a typical early and long-term complication after laparoscopic Roux-en-Y gastric bypass surgery. A recent multicenter study from 2023, which evaluated data from 46,918 patients from 2005 to 2015 from the New York SPARCS (Statewide Planning and Research Cooperative System) database, was able to determine a cumulative internal hernia rate of 4.8 % within 3 years. The cumulative rate at the end of the thirteenth year was 12 %. In the end, however, a declining incidence could also be found in the course of the last few years of the study [11]. A large Norwegian cohort study was able to work out a rate of 11 % within 5 years [1]. If there is a preoperative history of smoking, the hazard ratio of 2.3 is significantly higher than for nonsmokers [6].

The clinical symptoms of an internal hernia can vary greatly [9, 42]. Asymptomatic, intermittent, and chronic subacute symptoms make diagnosis and suspected diagnosis even more difficult.

In most cases, there are chronic symptoms that only ultimately lead to a diagnostic laparoscopy in the diagnostic exclusion procedure. Here, postprandial symptoms and colicky pain often occur early. These move into the left upper abdomen and can then also be accompanied by regurgitation and vomiting, usually clear fluid [23]. It is not uncommon for patients to report that, depending on their position in the lying position, the symptoms are decreasing. In many cases, these are transient and can progress to an acute stage with sometimes devastating pain, with the manifestation of ileus symptoms up to the development of intestinal gangrene and peritonitis.

There are various attempts to classify the internal hernia. They are based on the time of the first operation, early or late onset of the symptoms and time of consecutive surgery, extent of the obstruction, anatomical pathways through the mesenteric defects and affected loops alimentary, biliopancreatic and common channel in the sense of the ABC classification (A — alimentary, B — biliopancreatic, C — common channel) [7, 13, 18, 29]

Computed tomography has a sensitivity of 63—92 % and is therefore the most important imaging diagnosis [2, 45]

The so-called mesenteric swirl is the most specific sign and is easy to see when quickly scrolling the individual axial but also not negligible sagittal computer tomography (CT) images [20, 27].

If both the swirl sign and the so-called mushroom sign occur [38], which is created by a mushroom-shaped configuration through hernated small intestine loops with pneumatic stool contents, the sensitivity and specificity can be slightly increased [27]. Chylous ascites, enlarged mesenteric lymph nodes, mesenteric edema and venous congestion with the development of splenomegaly can be indirect signs of chronic recurrent torsion with twisting and obstruction of the mesenteric vessels [4]. Other signs may include the hurricane eye sign, the small bowel behind the superior mesenteric artery, and right-sided anastomosis [10].

However, if acute ileus signs or small intestinal obstruction are missing, diagnosis by CT is more difficult and does not seem to be suitable for the clarification of intermittent complaints or internal hernias, so only an exclusion laparoscopy is useful in order to avoid fatal complications [20]. Valid predictive scores for an internal hernia result from a CT-graphic swirl sign (SWirl), excess weight loss > 95 %, and detection of ascites (free Liquid), the so-called SWELL (SWirl, excess weight loss > 95 %, liquid in abdomen CT scan) score [15]. In consideration of 5 further clinical signs — the U- or C-shaped loop, beak sign, and fat notch sign — and two clinical signs of neutrophilia and abdominal tenderness, the rate of negative laparoscopies can be significantly reduced and the need for laparoscopy is given [15, 26].

The surgical treatment of the internal hernia continues to be a challenge and is associated with considerable risks [3, 30]. In-hospital treatment

pathways and surgical standards help avoid typical pitfalls [23]. In our clinic, an anti-Trendelenburg position is performed with spread legs for the surgeon and a slightly retracted upper body with legs bent in the beach chair position. If an internal hernia is suspected, both arms are attached in order to explore the small intestinal loops starting from the ileocoecal pole. In our clinic, the capnoperitoneum is created through the Veress needle via Palmers Point. This is because massive weight loss with melted visceral fat and a condition after an abdominoplasty are not uncommon. Then a 12 mm trocar is placed in the left upper abdomen for instrument change and tobacco pouch suture with a camera-guided atraumatic optic trocar. Another 10 mm trocar is placed in the middle abdomen supraumbilically, and a 5 mm trocar in the right upper abdomen and left upper abdomen. The incision at Palmers Point is used by another 5 mm trocar. These positions allow a change of position, confirmation of the diagnosis, retorsion of the intestine and closure of the mesenteric defects. For closure, a continuous slowly absorbable suture is now used in our clinic. Lesions of the small intestine during instrumental exploration, fixed intestinal loops due to the hernia gaps, contact vulnerability, lack of capnoperitoneum possibility and reliable overview of dilated small intestine loops make conversion necessary in some cases [23, 29].

Case presentation

Patient information

A 29-year-old patient presented with devastating abdominal pain in our emergency room. She complained of sudden epigastric pain that lasted overnight, radiated into the back and had been permanent since the morning hours. It was noticeable that the patient showed a permanent belching of air every 10 seconds. She reported that she had had problems with bowel movements since an abdominoplasty a month ago and repeatedly suffered from severe meteorism and belching, especially postprandial. In the surgical history, there was a condition after laparoscopic proximal Roux-en-Y gastric bypass surgery with an initial weight of 109 kg, which corresponded to a body mass index (BMI) of 42.6 kg/m^2 with a height of 160 cm. At that time, the patient already had arterial hypertension, urinary incontinence and hirsutism as obesity-associated comorbidities. During the last pregnancy, the patient developed insulin-dependent gestational diabetes. The primary surgery was performed 19 months ago as a laparoscopic placement of a proximal gastric bypass according to Roux-en-Y with a 100 cm alimentary channel and 100 cm biliodigestive channel, an antecolic antegastric with a 60 mm side-to-side jejunojejunostomy and a 30 mm linear gastrojejunostomy stapleranastomosis. A suture for mesenteric defects was not used as the clinic's own standard.

The adminoplasty 4 weeks ago was performed at a weight of 60 kg and a BMI of 23.4 kg/m^2. The weight loss was 45 % and the excess weight loss was 108.9 %.

Physical examination

The abdomen was peritonitically tense in the clinical examination and could hardly be examined. Under parenteral Novalgin and Dipidolor infusion, a soft lower abdomen was now present, but still peritonitically tense upper abdomen. Auscultatory, no peristalsis or elevated bowel sounds could be heard.

Diagnostic

The focused assessment with sonography for trauma showed partially dilated intestinal loops. Laboratory-chemically, no leukocytosis, no C-reactiv protein and lactatdehydrogenase elevation were shown, the creatinkinase and electrolytes were normal. Thrombocytosis with 392 platelets/nl (normal value: 140—360/nl), a slight glutamat-pyruvat-transaminase/alanin-aminotranferase increase of 38 U/L (norm 10—35 U/L) and a lipase increase of 77 U/L (norm $<$60 U/L) were conspicuous, the cholestasis parameters, renal retention parameters and coagulation were within the normal range. An abdominal CT was performed if an internal hernia was suspected.

Radiologically, the suspicion of a mesenteric malrotation with venous outflow disorder in the sense of a volvulus was confirmed (Fig. 1—3). In previous gastric bypass surgery, an internal hernia was considered a differential diagnosis without evidence of a hollow organ perforation. A swirl sign and a beak sign were depicted. Ascites as the third parameter of the SWELL score could not be documented. A massive edematous mesenteric root with congested vessels filling the entire ventrodorsal space of the abdomen was striking.

Therapy

We discussed an immediate, necessary diagnostic laparoscopy. Intraoperatively, the finding of an internal hernia was confirmed (Fig. 4, 5). The intestinal loops were extremely vulnerable to contact, the mesentery was edematously bloated with partial fibrinous sweating, and the venous vessels were congested. Portions of the alimentary channel were already purple in color. As a rule, exploration of the small intestine in internal hernia is carried out

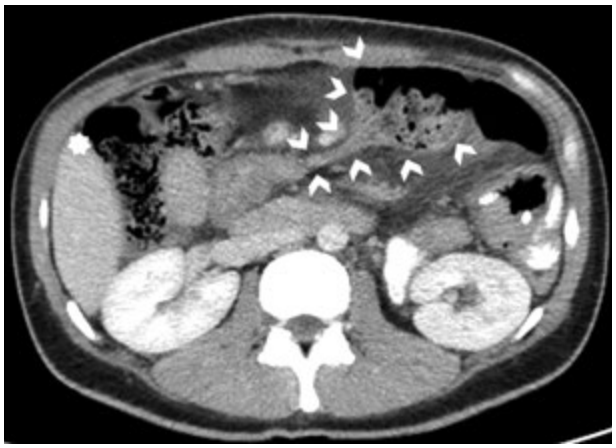

Figure 1. **Abdominal computer tomography. The arrows mark the left transverse colon, which tapers behind the mesenteric root (distended colon = head, narrowed colon = beak of the bird), the asterisk marks the torqued coecum mobile in the right upper abdomen**

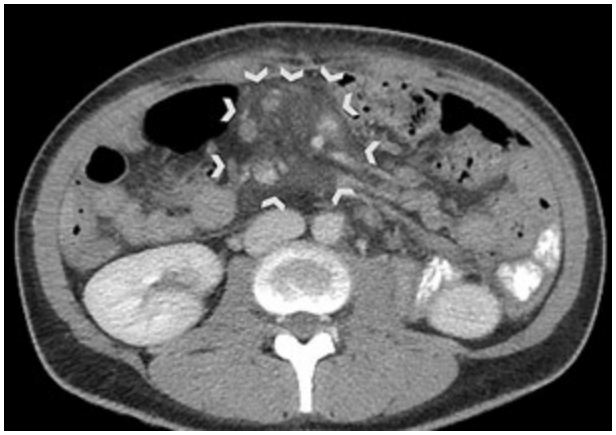

Figure 2. **The arrows mark the massively edematous torqueted mesenteric root, which occupies the entire abdominal space**

from the ileocoecalpole, but here an unusual picture emerged. The appendix was on the «wrong» side facing away and the coecum was relatively high in the right upper abdomen. The exploration of the typical gaps was impossible due to the massive swelling and fixed parts of the intestine that could not be repositioned. Only an exploration of the sigmoid colon revealed that this was a complete twisting of the common channel, ileococal area with attached right hemicolon and middle transverse through the Petersen space, as the left transverse colon suddenly dived towards Treitz and no longer continued towards the liver. The right hemicolon seemed to embrace the alimentary channel, which also passed proportionately through the mesenteric defect. It gave the impression that someone took the ileocaecal pole with the common channel, guided it through the Petersen pouch, took parts of the alimentary channel

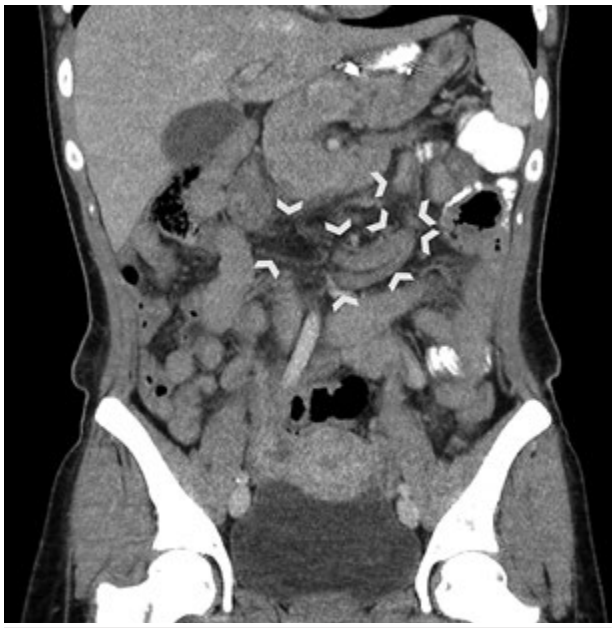

Figure 3. **Swirl sign and congested mesenteric vessels. The arrows indicate the mesenteric twist, when scrolling through the CT images, the swirl sign becomes clearer**

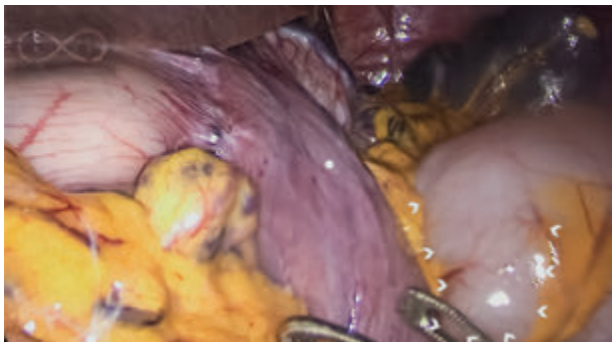

Figure 4. **The forceps mark the ischemic livid twisted alimentary loop, the arrows mark the submersible left transverse colon behind the mesenteric root with the formation of the typical beak sign**

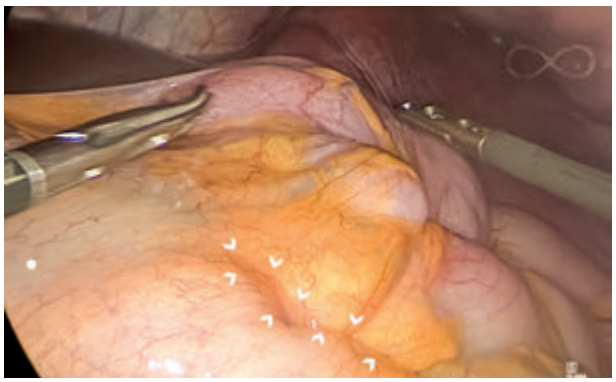

Figure 5. **The asterisk marks the mesenteric edema, the arrows mark the mesocolic lemniscate-like twist through the Petersen gap with narrowing of the «natural» passage of the left hemicolon retrograde of the alimentary loop, which is enclosed by the right hemicolon and common channel**

with it and put it over the right flexure in front of the mesentery of the transverse colon and right hemicolon, so that the coecum came to rest in the right upper abdomen in a correspondingly twisted manner. This necessitated a laparotomy to manually cancel the lemniscate-like loop and perform a closure of the mesenteric defect of Brolin and the Petersen pouch with a non-absorbable tobacco pouch suture. The intestinal loops recovered quickly. The postoperative course was without complications. The patient was able to leave the clinic on the 4th post-operative day with a proper diet build-up and well-being.

Discussion

The caecum mobile refers to a fixation anomaly with a misalignment of the coecum. The normal position of the caecum is the result of rotation, mesenteric fixation, and descensus due to growth in early childhood. In the absence of growth, the cecal pole can be located in a cranial direction, both ventrally or dorsally, as well as medially or laterally. If longer sections are insufficiently retroperitoneally fixed, a coecum mobile or an ascending mobile colon develops, which can ultimately lead to volvulus.

The term «volvulus» comes from the Latin volvere, which means «to turn». This condition has been described for thousands of years, as have rudimentary therapies. The first written documentation and therapy recommendation of the volvulus with the full picture of the acute abdomen was discovered in the Ebers Papyrus, an almost 19-metre-long, over 3600-year-old papyrus scroll from the 16th century BC, which the egyptologist Georg Ebers acquired in Luxor in 1873 and brought to Leipzig. It is the only completely surviving medical manuscript of antiquity (Eb 296 (52, 1—51, 7)) and describes the suffering of a patient with an intestinal obstruction caused by a worm-like twisting of the intestine [37].

The incidence of colonic volvulus varies considerably around the world. In Western Europe and the USA, only about 5 % or less suffer from it. In the so-called «volvulus belt» (Middle East, Africa, the Indian subcontinent, Turkey, and South America), volvulus is the cause of intestinal obstruction in up to 75 % of cases [12, 16, 32]. Coecum mobile is usually asymptomatic and is described in autopsies in 11 % of cases [35, 41]. The occurrence of a mobile colon, including the transverse, is much rarer. Coecumvolvulus is responsible for about 1.0—1.5 % of intestinal obstructions and about 10—40 % of all colonic volvulus cases and thus occurs significantly less than sigmoid volvulus [33]. The coecum volvulus can be divided into an axial ileocoelic volvulus (90 % of cases) and an upturned coecum volvulus (10 % of cases, «cecal bascule»). In the case of the patient, there was also a lack of suspension of the transverse colon. This congenital anomaly is very rare and is similar to Chilaiditi syndrome [5, 31].

The therapy of the coecum mobile and colon ascendens was discussed in detail as early as 1908 [8, 43]. Numerous cases were reported by the German surgeon Prof. Wilms, who worked at the University Hospital Basel, and processed by means of radiograms [43]. Various methods up to a cirrharmonica-like gathering with non-absorbable sutures of the caecum and colon ascendens have been described as early as the early 20th century [14]. A conservative treatment of volvulus was already described by Hippocrates [5]. He recommended blowing air into the intestine and inserting a 10-finger-long suppository. Endoscopic treatment is not expedient, as the length of the colon and the closed abdominal wall prevent the intestine from straightening. Thus, only surgical therapy such as coecopexy, hemicolectomy, coecostoma and colostomy can be considered. In the present case, however, it was not the mobile hemicolon that was the cause of the disease, but rather the Petersen pouch after proximal Roux-en-Y gastric bypass. The question of whether or not to have a primary mesenteric defect closure seems to have been clarified in bariatric surgery. Many retrospective analyses and prospective registry data indicate that the probability of developing an internal hernia in the course of life is so high that the respective authors recommend a defect closure of both the mesenteric gap of the jejunojejunostomy, so-called Brolin gap, and the gap between the raised alimentary jejunal loop, Treitz's ligament and transverse colon, so-called Petersen pouch after laparoscopic Roux-en-Y gastric bypass surgery. The assumption is based on the analysis of retrospectively and prospectively evaluated patient data sets [25, 40]. However, if one takes into account the complete scientific evidence, this contrasts with a meta-analysis from 2020, which determines a low incidence but documents an increased number of small bowel obstructions that cannot be attributed to an internal hernia [17]. Two other prospectively randomized studies found no difference between the primary closure and non-closure groups in the three-year and five-year follow-ups [36, 39]. Likewise, all studies show prolonged surgical time and a higher instant postoperative complication rate due to the mesenteric defect closure [24, 40].

So, the truth seems to lie in the middle. One study finds smoking to be an independent factor in the development of an internal hernia, while other studies suggest a higher incidence in pregnant women, which can be explained by the change in the spatial

conditions of the intestinal loops and growing uterus in the abdomen. Expert opinions recommend not doing any sports or strenuous activities for three months after surgery in order to avoid increased abdominal pressure and thus the formation of an internal hernia. Others recommend the regular cutting of the omentum majus in order to use this as a space seal.

Each centre should therefore go its own way. A first step would be to avoid a Roux-en-Y gastric bypass; a second step would be to check the surgical technique; and a third step would be to perform defect closure in high-risk patients such as smokers and young women who want to have children. The fourth step would be the choice of suture material and seam technique for the defect closure. A recommendation as to which closure technique should be chosen continuously — single button sutures, tobacco pouch sutures, absorbable, non-absorbable sutures, or clips — cannot be answered by the current state of studies. In our case, we chose a non-absorbable tobacco pouch suture to close the Petersen and Brolin gaps. A hernia recurrence has not occurred so far.

Conclusions

The detection of an internal hernia continues to be a challenge. It also helps to develop an internal standard and recommendations for action in patients with abdominal complaints after proximal Roux-en-Y gastric bypass. In diagnostic imaging, CT examination continues to be the most sensitive means of detecting an internal hernia. In this case, it is advisable to discuss the images with the radiologists, point out the typical signs, and review them retrospectively again after revision surgery.

Due to the formation of centers and sometimes complex course of the internal hernia, it is not uncommon (40—52 %) for false negative findings to be described in CT scans [3]. Therefore, the attending surgeon should not hesitate to strive for a diagnostic laparoscopy, according to the law of the Rhenish saying «Isch hab' da so ein Jefühl» («I have such a feeling»).

Declaration of interests

The authors declare that they have no conflicts of interest and that they have no financial ties to disclose.

Ethics approval and written informed consent statements

Oral and written informed consent was obtained from the patient to publish the patient-related data in anonymized form.

Authors contributions

C. R. D. Demtröder, T. H. Le, P. Kirchmeyer, D. Utz: surgery, treatment, literature research, literature review and draft of the manuscript; H. Agarius, U. Giger-Pabst, D. Dajchin: literature research, literature evaluation and critical revision of important contents of the manuscript.

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Внутрішня грижа з лемніскатоподібним перекрутом брижі після шунтування шлунка за Ру. Клінічний випадок

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Внутрішня грижа є типовим ускладненням після лапароскопічного шунтування шлунка за Ру. У більшості випадків є хронічні симптоми, які є підставою для проведення лапароскопії лише для заперечення діагнозу. Рідше трапляється гостра внутрішня грижа із виразним больовим синдромом, симптомами кишкової непрохідності та навіть розвитком гангрени кишечника. Описаний випадок був особливим викликом, оскільки призвів до лемніскатоподібного (вісімкоподібного) перекруту брижі крізь простір Петерсена, хоча перебіг був типовим.

Опис клінічного випадку. Пацієнтка, 29 років, поступила у відділення невідкладної допомоги зі скаргами на раптовий біль в епігастрії протягом ночі з іррадіацією в спину, що супроводжувався регургітаці-

єю кожні 10 с. Чотири тижні тому пацієнтка перенесла абдомінопластику. Після оперативного втручання скаржилася на нудоту після вживання їжі, метеоризм і запори. Відомо, що 19 міс тому пацієнтці з масою тіла 109 кг та індексом маси тіла 42,6 кг/м^2 було виконано шунтування шлунка за Ру. Поточна маса тіла — 60 кг, індекс маси тіла — 23,4 кг/м^2. Після проведення FAST-сонографії та виявлення розширення петель кишечника було виконано комп'ютерну томографію черевної порожнини. Рентгенологічно підтверджено підозру щодо мезентеріальної мальротації. Оцінка за шкалою SWELL була позитивною з КТ-ознакою завихрення, надлишкова втрата маси тіла становила 108,9% (> 95%), без хілусу й асциту. Прийнято рішення про негайне проведення діагностичної лапароскопії. На підставі ілеоцекальпоскопії не вдалося встановити правильної локалізації відриву шлунково-кишкового тракту. Дослідження сигмоподібної кишки як єдиної фіксованої точки показало, що це був повний фіксований заворот правої частини кишки із заворотом сліпої кишки в праву верхню частину живота крізь простір Петерсена. Це зумовило необхідність проведення лапаротомії для ручного усунення лемніскатоподібної петлі Бернуллі та ушивання дефекту брижі мезентеріального простору Броліна та простору Петерсена шовним матеріалом, що не розсмоктується. Пацієнтка швидко відновилася та була виписана на 4-ту добу після операції.

Висновки. Внутрішня грижа після шунтування шлунка є діагностич
ною проблемою попри досягнення в галузі візуалізаційних методів діагностики. У зв'язку зі збільшенням кількості пацієнтів, які потребують баріатричного хірургічного лікування, цей диференційний діагноз завжди слід установлювати за наявності абдомінальних скарг. Крім втрати надлишкової маси тіла (> 95%), цей випадок показує, що нещодавнє проведення абдомінопластики також може спричинити внутрішню грижу.

Ключові слова: внутрішня грижа, шунтування шлунка за Ру, ожиріння, баріатрична хірургія, дефект брижі, закриття брижі, простір Петерсена, простір Броліна, coecum mobile, Лемніската Бернуллі.

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A clinical case of secondary breast augmentation after previous implants removal

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The patient underwent primary breast augmentation at a different clinic. Two years later, the implants were replaced with larger breast implants (500 ml each). Three months after the procedure, inflammation of the right and left mammary glands occurred, which led to the removal of both implants. The patient was 24 years old when the surgery took place. She underwent a preoperative examination in accordance with the standards set by the Ministry of Health of Ukraine. The patient came to us for breast augmentation, correction of mammary gland contour imperfections, and management of postoperative scars. Round-shaped and moderate-profile implants were selected. Implant parameters: width 13 cm, projection 4.4 cm, implant texture — microtexture, volume 400 ml. We placed the implants in the retropectoral space, and used the dual-plane method for cavity formation. The surgical procedure lasted for a total of 140 minutes. The duration of the patient's hospitalisation was one day. No drains were used. The scars on the abdomen were also corrected and fixed in the projection of the inframammary fold. No complications occurred in the postoperative period. The patient received antibiotic therapy and took nonsteroidal anti-inflammatory drugs. Postoperative wound management was carried out. We prescribed compression underwear for the patient to wear for two months after surgery.

Mammoplasty is a commonly performed procedure in plastic surgery. It aims to produce predictable and agreed-upon aesthetic outcomes for the patient while maintaining a low rate of complications by adhering to modern surgical standards. The patient experienced complications that led to a significant scarring process. The pectoralis major muscle had a significant deformity, and the tissue showed scarring. The lack of muscle elasticity complicated the implant placement, leading to specific challenges throughout the operation. The occurence of complications following mammoplasty invariably has a lasting impact on the capsule's formation and increases the risk of developing both early and late postoperative issues.

Keywords
mammoplasty, breast augmentation, implant replacement.

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Breast augmentation surgery is one of the most common surgeries, with 1,892,777 surgeries performed worldwide in 2023. Two major aspects contributed to this scenario: the large number of plastic surgeons and the availability of various implant manufacturers [19, 11].

Numerous studies have been conducted on the adverse effects of silicone implants on breast tissue and approaches to addressing these problems [11]. Various indicators and methods can be used to select the ideal implant in terms of design, shape, and volume, including operative accesses, breast shape and contour, and nipple-areolar complex (NAP) position [12, 14].

Infectious complications after augmentation mammoplasty are rare, estimated to occur at a rate of 2—3 % [23].

About two-thirds of infectious complications emerge in the early postoperative period, while occasional cases of remote infectious complications developing years or even decades after surgery have been reported [25].

Infectious complications are more common after breast reconstructive surgery with implants compared to primary breast augmentation [3, 4, 21].

The major risk factors for infectious complications associated with breast implant placement

have not been thoroughly evaluated in prospective studies with long-term follow-up. The most significant determining factors have been identified as the surgical technique, the patient's general condition and the type of surgical intervention. Breast reconstruction after mastectomy and radiation therapy for breast cancer are particularly associated with an increased risk of infectious complications [7, 20].

The cause of infection in women with implants is difficult to determine, but potential sources include a contaminated implant, contaminated saline, the patient's skin, or milk ducts, as described in many studies where cultures were taken at the time of implant placement [27].

Late infection usually results from secondary bacteremia or an invasive procedure performed elsewhere in the body. Diagnostic and treatment strategies are provided and the importance of perioperative surgical prevention of remote infectious complications is discussed. The modern hypothesis about the possible role of normal microflora or subclinical infection in the occurrence of capsular contracture is also considered [9, 15—17, 24].

Anamnesis

Patient V., was born in 1999, was 24 years old at the time of surgery, and weighed 63 kg. She underwent primary augmentation mammoplasty in 2018 at the age of 19. Alergan implants in a round shape with a volume of 375 ml were placed.

Four years later (2023), the patient wanted to replace the implants with larger breast implants. She felt pain, discomfort, and changes in the aesthetic appearance of the mammary glands.

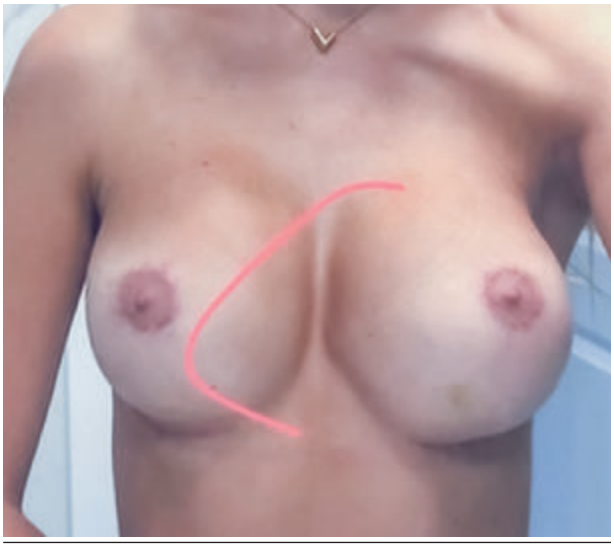

Figure 1. **Deformation of mammary gland contours after placement of 500 ml implants**

On March 30, 2023, she underwent placement of Mentor implants in a round shape with a volume of 500 ml. Fig. 1 presents the deformation of the mammary gland contours.

Three months after surgery, the patient reported a seroma on the right side and partially on the left side, along with pain and severe discomfort in the mammary glands. She had an elevated body temperature, and her chest became hot to the touch. The clinical signs progressed, and, in August 2023, a breast implant replacement surgery was conducted. The procedure included the removal of implants and the insertion of drains. According to the patient, the intraoperative visualisation of an intramuscular hematoma in the pectoralis major muscle and an inflammatory process supported the surgeon's decision.

Within two months after the operation, there was an inflammatory process in the suture area, followed by suppuration and long-term, considerable discharge from the drains.

In November 2023, hypertrophied scars appeared on the skin of the anterior abdominal wall, lower than the inframammary fold.

In 2024, the patient contacted us to discuss the possibility of correcting these complications. An operation was planned and carried out to reconstruct the pocket cavity for implants, increase the volume of mammary glands, manage scars, and relocate them to the projection of the inframammary fold.

At the preoperative examination and after agreeing on the desired volume of the mammary glands with the patient, it was decided to place round-shaped and moderate-profile breast implants. The implants had a width of 13 cm, which was determined by anthropometric tests, a projection of 4.4 cm, and Mesmo microtexture implant coating by Polytech Health and Aesthetics GmbH.

Before the operation, the patient had thickened scars around the areolas, their contours were unclear, and they were 4 to 7 mm wide. The scars from the previous surgical intervention were noted in the area of the abdomen, receding (at the most distant point) from the true inframammary fold by 5 cm to the right and 4 cm to the left. They were atrophic, measuring 4 to 8 mm wide, and tightly soldered to the body.

The contour of the mammary glands was clear, with a pronounced inframammary fold; the medial part was narrowed and deformed. The cleavage area at the level of the nipples was 8 cm, and at the level of the inframammary fold, it was 11.5 cm, as seen in Fig. 2*A*. When the pectoralis major muscles were contracted, the deformation of the contours of the mammary glands and their displacement laterally were noted, as seen in Fig. 2*B*, where white arrows

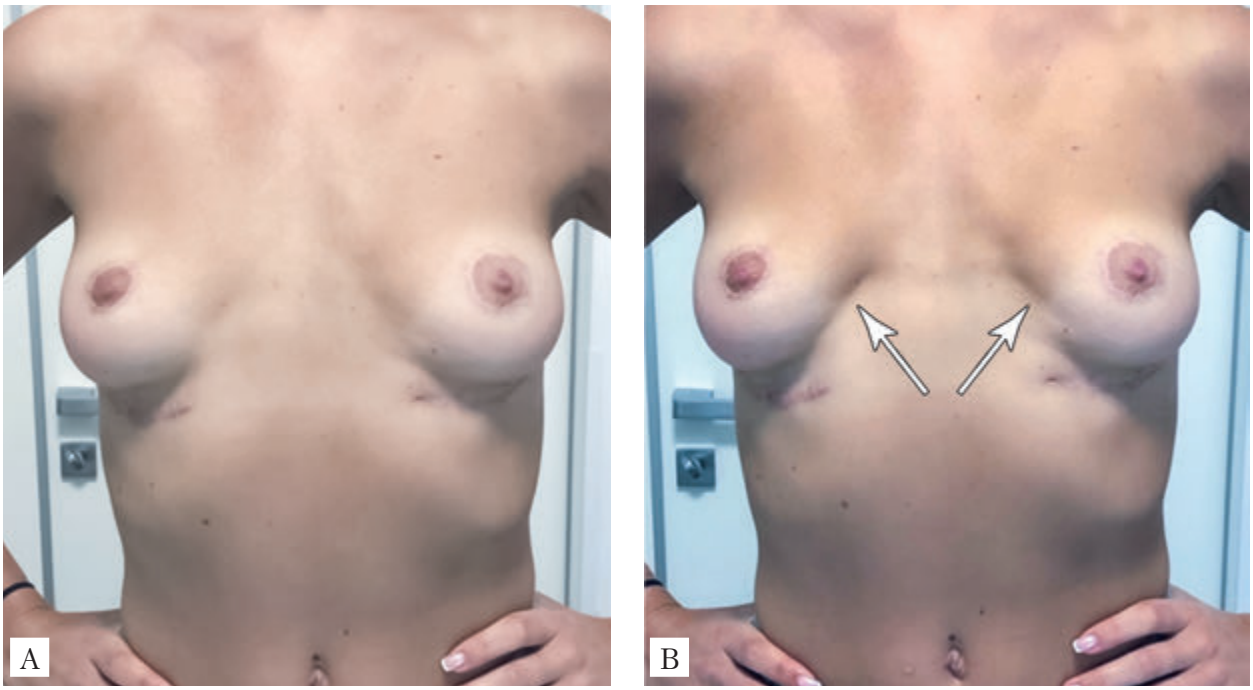

Figure 2. **The patient's condition before the reconstruction: without contraction of the pectoralis major muscles (A) with contraction of the pectoralis major muscles, which causes retraction and deformation of the internal contour of the mammary glands (B)**

mark the area of animation due to the pectoralis major muscles being strained.

The operation was performed under general anesthesia using local anesthesia (physiological solution 200 ml + lidocaine 10 % 4 ml + Bupivacaine 20 ml). The surgical procedure lasted for a total of 140 minutes. The duration of the patient's hospitalisation was one day. The preoperative marking of the patient is shown in Fig. 3.

After hydropreparation, the scars located on the anterior abdominal wall were excised. The dissection was conducted towards the inframammary fold. A planar dissection was performed, carefully selecting folds to ensure the proper contour of the mammary glands in the future. Further dissection was carried out in the retromammary space. The hard scars from the previous surgical procedure were dissected in the retromammary space up to the level of the nipples.

The pronounced scar process posed technical difficulties during the isolation of the pectoralis major muscle's edge. The muscle exhibited scarring, had a fibrous structure, and lacked elasticity. We formed a cavity to place the breast implants in the retropectoral space, then made vertical incisions in the scarred muscle due to its unelastic caudal part. The cavity was tamponed with Ceftriaxone antibiotic solutions. On both sides, the dissection and breast implant placement planes were symmetrical. On the left side, within the retropectoral space, there were remaining fragments of the previous implant capsule located in the central part of the retropectoral space. The capsule had dimensions of 5 × 4 cm, no additional inclusions, and a thickness of approximately 2 mm. We successfully removed it. After removing tamponing napkins, repeated hemostasis was performed. In such cases, we wash the implant cavity

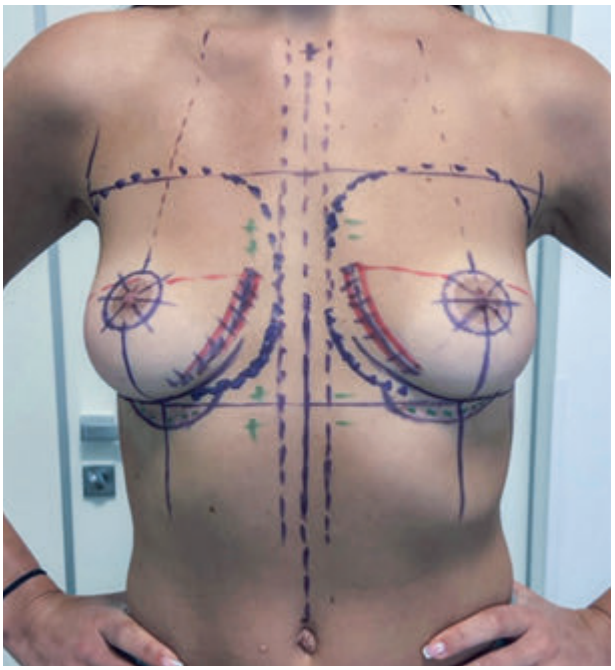

Figure 3. **Preoperative marking of the patient**

with a solution of Tranexamic acid at a concentration of 100 mg/ml. We used a Keller Funnel 2 to insert the implants in the prepared cavity.

No drains were used. The true inframammary fold was fixed in the correct position. The inframammary fold's fixation point was cranial to the lower part of the incision, as shown in Fig. 4.

A decision was made to extend the incision in order to align it with the inframammary fold in order to excise excess skin in the medial and lateral parts of the incision. The caudal part of the incision was not extended to the level of the inframammary fold. Instead, a dissection of the caudal part was carried out in a plane deeper than the superficial fascia. In the central part, the dissection was 10 cm long, which was enough to reposition the caudal part of the scar to the desired level of the inframammary fold. Since the caudal part of the incision was 25 cm and the cranial part of it measured 13 cm, the wound was sutured by absorbable suture poleglactine 3-0.

Figure 4. **The position of the caudal part of the postoperative scar in relation to the inframammary fold**

The correction of the scars around the areolas was not carried out due to a pronounced tension in this area, which could cause the development of non-cosmetic scars in the future. The patient was prescribed compression underwear.

The surgery lasted for a total of 140 minutes. The patient was hospitalised for a duration of one day and thereafter discharged for outpatient treatment. Prior to discharge, an ultrasound examination was performed, which revealed the absence of any fluid accumulation in the implant cavity.

In the future, examinations were conducted at intervals of 3—4 days. Pronounced postoperative swelling was noted for a period of 9—15 days. Immediately after the operation, a photo fixation of the obtained result was carried out. Fig. 5 shows the patient in a lateral projection immediately after the surgical procedure.

On the 5th day, up to 5 ml of fluid was detected around the implant on the right side, along with a localised hematoma measuring 4 ml in volume in the medial part of the mammary gland on the right side, namely in the retromammary space. Eight days after conservative treatment, a repeated ultrasound

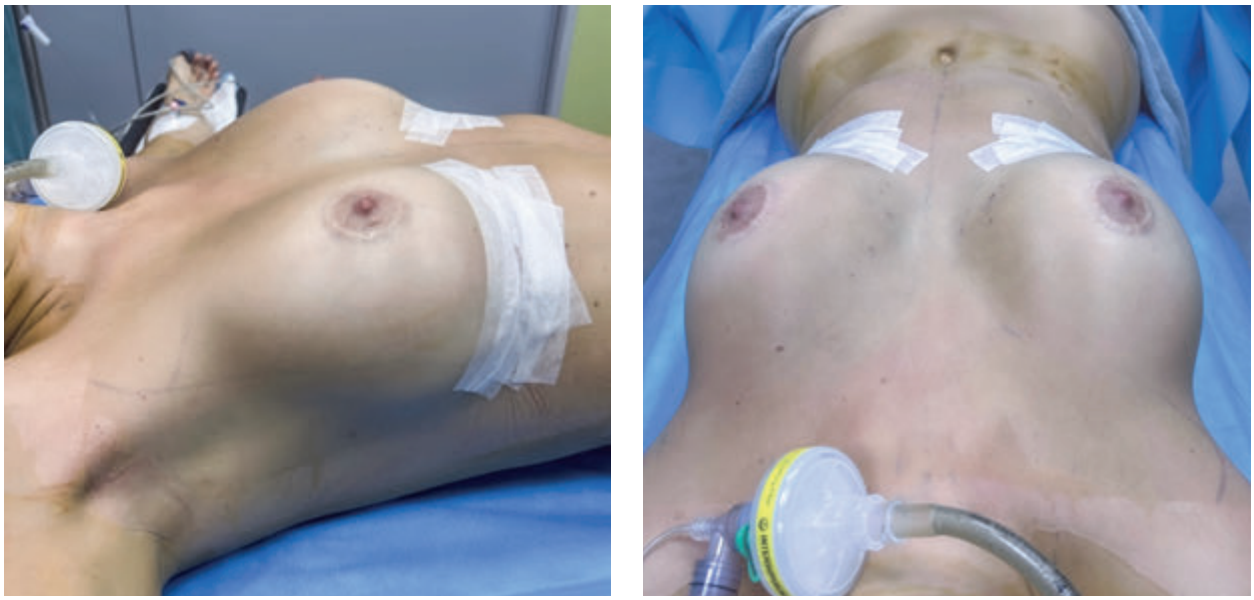

Figure 5. **The patient's condition immediately after the operation**

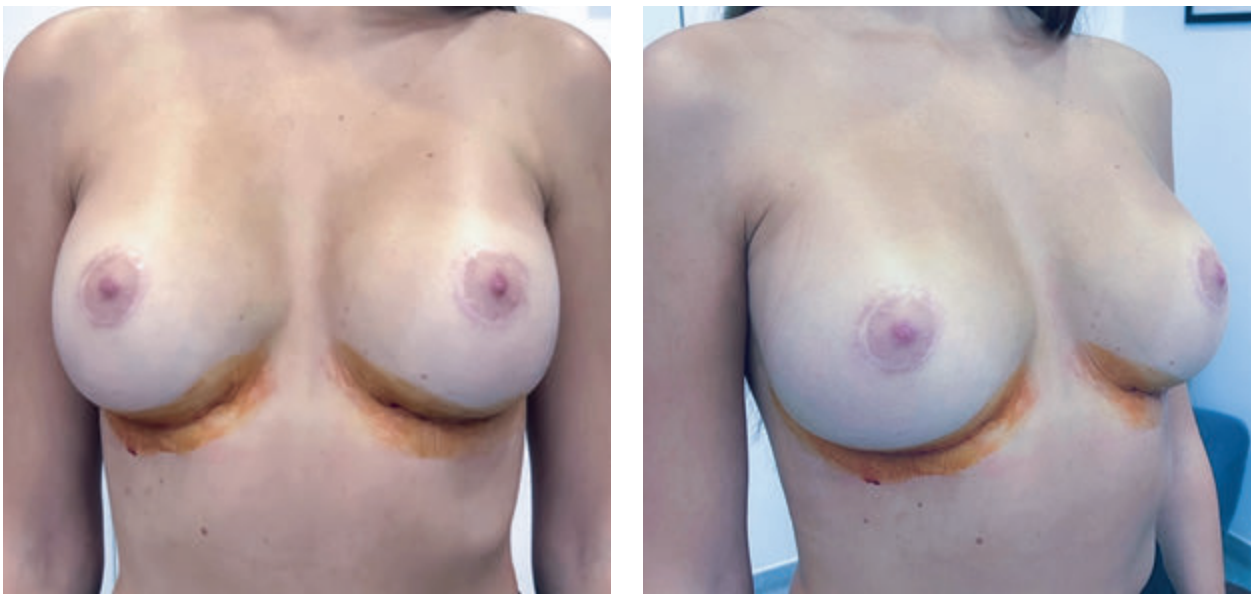

Figure 6. **The patient's condition on the 8th day after surgery**

examination did not reveal any free fluid in the area of surgical treatment. Fig. 6 shows the patient's condition on the 8th day after surgery.

The sutures were removed on the 14th day after surgery. An ultrasound study was conducted after 14 days to assess for any abnormalities, but no pathology was detected. The follow-up examination was made one month later. The implants were positioned symmetrically, and the neckline exhibited a symmetrical, clear contour without any deformities. The shape of the mammary glands was symmetrical, correct, and non-deformed. The implants showed minimal animation due to slight lateral displacement, which did not cause any changes in the mammary gland contour. The inframammary folds aligned with the location of postoperative scars. There was no skin deformation on the abdomen.

The main complication in the early postoperative period was impaired skin sensitivity in the area between the areola and the inframammary fold. However, this condition improved and returned to normal over a span of 2 months. The hematoma in the retromammary space, with a volume of 4 ml, cleared without complications and did not change the contour. No further accumulation of fluid around the implants occurred. No signs of purulent

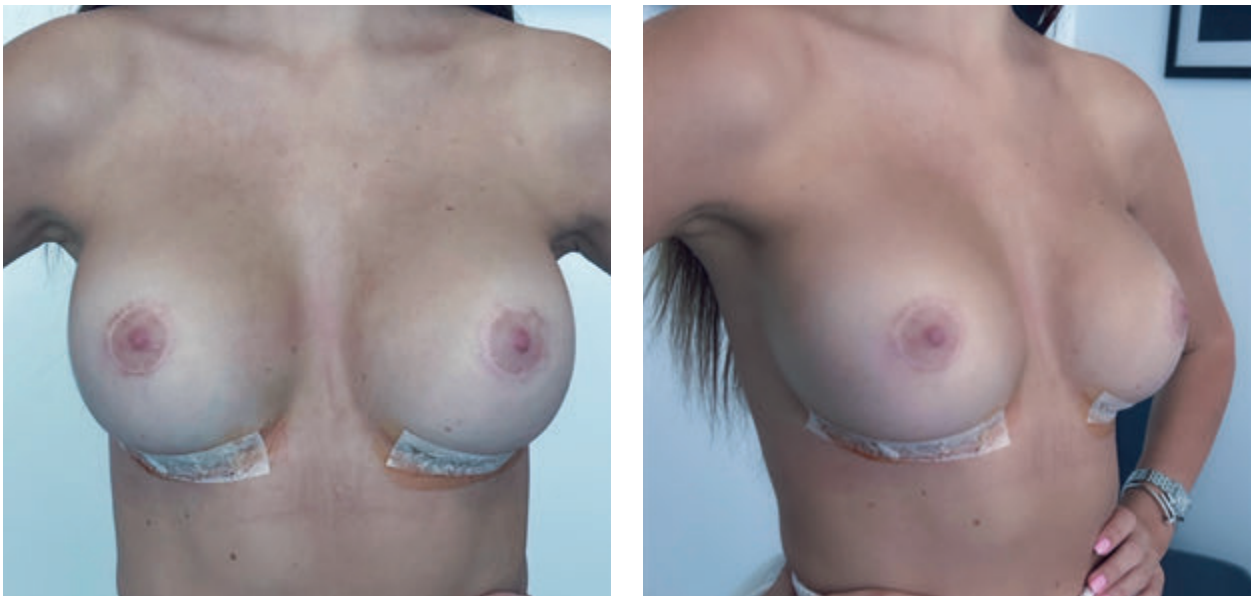

Figure 7. **The patient's condition one month after surgery**

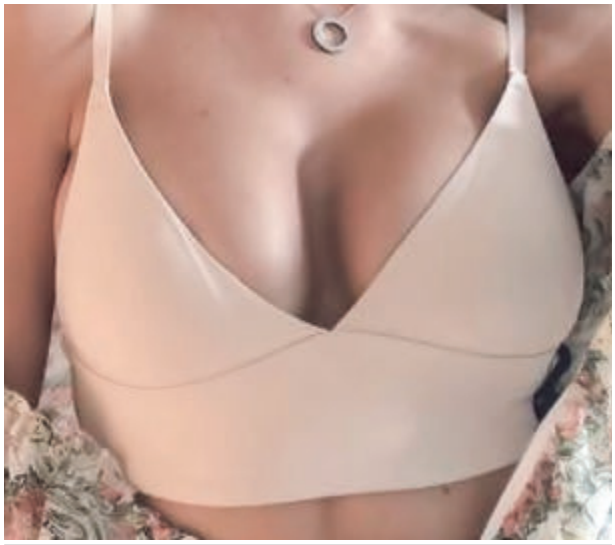

Figure 8. **The patient's condition three months after surgery**

inflammation were observed in the incision area (0 %). Fig. 7 shows the patient's condition one month after surgery.

Three months after surgery, the patient reported complete satisfaction with the outcome. The breasts exhibited optimal symmetry, with the folds aligning with the position of the scars. The scars healed without any signs of inflammation. Fig. 8 shows the patient's condition three months after surgery.

Discussion

Augmentation mammoplasty is one of the most common cosmetic surgeries, and the most common method of breast reconstruction after mastectomy is tissue expansion followed by implant implantation. Despite this, reoperation rates of up to 15 % and approximately 21 % for implant-based reconstructions have been documented. Therefore, strategies to reduce early postoperative and long-term complications are extremely important. In particular, the important prevention of contamination and the formation of further biofilms that cause the formation of capsular contracture are critically important [8, 22, 26].

Certain methods are employed to prevent bacterial contamination of the implant and biofilm formation. These include administering antibiotic prophylactic doses, avoiding periareolar incisions, selecting appropriate implant coverage, performing surgery in the double or subpectoral plane, sealing nipple films, irrigating implant cavities with a triple antibiotic solution, or PVP-I, and using plastic medical sleeves for implant placement [1, 2, 18, 28, 29].

Prior to any invasive percutaneous procedure, it is standard practice to decontaminate the skin using antiseptics. While there is ongoing debate about the most effective preoperative skin antiseptic to reduce the risk of surgical site infections (SSI), surgeons worldwide have traditionally used PVP-I as the most commonly used antiseptic.

PVP-I, commonly known as «betadine», is a water-soluble compound obtained from the combination of polyvinylpyrrolidone and molecular iodine. PVP-I preparations, which are most often used in surgery, are a scrub and an aqueous solution and are one of the best methods of skin treatment during aesthetic breast surgery, as proven by a number of studies [5, 6].

Although strict adherence to rigorous aseptic and antiseptic protocols is maintained, there is still a possibility of contamination of the implants or the created cavity by S epidermidis located at the wound edges during the placement of the implant [10].

Conclusions

Mammoplasty is one of the most common operations in plastic surgery. It aims to produce predictable and mutually agreed-upon aesthetic outcomes with the patient. When performed in accordance with established surgical standards, this procedure has a low incidence of complications.

The operation requires adherence to stringent aseptic and antiseptic protocols. The presence of infectious complications suggests a violation of these norms.

Correcting postoperative complications necessitates a proficient and highly qualified surgical team with superior technical skills. During the postoperative period, it is extremely important for the patient to follow all recommendations in order to minimise the occurrence of any complications.

Declaration of interests

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Ethics approval and written informed consent statements

Both oral and written informed consent was obtained from the patient to publish the patient-related data in anonymized form.

Authors contributions

O. Panchuk: concept and design of the study, material processing; I. Donets: material collection and processing; K. Galperin: writing the manuscript, material processing.

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Клінічний випадок вторинної аугментаційної мамопластики після видалення попереднього імплантату

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Пацієнтка була первинно прооперована в іншій клініці. Було проведено первинну аугментаційну мамопластику. Через 2 роки імплантати замінили на більший об'єм, він склав по 500 мл. Через 3 міс після заміни імплантатів виникло запалення правої та лівої молочної залози, що призвело до видалення обох імплантатів. На момент нашої операції пацієнтці було 24 роки. Обстежена в передопераційному періоді за стандартами МОЗ України. До нас звернулася з бажанням збільшити об'єм грудей, скоригувати деформацію контуру молочних залоз, виправити післяопераційні рубці. Було підібрано круглі імпланти, середньої проєкції. Параметри імплантатів: ширина 13 см, проєкція 4.4 см, текстура імплантату — мікротекстура, об'єм 400 мл. Імплантати встановлювалися в ретропекторальний простір, застосовувалася техніка формування порожнини для імплантів по методу Dual-plane. Операція тривала 140 хв. Пацієнтка перебувала у стаціонарі одну добу. Дренажі в порожнину імплантів не встановлювалися. Одночасно було проведено корекцію рубців на животі та фіксація їх в проєкцію інфрамаммарної складки. Післяопераційний період проходив без ускладнень. Пацієнтка отримувала антибіотикотерапію та приймала нестероїдні протизапальні препарати. Проводилися перев'язки післяопераційних ран. Компресійну білизну пацієнтка носила 2 міс після операції.

Мамопластика — одна з найпоширеніших операцій в пластичній хірургії, яка дає змогу досягти передбачуваних і узгоджених з пацієнтом естетичних результатів, а також при дотриманні всіх норм сучасного виконання операції має низький рівень розвитку ускладнень. Ускладнення, що виникли у пацієнтки та зумовили необхідність видалення імплантатів, спричинили виражений рубцевий процес. Великий грудний м'яз був деформований, тканина його рубцево змінена. Це не давало йому змоги розтягуватися для встановлення імплантату, що створювало певні труднощі на операції. Ускладнення, які виникають після мамопластики, завжди мають віддалений вплив на формування капсули та підвищують ризик розвитку ранніх та віддалених післяопераційних ускладнень.

Ключові слова: мамопластика, збільшення молочних залоз, заміна імплантатів молочних залоз.

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Pathophysiology of the gastrointestinal tract in burn disease

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The review of foreign publications resulted in a generalisation of medical reports on the pathological changes of the gastrointestinal tract in burn disease. Burn disease produces an immediate reaction in all organs and systems, which are not always able to maintain homeostasis and frequently suffer pathophysiological and morphological damage. One of those target systems is the gastrointestinal tract. Only in very rare cases do severe (mainly electrical) burns cause direct injury to the abdominal cavity organs, thus resulting in a very severe clinical course and high mortality. Patients of all ages who have experienced a burn injury have an increased overall risk of developing gastrointestinal diseases, which include pathology of the esophagus, stomach, and intestines, as well as lesions of the gallbladder, biliary tract, and pancreas. With a burn area of 40—95 %, 5.7 % of the victims were diagnosed with pathology of the abdominal organs. Among them, 26.0 % had an abdominal catastrophe (infarction or perforation), 37.0 % had bleeding from the upper parts of the gastrointestinal tract, 32.0 % had paralytic intestinal obstruction, and 5.0 % developed pancreatitis and acute necrotizing cholecystitis. Large burns are usually associated with a significant decrease in splanchnic perfusion. After severe burns, intestinal ischemia and hypoxia disrupt the intestinal epithelial barrier and enteric bacterial translocation, leading to serious complications such as systemic inflammatory response syndrome, sepsis, and multiple organ failure. Peritonitis or gastrointestinal bleeding accounted for 88.2 % of deaths among patients with gastrointestinal dysfunction. In general, gastrointestinal dysfunction was more common in patients with inhalation injuries, burn shock, large burn areas, and high analgesic requirements.

Keywords
burn disease, gastrointestinal tract, pathophysiology, review, treatment.

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According to the results of statistical research by the Institute for Health Metrics and Evaluation (Washington), Ukraine has one of the highest rates of burn mortality in the world (4.55 per 100 thousand), second only to ten countries in the post-Soviet area and the African continent, which emphasises the relevance of combustiological research in the country. Burn disease (BD) produces an immediate reaction in all organs and systems, which are not always able to maintain homeostasis and frequently suffer pathophysiological and morphological damage. One of those target systems is the gastrointestinal tract (GIT). [50, 54].

Only in very rare cases do severe (mainly electrical) burns cause direct injury to the abdominal cavity organs, thus resulting in a very severe clinical course and high mortality [16]. Therefore, our review focused on the mediated damaging dynamic effect of burn stress / shock and BD on the digestive system in general and its specific components, leading to the emergence of severe life-threatening syndromes and conditions.

Burn patients of all ages who have experienced a burn injury are at increased risk for gastrointestinal disease, including:

- esophageal, gastric, intestinal lesion;
- noninfectious enteritis and colitis;
- gallbladder, biliary tract, and pancreatic lesion.

The pediatric burn cohort had higher rates of hospitalisation and length of hospital stay than patients with abdominal pathology without burns [4, 50].

Stress ulcers are a well-known clinical phenomenon with a variety of features, ranging from asymptomatic superficial lesions and occult

gastrointestinal bleeding to overt clinically significant blood loss. Disruption of the intestinal barrier, where the mucosal glycoprotein is destroyed by increased concentrations of refluxed bile salts or uremic toxins, often leads to ulcer formation. Stress-induced hyperproduction of gastric acid due to increased secretion of gastrin is also likely [21, 24, 32]. Ulcers caused by burn stress / shock are mostly seen in the acid-producing regions of the body and the pyloric part of the stomach, but they can also be located in the antrum and duodenum [24, 32, 56]. Burn shock leads to splanchnic hypoperfusion and ischemia of the gastric mucosa, causing its atrophy, reduced ability to neutralise hydrogen ions, and impaired healing [8, 38, 56]. Initially, it can manifest itself in the form of erosive gastritis, starting with asymptomatic superficial lesions [24, 32, 37].

J. Swan (1823) first demonstrated the relationship between skin burns and damage to the GIT mucous membrane [41]. T. B. Curling (1842) described acute duodenal ulcers (which later became known as Curling's ulcers) in a group of burn patients [13, 42, 56]. Stress-induced gastritis can be called:

- diffuse mucosal damage;
- stress ulcer;
- hemorrhagic gastritis;
- erosive gastritis;
- Curling's ulcer;
- Cushing ulcer.

What they have in common is the presence of multiple surface erosions, beginning in the proximal acid-secreting part of the stomach and spreading distally. Cushing ulcers develop in BD as a result of damage to the central nervous system. Morphologically, Cushing ulcers are single and deep, can affect the esophagus, stomach or duodenum, emerge within a few hours after the injury, and appear as wedge-shaped hemorrhages on the mucous membrane with superficial necrosis. If these erosions continue to progress and spread to the submucosa, significant life-threatening bleeding may result [9, 24, 32, 51]. Most cases of Curling's ulcers in the current literature are secondary to severe thermal burns. There is a known casuistic case of their formation as a result of sunburn [21]. The risk of ulceration was higher in patients with burn area over 20 % total body surface area (TBSA) compared to patients with burn area less than 20 % TBSA (odds ratio 4.31). In addition, the incidence of ulcers was higher in patients with epigastric pain compared to patients without this symptom (odds ratio 4.55) [24, 56]. In burn patients with TBSA no less than 70 %, the frequency of Curling's ulcer was 40 % [8]; the risk of their development increased significantly under sepsis or septic shock [24, 50].

According to the diagnostic criteria for symptoms related to the gastrointestinal tract in BD, the dysfunction of the digestive system is characterised as follows [56]:

- flatulence: intestinal noise decreases, and food intolerance persists for more than 5 days;
- stress ulcer: gastric fluid aspirated through a gastric probe macroscopically has bloody impurities, and gastroendoscopically, the gastric mucosa is affected by erosions and ulcers;
- severe stress ulcer: blood loss exceeds 800 ml within 24 h;
- change in the intestinal microbiota: gram-negative *E. coli* are amplified, and the bacillus/coccus ratio is greater than 10 : 1;
- suspected systemic infection is confirmed after exclusion of the primary focus of the wound surface, pulmonary infection, and catheter-related sepsis.

Although stress ulcers can lead to perforation, this occurs with an incidence of less than 1 % [21, 24, 32]. Prevention of stress ulcers with the help of proton pump blockers, histamine-2 (H2)-receptors and early enteral nutrition has significantly reduced the incidence of Curling's ulcer and the frequency of its complications in recent decades [8, 9, 15, 23, 38, 39, 56].

Abdominal compartment syndrome

In patients with large burns, there is a significant risk of increased intra-abdominal pressure (IAP) in the presence of thermal damage to the abdominal cavity and capillary leak syndrome due to the systemic inflammatory response and aggressive fluid replacement [31]. The abdominal cavity has a certain tolerance for increased intraperitoneal volume without any marked increase in IAP, the increase of which does not necessarily cause abdominal compartment syndrome (ACS). The higher the IAP and the more trigger factors, the greater the risk of developing ACS [19, 53]. An increase in IAP causes progressive hypoperfusion and ischemia of the intestine and other peritoneal and retroperitoneal structures. The effect of IAP is not limited to the organs of the internal abdominal cavity but directly or indirectly affects each of the organ systems (dysfunction of the pulmonary, cardiovascular, kidney, liver, central nervous and gastrointestinal systems) [53].

ACS is a severe complication of BD with a mortality rate of (40—100) %. The percentage of burns on the total surface of the body is the main risk factor for the development of ACS:

- the prevalence of intra-abdominal hypertension reached 53 % in burn patients with TBSA over 15 % [48];
- ACS develops in every second patient with TBSA over 20 % in adults and with TBSA over 25 % in children;

- with TBSA over 60 %, ACS occurs always;
- morbidity in adults is higher than in children [7, 18, 19, 22, 31, 48, 52, 53].

A recent systematic review demonstrated that the infusion volume in particular was directly responsible for the development of ACS and was associated with 97 % mortality with TBSA over 60 % [53]. The development of ACS in a burn patient undergoing infusion therapy is quite difficult to identify [37]. Active fluid resuscitation in BD causes capillary leak syndrome and exacerbates splanchnic edema, which increases intestinal permeability, bacterial translocation, and elevated IAP. In patients with burn shock, it is necessary to try to quickly restore microcirculation using the minimum amount of fluid. Liquid resuscitation is usually used for BD, according to the Parkland formula 4 ml/Percentage of the total body surface per 1 kg within 24 h.

Due to diffusion and estimated compartment volumes, it is assumed that approximately two-thirds of the infused crystalloid solution enters the interstitial space [22, 44].

Both insufficient and excessive amounts of injected fluid lead to dysfunction of organs and tissues and the development of multiple organ failure syndrome (MOFS). An infusion volume of no less than 250 mL/kg administered within the first 24 h is a major risk factor for ACS. In case of fluid overload, splanchnic edema increases the intraperitoneal volume, and the abdominal wall is stretched to such a degree that further stretching becomes impossible. Combined with a systemic inflammatory response, this can lead to significant capillary leakage and diapedesis of fluid into the abdominal cavity (edema and ascites). The elasticity of the tissues of the abdominal wall decreases, which is associated with circular burns of the abdomen or chest (density of the burn scab). As a result, the ability of the abdomen to distend is limited, the critical point of the IAP growth is reached with a smaller increase in the intraperitoneal volume, and ACS can occur with smaller infusion volumes [2, 7, 19, 22, 26, 28, 53]. ACS is characterised by organ failure as a result of a long-term rise in IAP over 20 mm Hg [26, 29, 48].

The phenomenon of capillary leakage contributes to:
- ischemia-reperfusion injury;
- release of vasoactive substances;
- interstitial edema;
- activation of free radical oxidation.

Secondary intra-abdominal hypertension usually develops within 48 h of a burn, and ACS usually occurs with septicotoxemia. Patients with inhalation poisoning from combustion products have an increased risk of fluid sequestration [19, 31].

With TBSA less than 20 %, the prevalence of ACS is estimated at (4.1—17.0) %, with (65—75) % of the patients having a further risk of developing intraperitoneal hypertension without organ dysfunction [2, 19].

Elevated IAP leads to certain systemic disturbances [19, 22, 31]:

- over-upward displacement of the diaphragm, cardiac and pulmonary compression, decreased venous return, and subsequently hypoxemia, hypercapnia, atelectasis, and ventilation/perfusion mismatch;
- renal vasoconstriction, activating sympathetic innervation and the renin-angiotensin system; oliguria at an IAP over 15 mm Hg, and anuria at an IAP of no less than 30 mm Hg; in burn patients, the kidneys are particularly vulnerable to damage associated with elevated IAP, and 69.9 % develop acute kidney injury (AKI); the average period of development of AKI is about 3 days; individual analysis of the risk factors for AKI determined the relationship between the IAP, the use of glycopeptides and vasopressors;
- decreased perfusion of the intestinal mucosa at an IAP of 10—20 mm Hg; disturbed blood flow through the abdominal and superior mesenteric arteries at an IAP of no less than 40 mm Hg;
- compression of the mesenteric veins, impairing drainage and aggravating ACS, ultimately leading to further intestinal hypoperfusion, decreased intramural pH, and worsening lactic acidosis. Released inflammatory cytokines activate capillary permeability, which increases edema and IAP. This is a vicious cycle in which swelling leads to hypoperfusion of tissues, which, in turn, increases their swelling.

Careful monitoring of the IAP is recommended for every burn patient receiving an infusion of 250 ml/kg or more [53]. It is advisable to measure IAP every 2—4 h with TBSA at no less than 20 % [19]. IAP can be measured using an intraperitoneal catheter or indirectly by measuring pressure in the rectum, stomach, inferior vena cava, or bladder. The most acceptable and practical method is the registration of the IAP in the bladder. Physiological IAP ranges from 5 to 7 mm Hg. High systemic arterial pressure can maintain the perfusion of abdominal organs even in conditions of elevated IAP. Determination of abdominal perfusion pressure (APP) according to the formula

APP = mean arterial pressure (MAP) – IAP

is considered the best marker of perfusion of abdominal organs. Patients with IAP less than 10 mm Hg have no risk of developing ACS, while those with IAP no less than 25 mm Hg mostly develop it, and abdominal perfusion pressure less than 60 mm Hg

is associated with higher mortality after initiation of ACS [22, 53].

Clinicians should anticipate the risk of potential intestinal ischemia under ACS with the complication of late intestinal obstruction and recognise that the final pathological consequences of ischemic damage may occur many months after the first episode of ACS [22]. The TBSA percentage is directly correlated with ACS. The combination of:

- AKI;
- positive (daily and cumulative) fluid balance;
- high IAP;
- high extravascular lung fluid index (EVLWI);
- low APP

indicates a negative prognosis [45].

ACS can be treated using fluid resuscitation with continuous venous dialysis and ultrafiltration [17]. The current management of ACS consists of:

- decompression laparotomy using temporary abdominal closure techniques, including the Bogotá pouch;
- skin closure over open fascia;
- using Wittmann patch and vacuum techniques.

These methods are reliable, but temporary [28]. A circular burn of the abdominal area creates a tourniquet effect, and an urgent decompression escharotomy of the abdominal wall ensures a rapid decrease in the IAP. This improves ventilation, hemodynamic parameters, and oxygen exchange and can reduce mortality and treatment times. If simple escharotomy and decompression necrectomy do not lead to a decrease in the IAP, laparotomy decompression is performed [39, 53]. Fascial closure within 48 hours was associated with improved survival compared with later fascial closure [36]. The survival rate of burn patients with ACS after laparotomy is quite low (only 16 %). Better results can be achieved by following the strategy of immediate laparotomy and early fascial closure [36]. Although decompression laparotomy can save the lives of many patients with ACS, this procedure is associated with significant complications. Intestinal-cutaneous or intestinal-atmospheric fistula occurs in (2—45) % of patients after laparotomy and open abdomen. These fistulas are quite difficult to repair, and in about 40 % of cases, they can lead to electrolyte imbalance, hypotrophy, and death [28].

Decrease in splanchnic perfusion

Large burns are usually associated with a significant decrease in splanchnic perfusion. In animal model studies, mesenteric blood flow typically decreases shortly after burn injury by more than 50 % after burn at TBSA equal 40 %. This is associated with an increase in the resistance of mesenteric vessels, which is due to the action of [5]:

- vasoactive mediators:
  1) angiotensin II;
  2) vasopressin;
  3) vasoactive intestinal polypeptide 4;
- inflammatory mediators released from affected tissues:
  1) thromboxanes;
  2) leukotrienes.

Burns lead to a significant decrease in blood flow in the small intestine, which subsequently leads to intestinal mucosal dysfunction and villus tip ischemia [23]. Patients with burns have a high risk of developing ischemic enterocolitis (IE) in the immediate post-burn period. If intestinal pneumatosis is identified radiographically, diagnostic efforts should attempt to identify ischemia and necrosis, as these cause high mortality. IE is a rare condition characterised by gas formation in the gastrointestinal tract; its treatment and prognosis depend on the specific cause. The true incidence of IE is unknown, as most cases are asymptomatic. In burn patients, IE has an incidence of 0.5 % at clinical diagnosis; however, postmortem studies show that up to 50 % of burn patients have some degree of ischemic bowel injury. No patient developed IE earlier than 7 days after the injury [3].

Acute mesenteric ischemia (AMI) is a rare, severe complication of BD with a high mortality rate, the incidence of which is 1 % to 2 %. The main reported cause of AMI is a non-occlusive one, which is consistent with the hypothesis of intestinal perfusion limitation in the early phase of shock [29, 50]. Burn patients are at risk for intestinal ischemia due to massive fluid shifts, cardiac output limitations, and decreased regional organ perfusion due to reduced intravascular volume. In addition, there are reports that early enteral nutrition may play a fixed role in the development of intestinal ischemia after a severe burn injury [3].

Violation of the perfusion of the intestines, kidneys, and other internal organs leads to rapid liver and kidney failure, intestinal ischemia, and a decrease in the diaphragm mobility [14]. After a severe burn, blood flow is redistributed in favour of vital organs such as the heart and brain, due to which the blood flow to the intestine is noticeably reduced. Intestinal ischemia and hypoxia disrupt the intestinal epithelial barrier with subsequent enteric bacterial translocation, greatly contributing to the development of systemic inflammatory response syndrome, sepsis, and multiple organ dysfunction syndrome, which are common causes of burn mortality [15]. Hypercatabolism in BD is combined

with a decrease in regional oxygen delivery to a level insufficient to meet the metabolic needs of the intestine. Burn-induced intestinal ischemia leads to oxidative stress and hypoperfusion, resulting in limited nutrient supply [23, 29].

The initial response is intraperitoneal vasodilatation, but prolonged ischemia leads to vasoconstriction with redistribution of blood flow away from the splanchnic organs, which persists even after normalisation of intestinal blood flow. Venous congestion can lead to gut dysoxia and hypoperfusion, especially in the presence of right ventricular dysfunction. This early damage can lead to changes in intestinal integrity and can induce bacterial translocation from the lumen with the activation of systemic inflammatory pathways. Redistribution of blood flow also occurs at the microcirculatory level [29].

Recently, parameters of hemodynamics and use of catecholamines were not evaluated as potential triggers of AMI in BD [50]; only TBSA and sepsis were identified as potential risk factors, including severely burned patients with different study designs [29]. After a severe local thermal injury, approximately 25 % of all patients develop ulcers, bleeding, spontaneous perforations, and acute mesenteric infarction, which is the most severe complication. The most common causes of acute intestinal ischemia are:

- arterial embolism;
- arterial thrombosis;
- venous thrombosis;
- non-occlusive disease.

Although there is no precise data on the incidence and consequences of acute intestinal necrotizing ischemia in patients with severe burns, this complication is well known in specialised burn centres [47]. Burn patients with massive intestinal infarction have over 75 % mortality. Non-occlusive mesenteric ischemia is the most frequent cause of gastrointestinal infarction in burn patients compared to other ones, in which acute mesenteric ischemia is the result of occlusive mesenteric ischemia in 80 % of cases [3].

In the general population, acute mesenteric ischemia is found in only 1 % of patients with acute abdomen; most often, its cause is embolism and thrombosis in the area of the mesenteric vascular bed. In almost all cases, the upper mesenteric artery is affected; less often, the abdominal trunk and lower mesenteric artery. Only about 20 % of all cases of acute mesenteric infarction are caused by non-occlusive mesenteric ischemia (NOMI). In all cases of NOMI, there is a drop in perfusion in the area of the mesenteric arteries, which leads to hypoperfusion and necrosis of the intestine. Decreased mesenteric blood flow may be caused by hypotension, decreased cardiac output, vasospasm of the mesenteric arteries, or sepsis. Diagnosis of this vascular emergency in severely burned victims who are unable to report pain or nausea is difficult, so it is not surprising that this dramatic event is diagnosed in only 0.5 % of living patients. At autopsy, the diagnosis of acute mesenteric infarction increases to [29, 48, 50]:

- 2 % — in children;
- 7 % — in adults.

In critically ill patients, the feasibility of physical examination is uncertain; increased abdominal distension, peritoneal symptoms, or hematochezia require radiological evaluation [3]. The development of metabolic acidosis and increased serum lactate may also play a role as early markers of NOMI. Mortality and the risk of NOMI are higher among patients with high lactate levels and severe base deficiency. In this case, relapse of acidosis after successful resuscitation of burn shock combined with significant pneumatosis within 48 hours is an indication for urgent surgical intervention [3].

Disruption of the intestinal epithelial barrier and enteric bacterial translocation

After severe burns, intestinal ischemia and hypoxia lead to disruption of the intestinal epithelial barrier and enteric bacterial translocation (EBT), leading to serious complications such as [15]:

- systemic inflammatory response syndrome;
- sepsis;
- multiple organ failure.

Increased permeability of the intestinal mucosa and decreased expression of junctional complex proteins in the intestinal epithelium were observed after a significant burn. Cystic fibrosis transmembrane conductance regulator (CFTCR) is a protein that participates in the transport of chlorine ions across cell membranes and is widely expressed in epithelial cells. The function and expression of CFTCR in the intestinal epithelium after a severe burn are inhibited by hypoxia. The mutation causes a protein defect, a genetic disorder, and cystic fibrosis affecting the lungs, pancreas, liver, kidneys, and intestines [15].

The clinical picture of the intestinal form of cystic fibrosis is manifested by secretory insufficiency. Patients complain of dryness in the mouth, which is due to the increased viscosity of saliva. Putrefactive processes are activated in the intestine with flatulence and cramp-like pain, mostly in the epigastric area, which is due to insufficient duodenal neutralisation of gastric juice. This can cause the development of duodenal ulcers or the formation of small intestinal ulcers. Hepatomegaly is caused by cholestasis; there is a high risk of developing [15]:

- intestinal obstruction;
- secondary urolithiasis and pyelonephritis;

• disaccharidase deficiency and latent diabetes due to damage to the insular apparatus of the pancreas.

One of the mechanisms underlying the pathological process is excessive inflammation in the small intestine. Loss of CFTCR by the intestinal epithelium leads to increased release of proinflammatory cytokines, including interleukin-1β (IL-1β) and interleukin-8 (IL-8). In addition, tumour necrosis factor α (TNF-α), IL-1β, and IL-8 are known to promote denaturation of tight junction proteins (ZO-1, occludin) and induce increased intestinal barrier permeability, which may lead to intestinal inflammation, which becomes the source o a f systemic inflammatory response. In vitro studies of intestinal cells have shown that mitogen-activated protein kinase signalling is an important modulator of intestinal inflammation. Pentoxifylline attenuates burn-induced intestinal permeability and subsequent intestinal inflammation [6, 15]. Increased permeability of the mucous membrane of the GIT as a result of a burn occurs due to:

• a decrease in tight junction proteins in the intestinal epithelium;
• increased apoptosis of intestinal cells;
• impaired cell proliferation.

These effects also lead to inhibition of intestinal barrier function and bacterial translocation. A decrease in splanchnic blood circulation causes ischemia-perfusion injury of the intestines and sepsis [44].

Fibrous changes, mediated by the inflammatory state after a severe burn, contribute to a decrease in peristalsis of the small intestine [49]. Proliferation of smooth muscle cells correlates with poor tissue compliance. The proliferation of smooth muscle cells leads to the activation of the secretion of extracellular matrix (ECM) proteins. In inflammatory bowel disease, fibrous remodelling with the deposition of excess ECM proteins causes disturbances in colonic motility and absorptive function [49]. A number of studies have demonstrated that vitamin D3 exerts a protective anti-inflammatory effect on the intestinal epithelial barrier and prevents IE [15].

Syndromes of general gastrointestinal dysfunction

A severe burn is accompanied by inhibition of gastric emptying and contractility of the antrum, ileum, and colon [40, 43, 49]:

• global suppression of GIT motility is observed already 24 hours after the burn;
• the rate of gastric emptying decreases by 37—42 % after a burn already 6 h after the injury;
• small intestinal motility is reduced by 24—42 % after 6 h;
• colonic motility is reduced by approximately 34 %.

In critical burns, there are a number of syndromes of general gastrointestinal dysfunction, which include [44, 48]:

• delayed defecation;
• opioid-related bowel dysfunction;
• acute colonic pseudo-obstruction.
• In the gastrointestinal system, a burn leads to:
• increased gastric secretion;
• decreased intestinal peristalsis;
• decreased absorption of nutrients;
• increased permeability of the GIT mucosa;
• bacterial translocation;
• increased IAP.

It also increases the likelihood of mucosal ulceration and gastrointestinal bleeding. These effects cause constipation, sepsis and ACS [35, 44, 48]. In BD, 45.4 % of patients developed gastrointestinal dysfunction with various problems, including [48]:

• gastrointestinal bleeding or ulcers in 30.2 % of patients;
• nausea and vomiting in 22.1 %;
• delayed defecation in 43.0 %;
• abdominal distension in18.1 %
• diarrhea in 5.4 %.

Gastrointestinal dysfunction was involved in 88.2 % of deaths if it manifested as gastrointestinal bleeding or nausea and vomiting, but if functional symptoms such as constipation and/or diarrhea did not predominate. In general, gastrointestinal dysfunction was more common in patients with [48]:

• inhalation injury;
• burn shock;
• large burn area;
• high opiate requirement.

Constipation in burn patients is very common and multifactorial in its etiology. A high prevalence (36.1 %) of late defecation (absence of defecation within 6 days after hospitalisation in the intensive care unit) in critically ill adult patients with thermal injury was described. Late defecation may reflect global gastrointestinal motility dysfunction, as demonstrated by more frequent episodes of constipation after the first defecation, feeding intolerance, and total parenteral nutrition [44].

Gastrointestinal-related sepsis and MOFS may still occur, even if the initial GIT dysfunction is relatively mild and reversible. These effects may be related to dysbacteriosis, with the overgrowth of harmful bacteria due to disruption of the normal intestinal barrier and / or altered immune response [48].

Dysfunction of the GIT leads to acute colonic pseudo-obstruction (ACPO), which is also known as Ogilvie syndrome. Acute non-toxic megacolon is a functional obstruction of the lower parts of GIT; first described by W. H. Ogilvie (1948) in burn

patients [11], it is a rare state characterized by acute dilatation of the colon in the absence of mechanical obstruction. This manifestation of intestinal pseudo-occlusion is associated with several etiological factors [29, 38, 48, 50]. Burns and antipsychotic drugs have been identified as risk factors. Opiates, such as fentanyl, are the drugs most commonly implicated in Ogilvie syndrome; their effect on intestinal transit is diverse:

- increasing the tone of the ileocecal and anal sphincters;
- reducing the peristalsis of the small and large intestines;
- reducing the sensitivity to stretching;
- changing the defecation reflex.

All these factors contribute to the slowing of transit and lead to constipation.

Ogilvie syndrome is a more serious complication than those that can develop in some patients after the use of opiates. Sedatives, such as midazolam, can also disrupt intestinal motility through inhibition of vagal tone. Studies of patients receiving analgesia with benzodiazepines have demonstrated abnormalities in intestinal motor activity, including increased contractions, which may lead to pseudo-obstruction syndromes. These abnormalities were reversible after drug discontinuation [25]. The incidence of this syndrome ranges from 0.5 to 1 % in burn centres in patients with more than 15 % of the body surface affected by burns [25, 33]. Functional obstruction leads to a colonic reflex that impairs motility and increases dilation.

- ACPO is characterised by [50]:
- massive distension of the colon in the absence of mechanical obstruction (80—90 %);
- abdominal pain and hypertympanism (80 %);
- nausea and / or vomiting (60 %);
- constipation (40 %);
- fever (37 %),
- and also by tachycardia and leukocytosis.

Analgesics and sedatives used in burn patients may also be associated with this state and are thought to be secondary triggers for vagal depression [33]. The course of ACPO in burn patients is significantly different and often more complicated than in abdominal ones without thermal injuries [12]. The clinical picture of ACPO is often vague, no sign is pathognomonic for the disease. Abdominal bloating, with or without pain, is the most common symptom. These patients often have constipation, although the ability to defecate or pass gas is preserved in 40 % of patients [12]. Contrast-enhanced abdominal tomography is the ideal imaging study to evaluate a possible site of occlusion or complication [33].

Patients with Ogilvie syndrome are usually treated conservatively if the diameter of the distended bowel is less than 12 cm and there is no evidence of intestinal ischemia or perforation. The treatment is carried out with the help of a nasogastric and transrectal probe for decompression within 48—72 hours along with correction of hydroelectrolyte imbalance, withdrawal of sedatives and treatment of infections. Conservative treatment during the first two to six days is effective in (83—96) % [33]. In case of deterioration or expansion of the intestine by more than 12 cm, medical or surgical treatment is indicated. Intravenous administration of neostigmine, which is a reversible acetylcholinesterase inhibitor that indirectly inhibits muscarinic receptors and promotes colonic motor activity, has been recommended [12, 33]. Bowel perforation is the most serious complication of HPTC, the risk of which increases significantly with the duration of bowel distention. General guidelines indicate that a cecal diameter over 9 cm is abnormal, and a diameter over 12 cm is at high risk of perforation. The thin-walled cecum is the least adapted to a sharp increase in intraluminal pressure (according to Laplace law) [12]. Ulceration and necrosis of the colon in burn patients are rare and usually occur in the cecum with the formation of stercoral peritonitis with a negative prognosis. The risk of perforation increases with age and is higher in men [5, 25]. Among the complications [20, 35, 37]:

- 26 % of patients had an abdominal catastrophe (infarction / perforation);
- 37 % had bleeding from the upper parts of the GIT;
- 32 % had paralytic intestinal obstruction;
- 5 % developed pancreatitis and acute necrotizing cholecystitis.

Small bowel intussusception is a rare clinical state in BD with symptoms of intestinal obstruction such as:

- abdominal pain;
- vomiting;
- rectal bleeding;
- food intolerance.

It requires an emergency laparotomy to eliminate intestinal obstruction; otherwise, ischemia, necrosis, and intestinal perforation may develop [25, 46].

Violation of the GIT barrier function is an important initiator and stimulator of the systemic inflammatory response syndrome, sepsis, and MOFS in BD [54]. The functionality of the gastrointestinal barrier can be impaired along with increased intestinal permeability and subsequent translocation of bacteria/endotoxins through:

- autophagy in the visceral organs;

- expression of tight junction proteins and inflammatory cytokines;
- disruption of the gut microbiota;
- low blood flow;
- septic shock;
- administration of catecholamines;
- stress of the endoplasmic reticulum,
- mucosal atrophy;
- lack of enteral nutrition.

A disturbed intestinal epithelial barrier is responsible for systemic inflammatory response syndrome, sepsis, multiple organ dysfunction syndrome, and other severe complications [58]. The translocation of endotoxins from the intestine has been identified as a factor in mortality [30]. An increase in the growth of intestinal bacteria after a burn injury has been noted as a result of decreasing intestinal immunity, hypoperfusion, and impaired intestinal motility. An increase in intestinal permeability has been documented for several hours to several days after burn injury, allowing intestinal bacteria to enter extraintestinal sites (mesenteric lymph nodes, liver, and lungs). The process recurs when additional triggers of intestinal hypoperfusion occur (blood loss, sepsis). The faecal microbial communities of healthy people are dominated by the following families:

- *Bacteroidaceae*;
- *Lachnospiraceae*;
- *Ruminococcaceae*.

Faecal samples from patients with burn injuries show a marked decrease in the relative abundance of these three families, but a dramatic increase in the relative abundance of *Enterobacteriaceae* [10].

Diarrhea often occurs in BD, which is explained by a violation of intestinal integrity and dysbacteriosis. The prevalence of nosocomial diarrhea in BD was 120/10 thousand, and 21 % of these were caused by *C. difficile* infection [54]. Soluble fibre can improve intestinal barrier function and prevent bacterial translocation. Soluble fibre is rapidly fermented by commensal bacteria and produces short-chain fatty acids [34, 55].

The hypermetabolic response to burn injury is highest among critically ill patients [1]. In patients with burns, gastrointestinal stasis leads to impaired digestion and absorption; this increases concern about protein nutrition, increasing the burden on the kidneys [27]. As a result of insufficient nutrition, the intestinal mucosa is damaged (autophagy), which leads to bacterial translocation and gram-negative sepsis [39]. In the early stage of BD, intestinal adynamia may occur, with a high risk of acute gastric ulceration, which can be reduced by early enteral feeding aimed at maintaining body weight and endocrine homeostasis [3, 37, 39, 40, 43].

Dysphagia of various degrees was found in 27.78 % of people; its risk factors include [57]:

- TBSA over 18 %;
- older age;
- head and face injuries;
- the presence of inhalation trauma.

Patients with a single residual gastric volume of no less than 250 mL were classified as having gastrointestinal motility disorders. There are three main problems with enteral nutrition [39, 40]:

- gastric ulcer;
- intestinal obstruction;
- mucosal damage.

Post-pyloric administration of nutritional mixtures is a modern standard method of enteral feeding [3, 43]. Parenteral nutrition should be used selectively for specific conditions such as paralytic ileus, pancreatitis, intestinal obstruction, or contraindications to enteral feeding, as it is associated with a higher rate of infection due to prolonged access to central veins [39]. A combination of [13]:

- early optimal infusion resuscitation;
- early initiation of enteral nutrition (within 24—48 hours after injury);
- prevention of gastric ulcers;
- use of prokinetic drugs;
- avoidance of NSAIDs and steroids
- allows, in most cases, to prevent gastrointestinal dysfunction in patients with severe burns.

Conclusions

Unfortunately, very little attention is paid to the pathophysiology of the digestive system in case of skin burns in available domestic literary sources.

Based on the analysis of foreign publications, we conducted a certain generalisation of medical reports on the pathological changes of the GIT in burn disease.

The authors hope that the collected information will be useful for combustiologists, gastroenterologists, and doctors of other specialties.

Declaration of interests

The authors declare that there is no conflict of interest and their own financial interest in the preparation of this article.

Authors contributions

O. V. Kravets, V. V. Yekhalov: conceptualization, writing the original text; V. V. Gorbuntsov: editing, translation.

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Патофізіологія шлунково-кишкового тракту при опіковій хворобі

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На основі аналізу зарубіжних публікацій проведено узагальнення медичних повідомлень щодо патологічних змін шлунково-кишкового тракту (ШКТ) при опіковій хворобі. Опікова хвороба від самого початку супроводжується негайною реакцією всіх органів та систем, які не завжди здатні підтримувати гомеостаз і здебільшого набувають патофізіологічних та морфологічних ушкоджень. До таких органів-мішеней належить ШКТ. Лише в дуже рідкісних випадках тяжкі (переважно електричні) опіки спричиняють пряму травму органів черевної порожнини, яка супроводжується тяжким клінічним перебігом та високою летальністю. Пацієнти всіх вікових груп, які перенесли опікову травму, мають підвищений загальний ризик розвитку шлунково-кишкових захворювань (патологію стравоходу, шлунка, кишечника, ураження жовчного міхура, жовчних шляхів і підшлункової залози). При площі опіку 40—95 % у 5,7 % постраждалих було діагностовано патологію органів черевної порожнини, серед них у 26,0 % виникла абдомінальна катастрофа (інфаркт/перфорація), у 37,0 % — кровотеча з верхніх відділів ШКТ, у 32,0 % — паралітична кишкова непрохідність, у 5,0 % — панкреатит та гострий некротичний холецистит. Великі опіки зазвичай асоціюються зі значним зниженням спланхічної перфузії. Ішемія кишечника та гіпоксія після тяжкого опіку спричиняють порушення кишкового епітеліального бар'єра та ентеральної бактеріальної транслокації, що призводить до серйозних ускладнень — синдрому системної запальної відповіді, сепсису, поліорганної недостатності. Дисфункція ШКТ спричинила близько 88,2 % смертей, якщо вона ускладнювалася перитонітом або шлунково-кишковою кровотечею. Загалом дисфункція ШКТ була більш поширеною в пацієнтів з інгаляційною травмою, опіковим шоком, великою площею опіку та високою потребою в знеболювальних препаратах.

Ключові слова: лікування, огляд, опікова хвороба, патофізіологія, шлунково-кишковий тракт.

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