MEDICAL UNIVERSITY – VARNA
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Conventional operative treatment of incisional hernias – opportunities and challenges

ABSTRACT

of a dissertation for the award of the educational and scientific degree "DOCTOR"

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Scientific supervisor:

Prof. Plamen Milchev Chernopolski, MD,PhD,DSc

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The dissertation contains a total of 203 standard pages, illustrated with 45 tables and 78 figures. The bibliography includes 418 literary sources, 9 of which are in Cyrillic and 411 in Latin, and is 38 pages long.

The dissertation was discussed, accepted, and referred for defense before a scientific jury by the Department Council of the Department of Surgery, Prof. Dr. Paraskev Stoyanov Medical University – Varna on November 5, 2025.

The doctoral student works as physician in Second surgery clinic at the University Hospital "St. Marina" – Varna and the Department of Surgery, Medical University – Varna.

The public defense of the dissertation will take place on January 23, 2026, at 1:30 p.m. at St. Marina University Hospital before a scientific jury composed of:

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The materials related to the defense are available at the Scientific Department of MU Varna and are published on the website of Medical university "Prof. Dr. Paraskev Stoyanov" – Varna.

Contents

Abbreviations used in the text:

BHD	Bulgarian Surgical Society
AFC	Association francaise de chirurgiens (French Society of Surgery)
AIHW	Australian Institute of Health and Welfare
BMI	Body mass index
EHS	European Hernia Society
ePTFE	Expanded polytetrafluoroethylene
HPW	Hernia-Patient-Wound
LAD	Loss of abdominal domain
MMF	Mycophenolate mofetil
NSQIP	National Surgical Quality Improvement Program
PET	Polyethylene terephthalate
PEU	Polyether urethane
PG 910	Polyglactin 910
PGACL	Polyglycolic acid caprolactone
PGCA	Polyglecaprone acid
PGA	Polyglycolic acid
PLA	Polylactic acid
PMSI	Programme for the Medicalization of Information Systems in France
PP	Polypropylene
PTFE	Polytetrafluoroethylene
PVDF	Polyvinylidene fluoride
PVP	Polyvinylpyridylone
PU	Polyurethane
RCT	Randomized controlled trial
SAW	Surface of the anterior abdominal wall
SSI’s	Surgical site infections
TAR	Transversus abdominis release
VHWG	Ventral Hernia Working Group
WDS	Wall defect surface

I. Introduction

Incisional hernias are a common long-term complication of abdominal surgery, with a reported incidence of 2% to 20% in modern practice [167,169,235,271,372]. The increasing annual number of abdominal surgeries performed worldwide has inevitably led to a proportional increase in the number of incisional hernia cases, which has turned the disease into a health problem that significantly impairs patients' quality of life and poses considerable challenges to health systems. Statistics show that 4 to 5 million laparotomies are performed annually in the United States, suggesting a morbidity of at least 400,000 to 500,000 patients with incisional hernias on an annual basis. The magnitude of the medical and socioeconomic burden that abdominal wall reconstruction surgery places on the US healthcare system is confirmed by the fact that 150,000 - 200,000 interventions for incisional hernias are performed annually [124,276]. Postoperative hernias also pose a significant challenge to surgical practice in Europe and Asia. According to Prismant, 100,000 laparotomies and 3,900 abdominal wall reconstructions for incisional hernias are performed annually in the Netherlands [313]. The high incidence of incisional hernias is also confirmed by the 41,000 reconstructive surgeries performed annually in Germany and 2,150 in Korea for this reason [175].

Eight to twenty-nine percent of incisional hernias are asymptomatic and can only be diagnosed through targeted clinical examination [156,165,310]. In most patients, the clinical presentation of the disease includes a wide range of symptoms - from intermittent to constant discomfort that limits daily activities, chronic pain that dramatically impairs quality of life, and skin problems to a pronounced picture of complications of the condition—intestinal obstruction, incarceration (6-15%), strangulation (2%) [219,281,388]. There is often dissatisfaction with the body image due to cosmetic changes, as well as psychological distress due to fear of worsening symptoms, the potential need for repeat surgery, and uncertainty about the outcome of treatment [328]. This is justified by the chronic cyclical nature of the condition, which significantly increases medical and surgical morbidity, the need for repeat hospitalizations, and, respectively, healthcare costs—patients with incisional hernias are admitted to hospital for treatment 2.5 times more often, have a threefold increase in overall medical morbidity and more than 4.5 times higher surgical morbidity [324]. Prolonged recovery periods, loss or limitation of working capacity, and the resulting need for social support add to the remarkable socioeconomic impact of incisional hernias [360].

The etiopathogenic mechanism of incisional hernia formation is multifactorial, with both patient-related variables and technical aspects influencing the process [119]. These chronic comorbidities of the patient, which can be influenced preoperatively to optimize the outcome of surgical treatment, are known as modifiable risk factors. These include obesity (BMI≥ 30 kg/m2) [123,169], diabetes mellitus [123], smoking [363], COPD [14,253], immunosuppressive therapy [195], etc. Other causes reported in the literature as independent risk factors for the development of incisional hernias are: advanced age of the patient [62,363], gender (male [241,264,363] and female [362]), previous conventional abdominal surgery [382], type of incision used [348,362,382], emergency procedure [266] and duration of the operation [264,273], increased blood loss requiring red blood cell transfusion [413], method of abdominal wall closure [100,182, 264,388,393], etc.

Despite the undeniable progress in the surgical knowledge of incisional hernias and the evolution of the synthetic industry, which has led to the introduction of various types of biomaterials used for abdominal wall prosthetics, the results of conventional treatment of incisional hernias are far from ideal—the frequency of reported recurrences is 12.3% in the fifth year, reaching the not insignificant value of 23% in the tenth year [50]. This demonstrates the need for ongoing monitoring and care for these patients, far from the generally accepted understanding, although recurrent incisional hernias tend to present clinically earlier than initial ones, with some authors reporting that up to 84% of recurrent incisional hernias form within the first year after reconstruction [390]. The increasing risk of recurrence after each subsequent abdominal wall repair [65,121] indicates that, along with the development and implementation of increasingly new and complex (including laparoscopic and hybrid) techniques and prosthetic materials in an attempt to achieve the "ideal incisional hernia repair," the focus of researchers, industry, and surgeons should be on disease prevention. The application of individualized strategies to optimize modifiable risk factors, prophylactic prosthetics for high-risk patients, the improvement of surgical techniques, and the increased use of minimally invasive abdominal techniques, are important steps in this direction. With so many aspects to resolve in an attempt to improve the results of incisional hernia treatment, the topic will remain relevant for both current and future generations of herniologists.

II. Aim and scientific objectives

2.1. Aim

To study, analyze, and define the challenges associated with the conventional surgical treatment of incisional hernias in order to optimize treatment outcomes, reduce complications, and improve economic indicators.

2.2. Scientific objectives

2.2.1. Retrospective analysis of patients operated for incisional hernias using conventional approach at the Second surgery clinic for the period 2017–2021.

2.2.2. Defining the risk factors for the development of incisional hernias

2.2.3. Analysis of postoperative complications and the possibility of recurrence

2.2.4. Economic evaluation of the results of conventional surgical treatment for incisional hernias

2.2.5. Standardization of the preoperative and postoperative approach in conventional surgical treatment of incisional hernias

III. Materials and methods

3.1. Study design

3.1.1. Subject of the study

Analysis of risk factors for recurrence of incisional hernias , conventional surgical methods used, postoperative complications, and economic indicators.

3.1.2. Patient selection

273 patients with primary and recurrent incisional hernias , operated at the Second surgery clinic of UMHAT "Sveta Marina" in the period 2017-2021.

3.1.3. Specific studies

To achieve the research objectives and solve the pre-formulated tasks, the data of patients with incisional hernias before, during, and after hospital treatment were studied and analyzed. The cohort of patients studied underwent examinations using the standard clinical method: medical history, physical examination, laboratory tests - CBC, blood glucose, biochemical indicators, ECG, consultation with an anesthesiologist to assess the anesthesiological risk, and consultation with a cardiologist in case of concomitant cardiovascular pathology. Based on the assessment and indications related to the primary diagnosis and accompanying conditions, preoperative imaging and functional tests are also performed—abdominal and chest X-rays, abdominal ultrasounds, CT scans etc.

3.1.4. Conduct and organization of the study

- Study period: 2017-2021
- The study was conducted at the Second surgery clinic of the University Hospital "Sveta Marina" EAD
- After processing the results and determining the leading determinants, the actual study was conducted by processing the data with the SPSS v31 mathematical-statistical processing package.

3.2. Research methods

3.2.1. Non-operative methods

3.2.1.1 Documentary method

The necessary data for the patients included in the study were collected from the available medical documentation—medical history (MH), surgical journals, surgical protocols, anesthesiology and resuscitation sheets and outpatient journals.

3.2.1.2 Clinical methods

Medical history, physical examination, follow-up examinations. When taking the medical history and assessing the general condition, attention was focused on the following factors that are more important for the pathology under study:

- **Habitual** factors—gender, age, presence of overweight and specific BMI, data on connective tissue diathesis (hemorrhoidal disease, joint laxity, varicose veins of the lower extremities, and presumed expression of type III collagen), smoking, increased intra-abdominal pressure, immunosuppressive and chemotherapy, primary and recurrent hernia, duration of the disease, previous surgery or surgical repair of the abdominal wall, type of previous surgery (elective/emergency) and complications after it.
- **Chronic comorbidities**—COPD, bronchial asthma, diabetes mellitus and its control, BPH, and data on inactivity and muscle hypotrophy, oncological and autoimmune diseases.

When diagnosing a postoperative hernia, the findings from the physical examination of the abdomen are crucial. The examination is performed in an upright and supine position, supplemented by the Valsalva maneuver. The examination in an upright position leads to a clinical diagnosis of incisional hernia in the presence of swelling in the area of the scar from a previous surgical intervention. Palpation determines the presence and approximate size of the hernial defect(s), with or without a formed hernial sac, the presence or absence of contents in the sac, and its characteristics (surface, consistency, reducibility, presence of fluctuation). In cases of suspected incarcerated hernia, an important symptom is pain in the area of the irreductible hernia, accompanied by reflex vomiting and signs of intestinal obstruction. In the event of necrosis and inflammation in the area of the hernia, changes in the overlying skin may be observed, as well as signs of incipient or developed peritonitis. The physical examination is supplemented by auscultation of the abdomen, which reveals the presence and possible changes in intestinal peristalsis (resonant, overcoming, weakened).

3.2.1.3 Laboratory tests

- CBC
- Blood glucose
- Biochemical indicators—urea, creatinine, and others as necessary and at the discretion of the physician
- Coagulation status
- Urine - pH analysis and sediment

3.2.1.4 Instrumental examinations

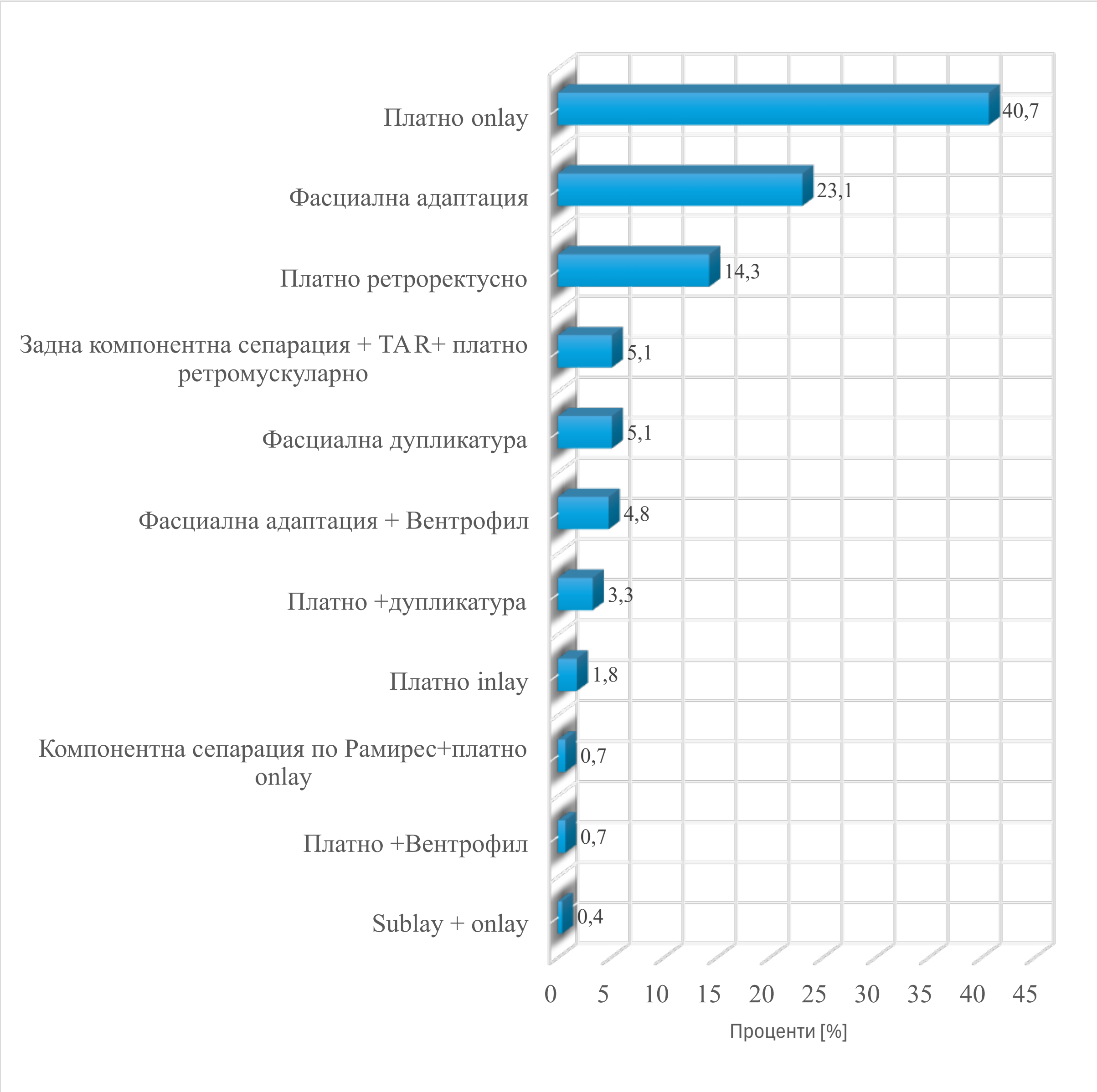
- ECG and consultation with a cardiologist in case of known or newly established pathology of the cardiovascular system
- Imaging tests – preoperative abdominal X-ray or abdominal ultrasound, if indicated – chest X-ray, CT scan, upper/lower GI endoscopy
- If necessary, functional diagnosis of the cardiovascular system and lungs – functional respiratory examination (FRE), echocardiography, and others.
- If there is a history of allergies – testing for allergies to the medications used during anesthesia.

3.2.2. Operative methods

- **Conventional surgical methods without the use of prosthetic** material – elimination of the hernial defect through fascial adaptation with or without the use of Ventrofil, fascial duplication
- **Conventional surgical methods with the use of prosthetic material** – placement of a mesh in different positions according to the International Classification of Abdominal Wall Planes (ICAP),combining prosthetics with fascial duplication or metal laparosynthesis with Ventrofil, combined placement of two prostheses in different anatomical planes , anterior or posterior component separation with additional mesh placement

The surgical techniques used in this study are presented in Fig. 1.

Figure 1 *- Conventional operative methods used in the study.*



3.2.3. Statistical methods

The following statistical methods were used to analyze the data obtained in order to reveal the essence of the observed phenomena and their interdependencies covered by this dissertation:

- Statistical grouping of data
- Descriptive methods
- Correlation analysis
- Regression analysis

3.2.3.1 Statistical grouping of data

In order to build an empirical model, it is necessary to record information about individual statistical units (patients). It is important to take into account the following factors: time and place of observation, period of registration, observation bodies.

Statistical grouping of data is a fundamental part of the process of any statistical study, as it provides an opportunity to penetrate the structure of the phenomenon under study and reveal trends and dependencies. In this dissertation, statistical grouping of data yields empirical distributions of a one-dimensional and two-dimensional nature.

3.2.3.2 Descriptive methods

Descriptive methods are directly related to the distribution of statistical units according to the values of their characteristics. The following descriptive tools are used in the dissertation:

- arithmetic mean, mode, and median to establish central tendencies
- mean square deviation to establish the differences between the units
- coefficient of asymmetry, coefficient of excess to establish deviations from standard distributions

The graphical representation of the empirical distribution is an essential part of the descriptive statistical methodology. The following graphical representations are used: histogram, structural diagram, bar chart.

The study was developed using SPSS Version 26.0 software.

3.2.3.3 Correlation analysis

Correlation analysis is a statistical method that measures the strength and direction of the correlation between two or more variables. When developing a correlation model, it is essential to correctly define the independent variable X (factor) and the dependent variable Y (effect).

It is important to assess whether the obtained correlation coefficient r is statistically significant. When testing correlation models in SPSS, the decision on statistical significance boils down to a comparison of the accepted reference level of significance (risk of error α) and the calculated threshold level of significance p.

The nonparametric contingency correlation coefficient is used, which is applicable when studying dependencies with variables located on a nominal scale. When studying relationships and dependencies between interval-located variables, Brave's correlation coefficient is used.

3.2.3.4 Regression analysis

In order to measure the impact of pre-selected factor variables on direct costs, a regression model was tested. An extremely strong positive correlation was found between the factor variables in the model and the dependent variable.

IV. Results

4.1. Description of the patients operated for incisional hernias at Second surgery clinic of UMHAT "Sveta Marina" EAD-Varna for the period 2017-2021

During the study period a total of 273 patients were operated at the clinic with the predominant percentage of patients – 59.3% (n=162) – being female (Fig. 2).

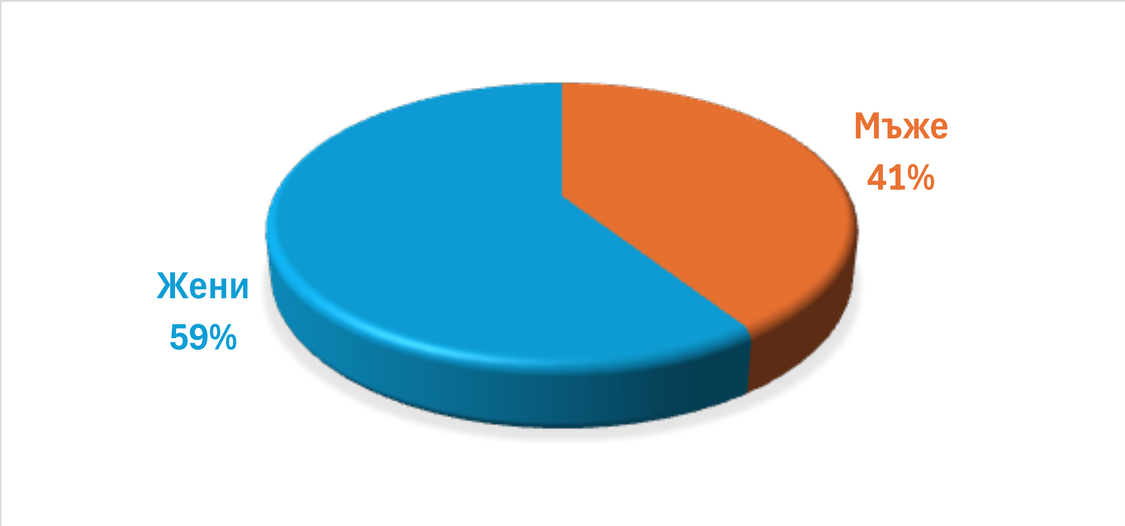


Figure 2 *- Distribution of patients by gender.*

The average age of the cohort studied was 60.3 years (± 12.8 years), with the youngest patient being 23 years old and the oldest 88 years old (Fig. 3). Accordingly, logically, the majority of patients were aged 60-79 years, accounting for 56.8% of all patients operated for incisional hernia. The highest incidence of incisional hernias was found in the sixth decade – in 92 patients, representing 1/3 of the study group – 33.7% (Fig. 4).

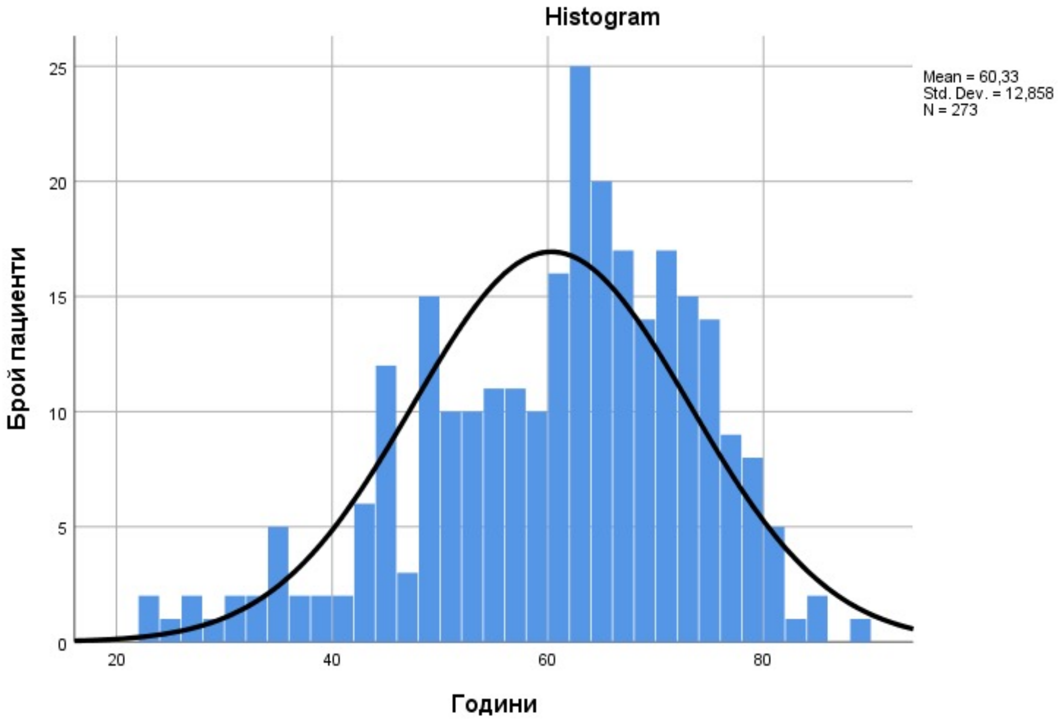


Figure 3 *- Distribution by age*

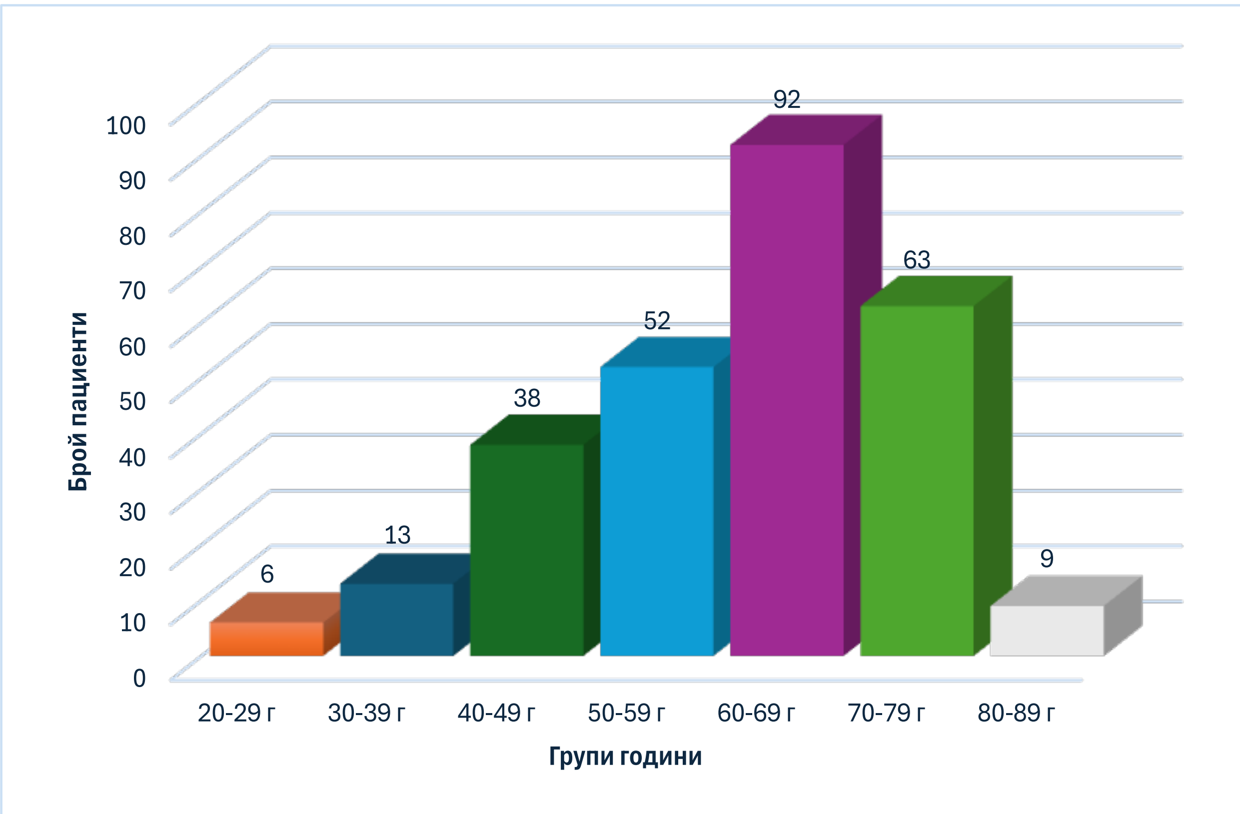


Figure 4 *- Distribution by age groups*

The average reported BMI was 29.57 with a standard deviation of 6.017, which shows that the proportion of patients with optimal weight (BMI 18.5-24.9) is extremely low, compared to patients who are overweight or obese (I and II degree) (Fig. 5).

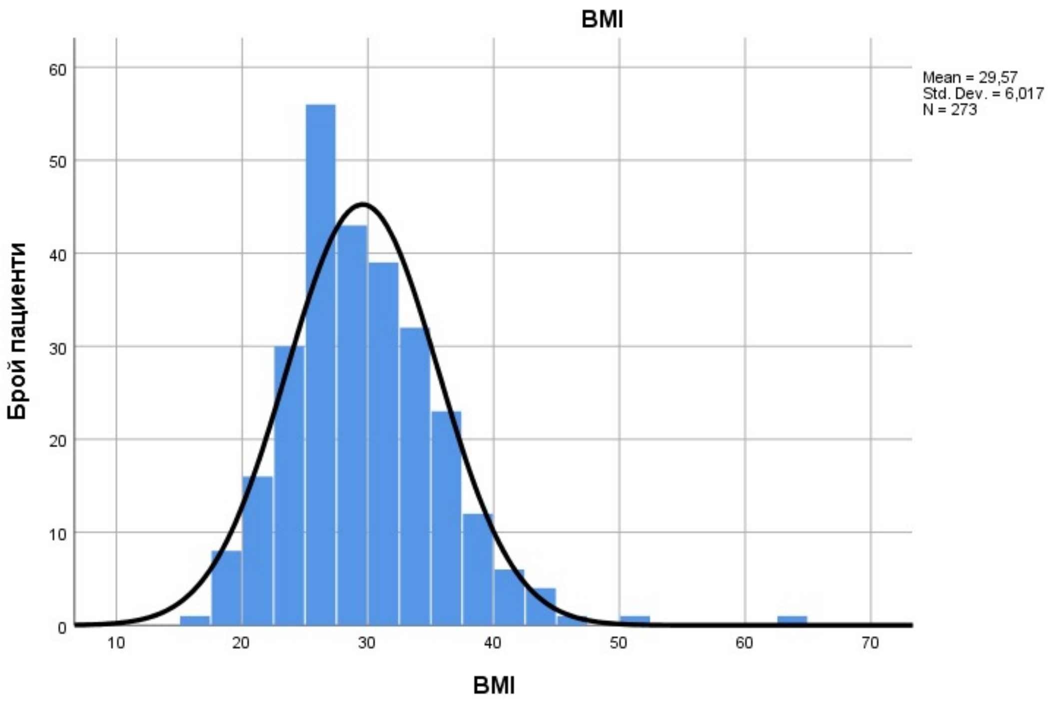


Figure 5 *- Distribution of patients according to calculated BMI*

In order to identify and prove patient-related risk factors for the occurrence or recurrence of the incisional hernias , the cohort of patients was specifically examined for the presence of specific comorbidities and their control. In the analyzed group of patients, the frequency of diabetes mellitus as a concomitant pathology was reported in 22% of cases (n=60) (Fig. 6), with the majority of them having unsatisfactory control of the disease, namely 70% (n=42).

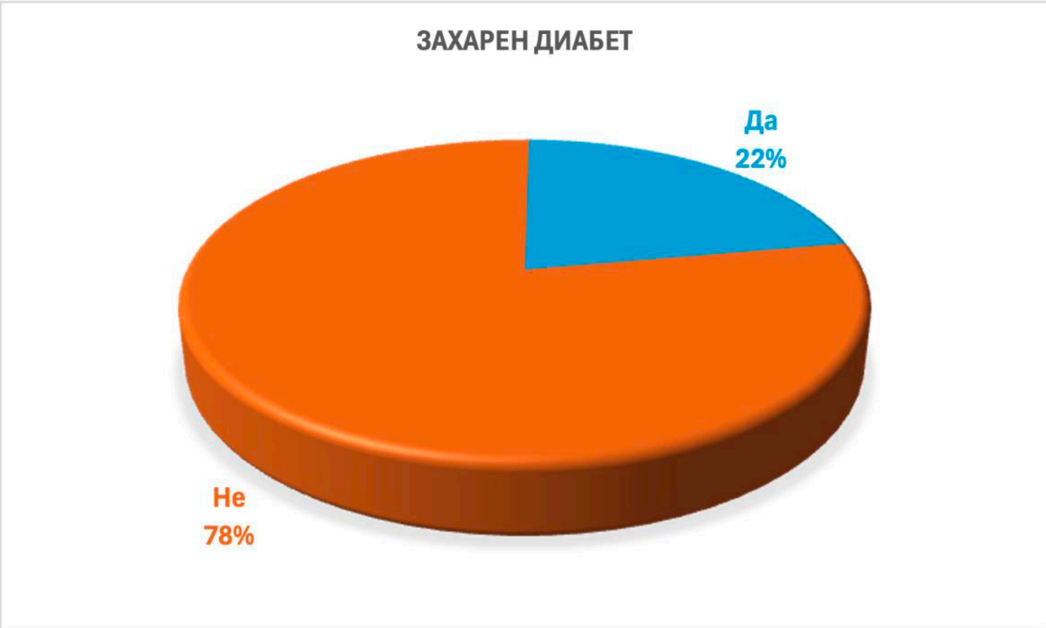


Figure *6 - Proportion of patients with concomitant diabetes mellitus.*

Connective tissue disorders (including hemorrhoidal disease, varicose veins of the lower extremities, joint laxity, etc.) were reported in 9.52% of patients (Fig. 7).

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Figure *7 - Distribution of patients with concomitant connective tissue disease.*

In 13.1% (n=36) of the examined 273 patients who underwent surgery for incisional hernia, a concomitant respiratory disease was found, associated with symptoms of bronchial obstruction and leading to episodes of persistent coughing and increased intra-abdominal pressure. Of these, 22.2% (n=8) had documented chronic bronchitis, 30.56% (n=11) had bronchial asthma, and 47.22% (n=17) had COPD (Fig. 8).

Figure 8 *- Distribution of patients with concomitant respiratory disease.*

Smoking was examined as a potential risk factor leading to the development and recurrence of incisional hernias due to its known effect on collagen synthesis, which is essential in the postoperative period after abdominal surgery, including reconstructive surgery of the abdominal wall. Tobacco users represent 28.2% (n=77) of our total sample of operated patients (Fig. 9).

Figure 9 *- Proportion of patients who use tobacco products.*

The relative share of patients with concomitant autoimmune disease is 8.1% (n=22), with the most frequently reported being autoimmune thyroiditis – 6 patients, followed by chronic ulcerative colitis, Crohn's disease, and Reiter-Leroy syndrome – 3 patients each (Fig. 10).

In 18.1% (n=4) of patients with a diagnosed concomitant autoimmune disease, a second disease was also recorded: in two patients, vitiligo; in one, primary sclerosing cholangitis; and in one, autoimmune thyroiditis (Fig. 11).

Figure 10 *- Distribution of patients with concomitant autoimmune disease.*

Figure 11 *- Distribution of patients with a second concomitant autoimmune disease.*

Fig. 12 shows that after consultation with an anesthesiologist and calculation of the anesthetic risk (ASA class), the majority of patients—65.9% (n=180)—are at increased risk and fall into ASA III (n=141) and ASA IV classes (n=39).

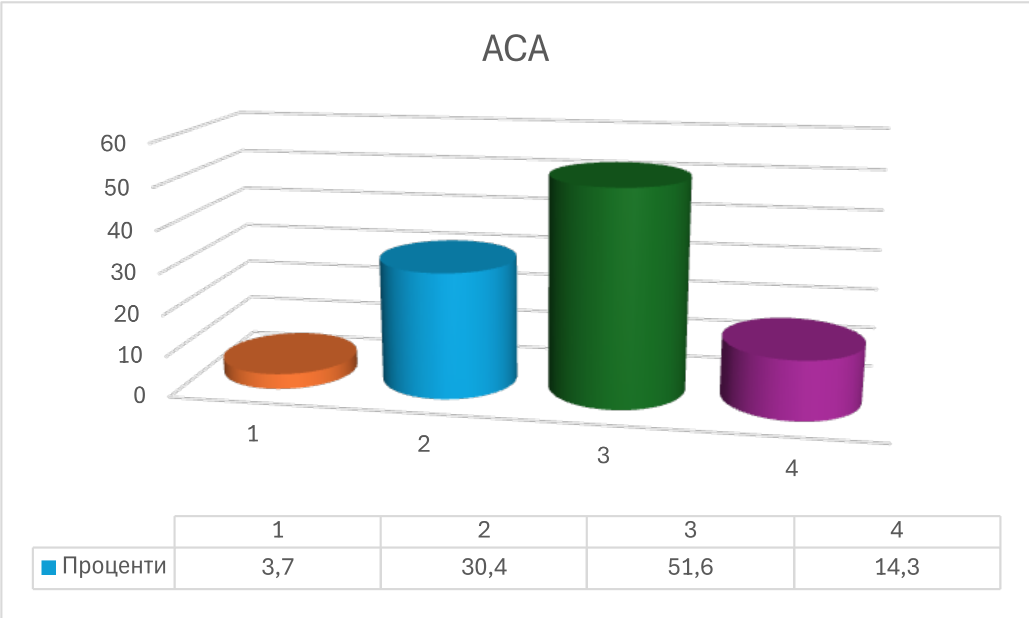

Figure 12 *- Distribution of patients according to ASA class*

A total of 422 previous interventions were reported in the 273 patients studied, performed both in our hospital and in other university, municipal, and private medical facilities. The highest frequency was for oncological operations - 17.8% (n=75) and gynecological operations - 14.7% (n=62). The high frequency of incisional hernias in the studied cohort after laparoscopic cholecystectomy - 4.3% - is striking, as in all cases this is at the port for camera insertion (Table 1).

Table 1. *Types of previous interventions.*

Types of previous interventions		
Type of intervention	**Percentage**	**Number of patients (n)**
Oncological surgeries	17.8	75
Gynecological surgeries	14.7	62
Appendectomy	8.5	36
Upper GI tract surgery	7.8	3
Biliary surgery	7.3	3
Lower GI tract surgery	6.9	29
Umbilical hernia	5.5	2
Laparoscopic cholecystectomy	4.3	18

Types of previous interventions		
Type of intervention	**Percentage**	**Number of patients (n)**
Liver and pancreas surgery	4	17
Ileus	3.8	1
Abscessotomy of the parietal abdominal wall	2.6	11
Ventral hernia	2.1	9
Inguinal canal plastic surgery	1.9	8
Laparoscopic surgery on the upper gastrointestinal tract	1.9	8
Peritonitis	1.7	7
Surgery for intra-abdominal abscesses	1.4	6
Aorto-coronary bypass	0.9	4
Epigastric hernia	0.7	3
Nephrectomy	0.7	3
Evisceration	0.5	2
Parietalis abdominis fistulotomy	0.5	2
Penetrating abdominal trauma	0.5	2
Non-penetrating abdominal trauma	0.5	2
Nephrolithotomy	0.5	2
Prostatectomy	0.5	2
Aortic valve replacement	0.5	2
Axillo-femoral bypass	0.2	1
Ureterolithotomy	0.2	1
Rupture of Ao aneurysm	0.	1
Aorto-renal bypass	0.2	1
Splenectomy	0.2	1

The frequency of occurrence depends on the type of previous surgical interventions and the surgical approach used. Despite the reported data on the highest incidence of incisional hernias after midline laparotomy, it remains the preferred access for interventions when rapid and/or complete exploration of the abdominal cavity is necessary. In the series of patients studied, 72.9% (n=199) of incisional hernias were in the area of a previous midline laparotomy scar, 7.1% in the area of a scar from a transverse incision around the umbilicus (n=19), and 5% along or near a scar from a Pfannenstiel incision (n=14) (Fig. 13).

In terms of the time of occurrence of incisional hernias , the largest relative share was found

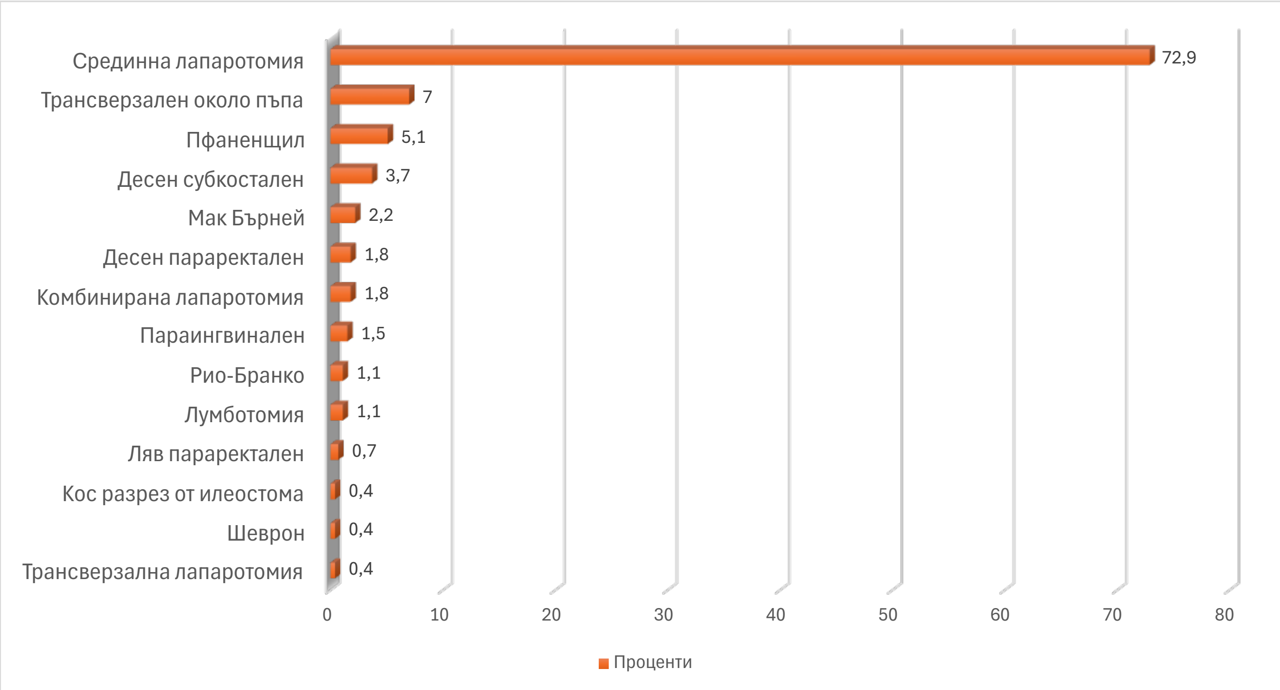

Figure 13 - *Distribution of types of previous surgical access.*

in the period between the second and sixth month - 24.2% (n=66), with 47.2% (n=129) of incisional hernia cases registered by the end of the first year after the previous surgery. The reported frequency of development after the fifth year, 18.7% (n=51), corresponds to the need for long-term follow-up of this type of patients, despite the literature data on the predominant manifestation of the disease by the end of the second year (Fig. 14).

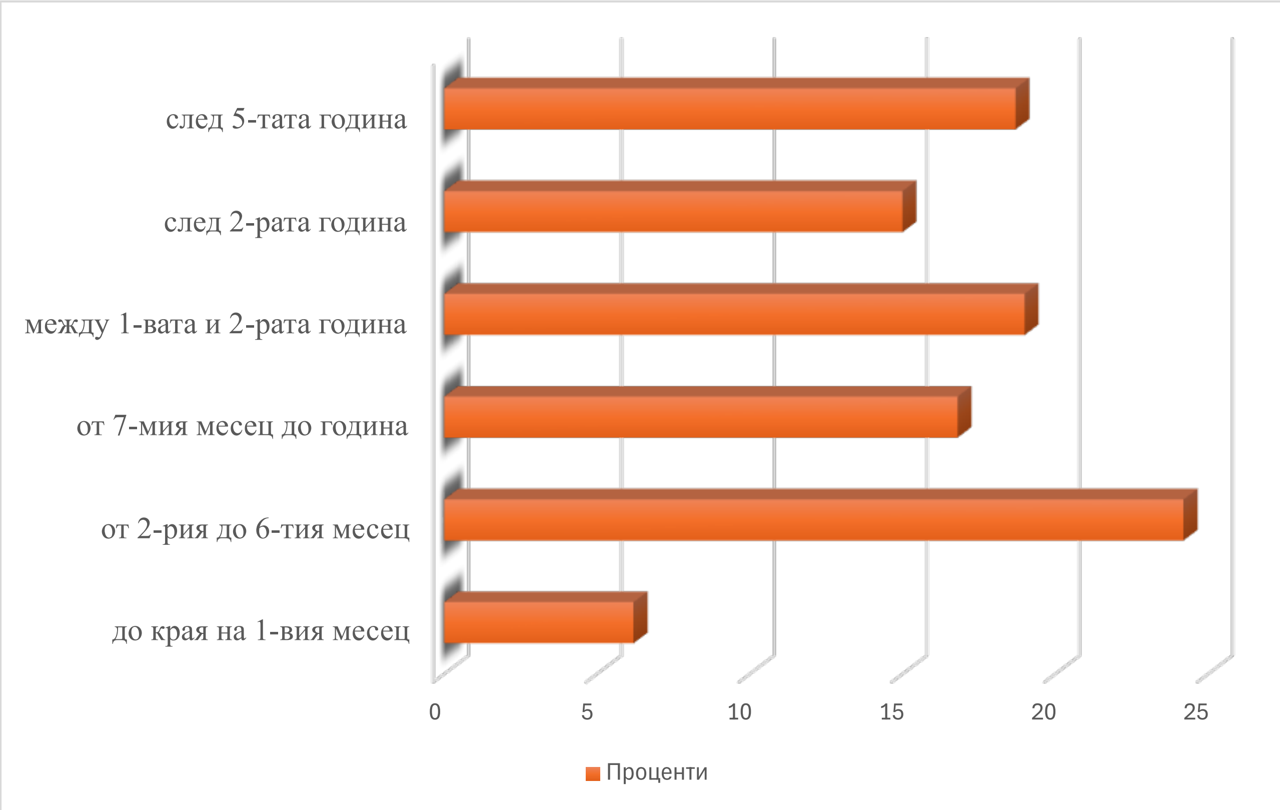

Figure 14 *- Distribution of incisional hernias according to time of onset*

After analyzing the medical history and the available medical documentation from previous surgical interventions (comparison of baseline and postoperative levels of Hgb, Hct, etc., as well as postoperative transfusions of blood substitutes), information was collected on increased bleeding during previous operations and the resulting consequences for the healing of the surgical wound. In the study group, the frequency of increased blood loss was 24.91% (n=68).

In 93 patients (34.1%), there was reliable evidence of surgical wound infection in the early postoperative period, with details on the severity of the process and its treatment being extracted from the patients' medical history, but were not accurately reflected in the medical documentation in all cases.

After the previous surgical intervention, chemotherapy was performed in 15.8% (n=43) of the patients included in the study (Fig. 15).

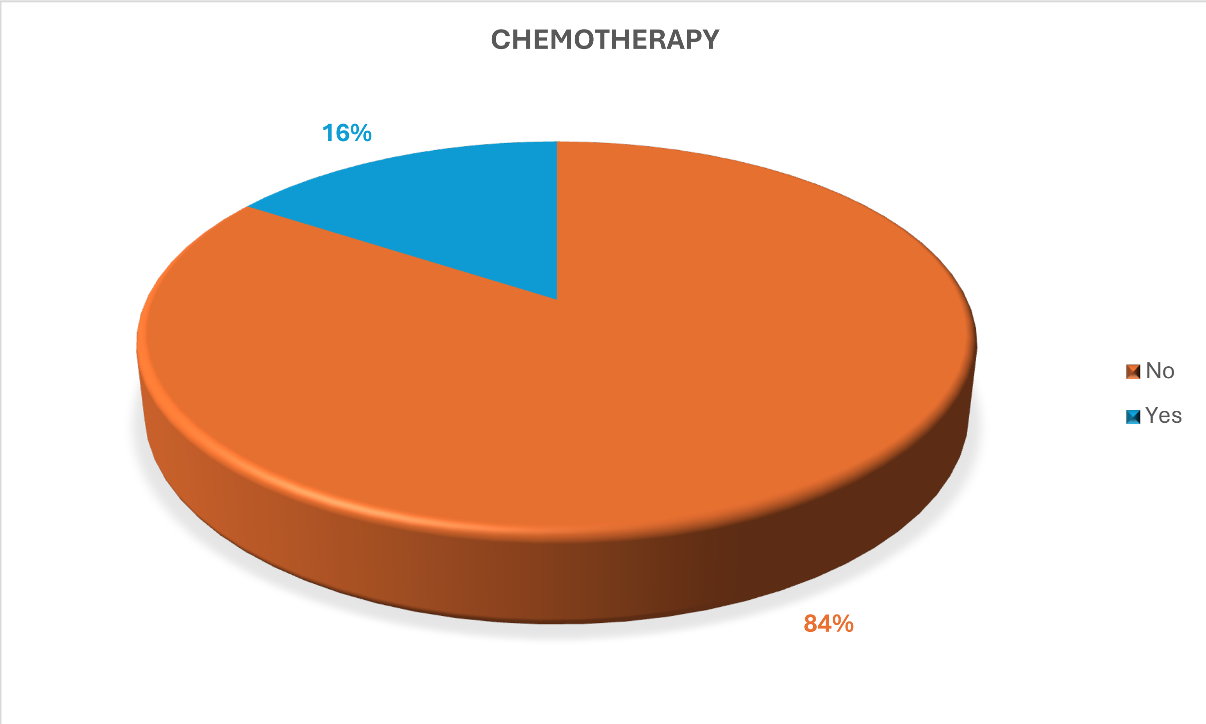

Figure 15 *- Proportion of patients who underwent CT after the previous surgical intervention.*

After conventional surgery or abdominal wall repair surgery, patients are given instructions on physical activity in the postoperative period. It is recommended to limit heavy physical exertion due to the respective increase in intra-abdominal pressure and the risk of postoperative hernia formation. Due to lack of compliance on the part of patients or inability to follow the recommendations for various social or economic reasons, a violation of the prescribed physical activity regimen in terms of weight lifting in the period after the previous surgery was found in 45.79% of cases (Fig. 16).

In connection with a concomitant respiratory disease causing bronchial obstruction, nicotine product abuse, or a postoperative complication with coughing, 17.6% (n=48) of the patients surveyed reported extensive coughing fits in the period following the previous surgical intervention (Fig. 17).

*Figure **16** - Percentage of patients who performed strenuous physical activity after the previous surgical intervention.*

***Figure 17** - Proportion of patients with persistent coughing attacks after the previous surgery.*

Data were also collected on other medical conditions causing increased intra-abdominal pressure, which may contribute to the development of incisional hernia – development of ileus symptoms after previous surgery, accompanying diseases with concomitant ascites, benign prostatic hypertrophy, chronic constipation. Although pregnancy is considered one of these circumstances, no patients in our series had been pregnant in the period following the previous surgery. The percentage frequency of conditions leading to increased intra-abdominal pressure is shown in Figs. 18, 19, 20, and 21.

Figure 18 *- Proportion of patients with increased intra-abdominal pressure due to ascites after previous surgery.*

Figure 19 *- Proportion of patients with increased intra-abdominal pressure due to ileus after previous surgery.*

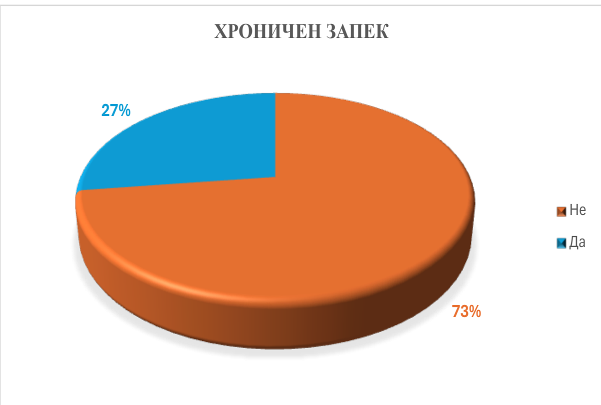

Figure 20 *- Proportion of patients with increased intra-abdominal pressure due to chronic constipation.*

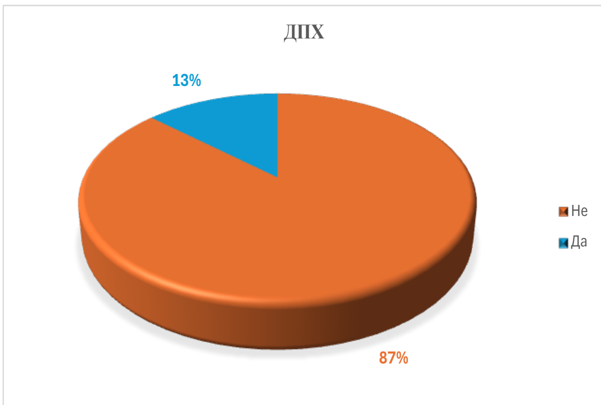

Figure 21 *- Proportion of patients with increased intra-abdominal pressure due to BPH.*

Of the 273 patients included in this study, 27.1% (n=74) underwent surgery for recurrent postoperative hernia, with the majority of them - 74.3% (n=55) - experiencing their first recurrence, 20.3% (n=15) underwent reconstructive surgery of the anterior abdominal wall due to a second recurrence, and for 5.5% (n=4) it was a third or fourth recurrence of the hernia (Fig. 22).

Figure 22 *- Distribution of patients with recurrent postoperative hernia according to the number of recurrences.*

The results of the analysis of the types of previous repairs in recurrent incisional hernias demonstrate a predominant relative share of previous repairs with mesh – 59.4% with prosthetic material placement and 1.3% with a combination of prosthetic technique and fascial duplication – a total of 45 patients. Insufficient data in some patients regarding the anatomical position of the expantoplast insertion in the previous medical documentation made it impossible to group and further compare this group of patients in terms of the specific surgical technique. Even so, the results obtained contrasted with the preliminary hypothesis that the majority of patients with recurrent incisional hernias would be those who had undergone fascial adaptation technique, due to the higher rate of recurrence after such surgery reported in the literature. In our series, the recurrences after non prosthetic techniques, with/without additional metal laparosynthesis with Ventrofil, totaled 39.3 % (n=29) (Fig. 23).

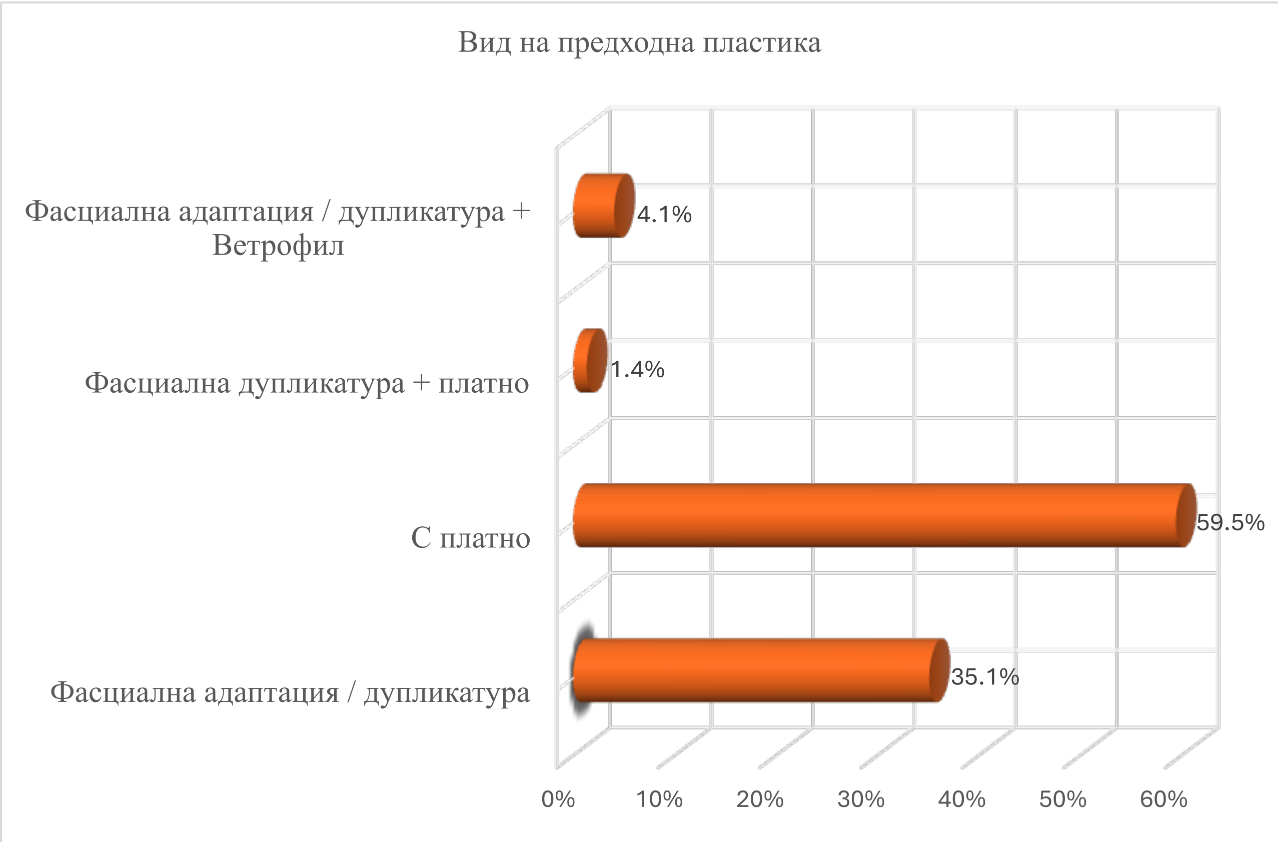

Figure 23 *- Distribution of types of previous repairs in patients with recurrent incisional hernias .*

4.2. Description of the perioperative results of conventional surgical treatment of incisional hernias for the period 2017-2021 at the Second surgery clinic.

As part of a university medical center, the focus of our department is in the field of elective surgery, so it is not surprising that only 12.09% (n=33) of the studied cohort of patients with incisional hernias underwent emergency surgery (Fig. 24).

Patients operated for large incisional hernias – types W2 and W3 according to the EHS classification of incisional hernias – predominate, while small hernias (W1 – with a hernial defect width of less than 4 cm) account for only 26% (n=71) (Fig. 25).

Figure 24 *- Distribution of interventions for incisional hernias according to the order of performance.*

Figure 25 *- Distribution of incisional hernias according to defect width.*

The average reported area of the hernial defect is 87.25 cm² with a standard deviation of 106.1 cm², i.e. most incisional hernias have an area of up to 200 cm² (Fig. 26).

The conventional techniques used for reconstruction of the 273 incisional hernias covered by the study are presented in Table 2.

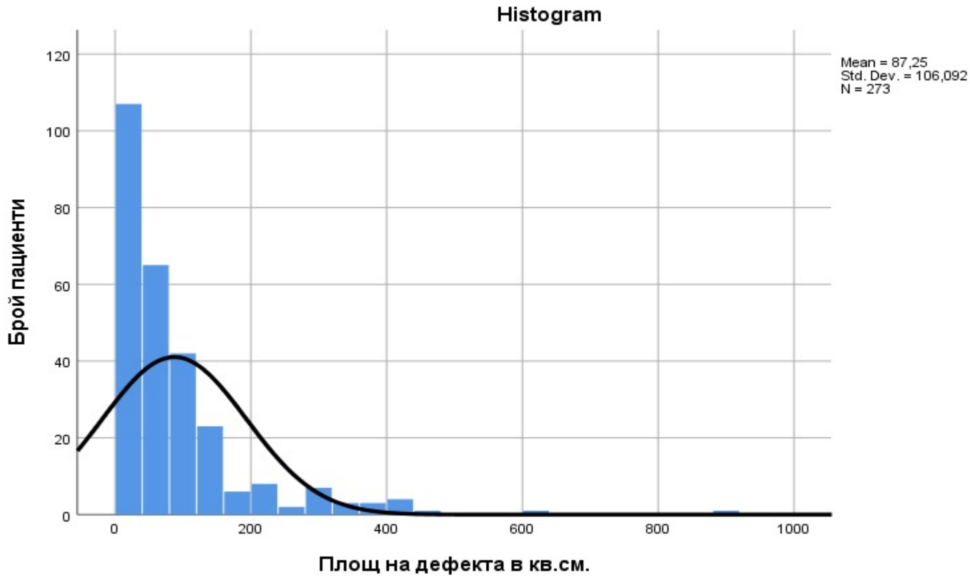

Figure 26 *- Distribution of incisional hernias according to defect area in cm².*

Table 2. Types of techniques used for reconstruction of the anterior abdominal wall

Type of technique used	*Number of patients N*	*Percentage*
Onlay position	*111*	*40.7*
Fascial adaptation	*63*	*23*
Retrorectal position	*39*	*14.3*
Facial duplication	*14*	*5*
Posterior component separation + TAR + retro-rectal position	*14*	*5.1*
Facial adaptation + Ventrofil	*13*	*4*
Fascial duplication + canvas	*9*	*3.3*
Canvas in inlay position	*5*	*1.8*
Component separation according to Ramirez + onlay plate	*2*	*0*
Membrane + Ventrofil	*2*	*0.7*
Onlay + retrograde position	*1*	*0*

To summarize the results shown in Table 2, only 67% (n=183) of the anterior abdominal wall reconstructions performed involved prosthetic replacement with expantoplast, with the largest relative share being its placement in the onlay position – 40.7% (n=111), followed by retro-rectus insertion – 14.3%. Methods without mesh placement, which represent 33% of the cases in the cohort, were used almost exclusively in situations where the surgical intervention was performed on an emergency basis (12.09%) and there was contamination of the surgical field, in cases of small incisional hernias (defect width less than 4 cm – 26%) and when the patient refused mesh use for various reasons, mainly socio-economic. The separation of the components of the abdominal wall in combination with prosthesis placement was applied in cases of incisional hernias with extreme tissue loss (LOD)- in a total of 5.8% of cases, and it is noteworthy that patients with a defect width between 10 and 30 cm This leads to the conclusion that other plastic methods were also used in the group with a defect width of 10-20 cm.

In patients with prosthetics (n=183), different chemically derived meshes were used, which can be summarized in three groups: polypropylene, polyester, and biological. The characteristics of the meshes used are presented in Table 3.

Table 3*. Characteristics of the synthetic and biological meshes used in the study.*

Type of fabric (Manufacturer)	Material	Available sizes	Filaments	Pore size (mm)	Thickness (mm)	Weight (g/m^2)
Microval 2D Mesh implant (Microval)	Polypropylene	7.5/15 15 30	Monofilament	1.31	0.56	91 g/m
Versatex™ (Medtronic)	polyester	15/15 30/30	Monofilament	2.1x 3.0	0.7	64 g/m
Parietene™ (Medtronic)	polypropylene	6/11 10/15 15/15	Monofilament	2.0 x 2.4	0.6	46 g/m
Biodesign® Hernia graft (COOK Medical)	Pig small intestine submucosa	8/15 10 15	-	-	-	-

The majority of patients underwent prosthetic repair with polypropylene mesh – 90.7% (n=67), in line with the widespread use of this type of mesh for extraperitoneal implantation in the treatment of incisional hernias , where it demonstrates its advantages – strength, relatively low cost compared to other types of prostheses, and lack of conditions for the formation of adhesions to the internal abdominal organs. The size of the hernial defect was the leading factor in the choice of prosthesis size. The individual preferences of the operating surgeon and the socio-economic status of the patient were the main factors in the selection of the type of expantoplast according to the manufacturer. The most commonly used type of mesh in the study was the Microval 2D mesh implant, size 7.5/15 cm, in 36.6% of patients (n=67). In general, the higher relative share of Microval prostheses, regardless of size, can also be explained by the availability of other types of meshes in the hospital network at a later stage of the study. The distribution of the types of meshes used according to the number of cases is presented in Fig. 27.

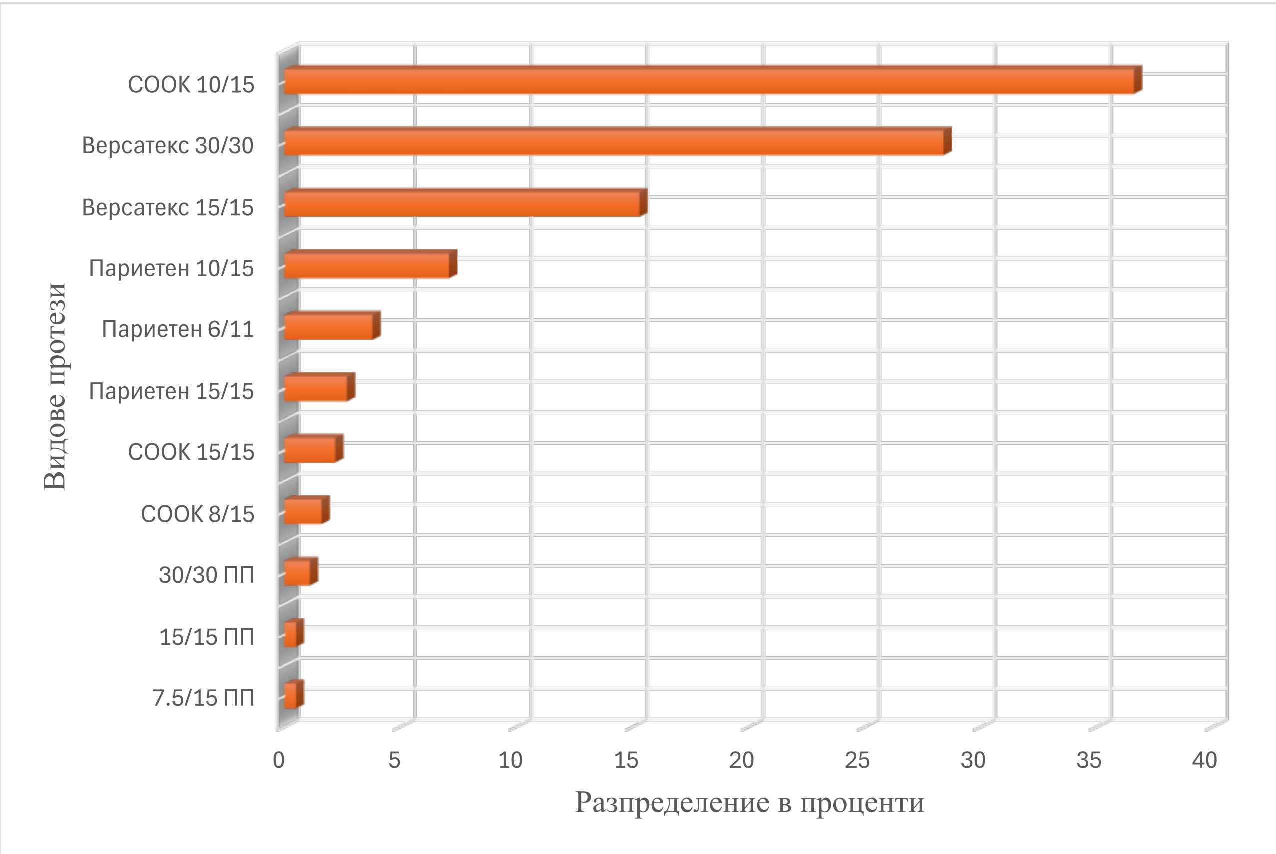

Figure 27 *- Distribution of meshes used.*

In 2% (n=4) of the prosthetic patients, a second mesh was also placed during the surgical intervention – 1 Microval 2D Mesh implant 7.5/15 cm, 1 Microval 2D Mesh implant 15/15 cm, 1 Parietene™ 6/11 cm, and 1 Parietene™ 15/15 cm.

With regard to the minimum acceptable overlap of the mesh in healthy muscle-fascial tissue, the European Hernia Society and the American Hernia Society make the following recommendations: for conventional surgical treatment of incisional hernias:

- with a size < 1 cm – overlap ≥ 2 cm.
- with a size of 1-4 cm – overlap ≥ 3 cm
- size > 4 cm – overlap ≥ 5 cm. a

For all laparoscopic reconstructive surgeries of the anterior abdominal wall for ventral and incisional hernias , the minimum overlap is 5 cm. [310]

Taking into account the above, in our series we set the overlap limit at 5 cm due to the prevailing frequency of hernias with a defect width of more than 4 cm. Satisfactory overlap of the mesh ≥ 5 cm was found in 40.8% of cases (Fig. 28).

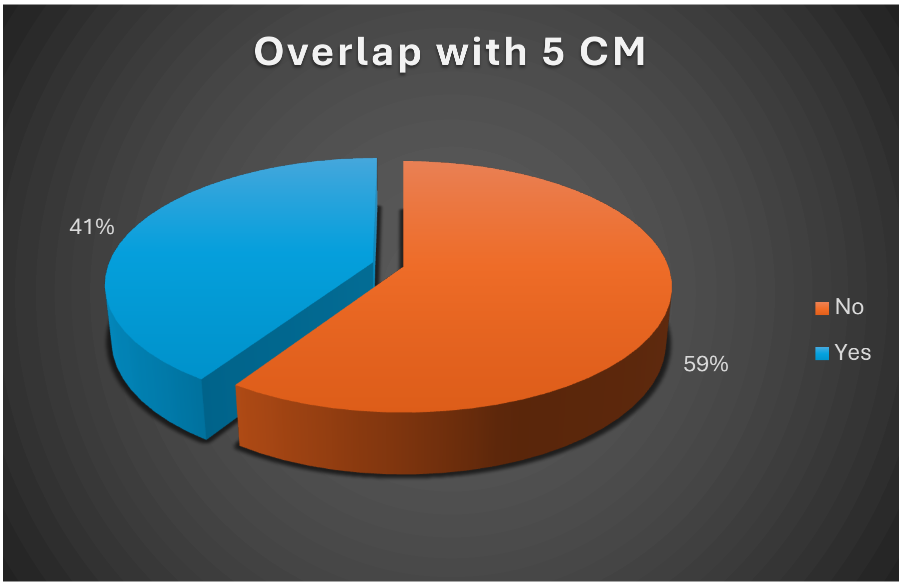

Figure 28 *- Distribution of reconstructive operations with prosthesis in relation to the overlap of the mesh.*

The average operating time for the 273 patients operated was 108 minutes (Fig. 29).

Drains were placed in 199 patients (73%) from the study group, with the majority of incisional hernia repair drained using Redon drains placed on active suction, the distribution of which was uniform in terms of number (with one Redon drain, the surgical intervention was completed in 96 cases, with two - in 98) (Fig. 30).

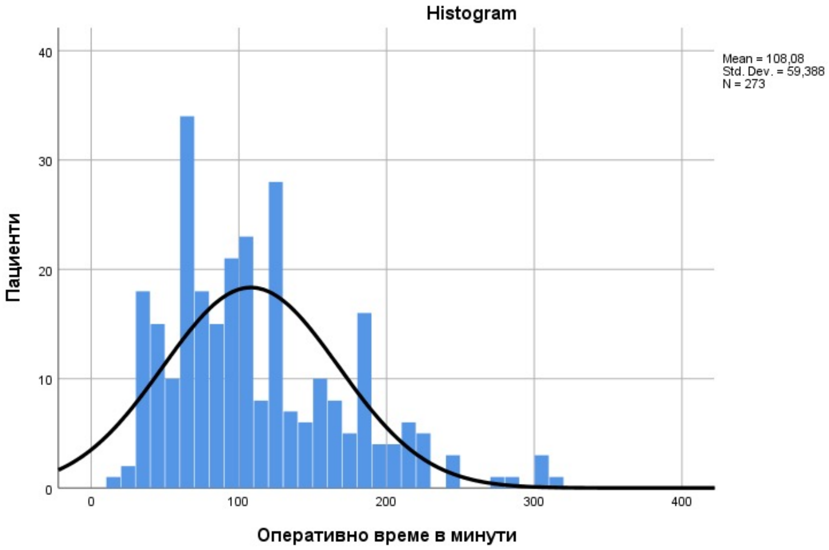

Figure 29 *- Average operating time in minutes.*

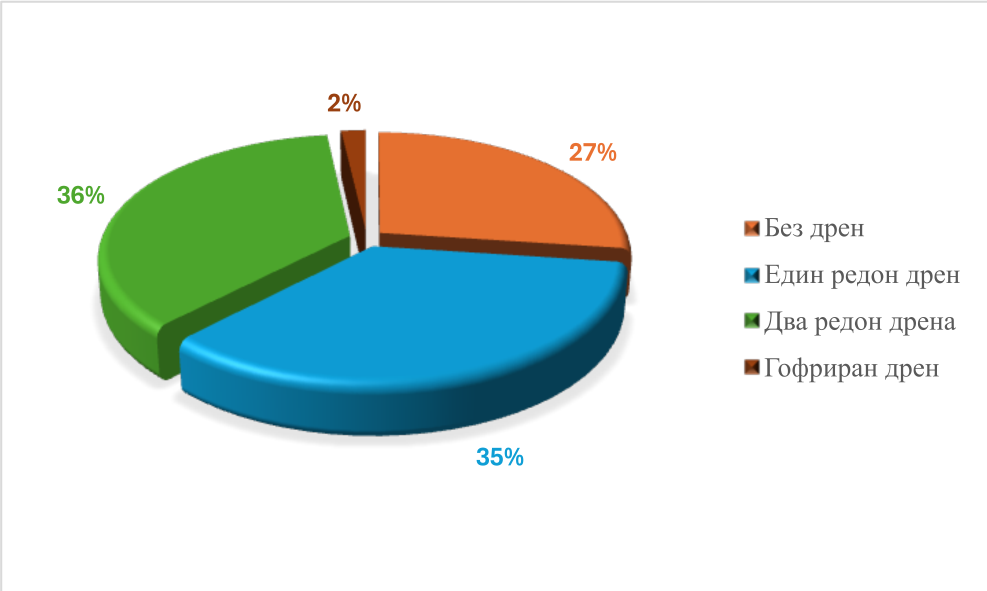

Figure 30 *- Distribution of patients according to the number and type of drains placed.*

The anatomical plan for prosthesis insertion, the patient's habitual characteristics, and the size and volume of the residual space around the mesh were the main factors in determining the need for and type of drainage. There is an overlap in the data on small incisional hernias (26%) and the lack of drainage placement in 27% of the operations, which leads to the conclusion that the patients in these two groups overlap.

In 50% (n=100) of patients with at least one Redon drain placed, it was removed on the second postoperative day, and on the third postoperative day - 23.5% (n=47) (mean value 2.24 with standard deviation 0.95)(Fig. 31).

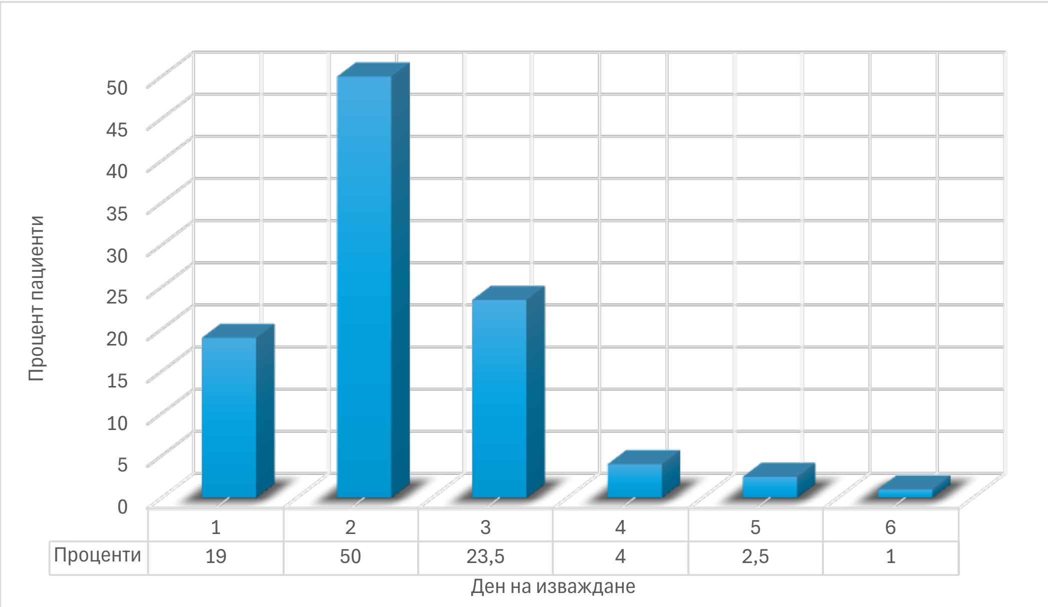

Figure 31 *- Distribution of patients drained with at least 1 drain according to the day of removal.*

Similarly, in those with 2 Redon drains placed at the end of the surgical intervention, in 73.5% (n=72) the second drain was removed on the 2nd-3rd postoperative day (Fig. 32). This shows that in

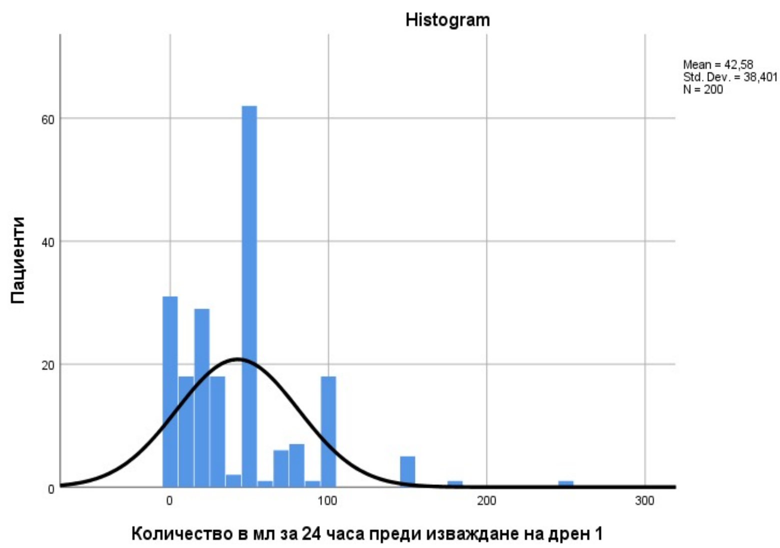

Figure 32 *- Average amount evacuated from drain 1 24 h before removal.*

most cases the drains were removed simultaneously and the need for a second drain may be related only to a larger residual cavity in contact with the reconstruction of the abdominal wall.

The average amount of fluid drained in 24 hours before removal for the first drain was 42.58 ml += 38.40 ml, and for the second drain – 51.48 += 53.51 ml. (Fig. 33 and Fig. 34).

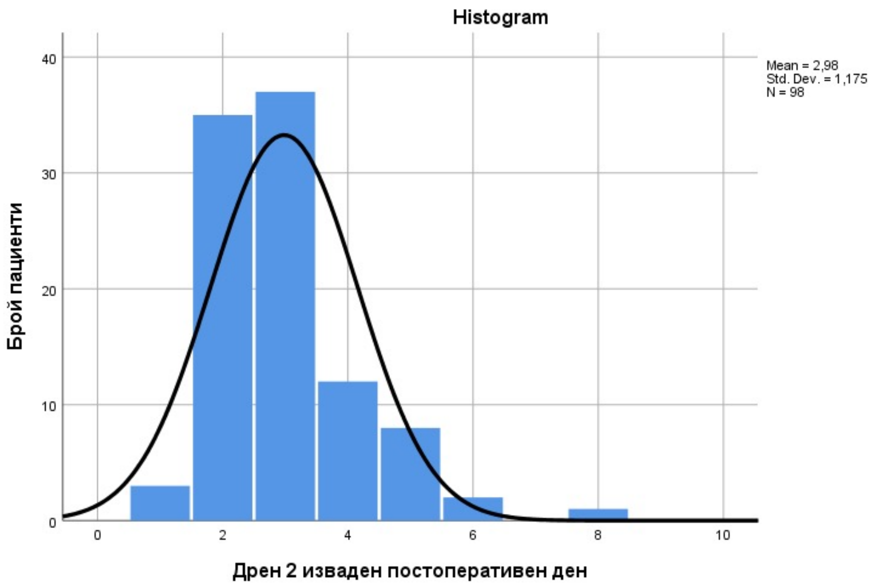

Figure 33 *- Distribution of patients drained with 2 drains according to the day of removal.*

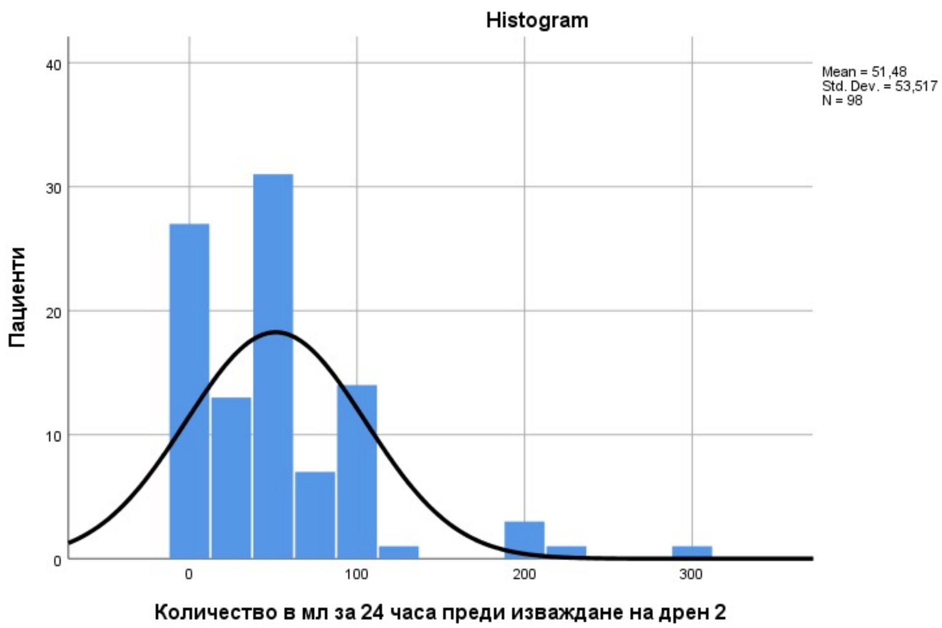

Figure 34 *- Average amount evacuated from drain 2 24 h before removal.*

Antibiotic prophylaxis in the postoperative period was performed in 77.3% (n=211) of patients for varying durations (Fig. 35).

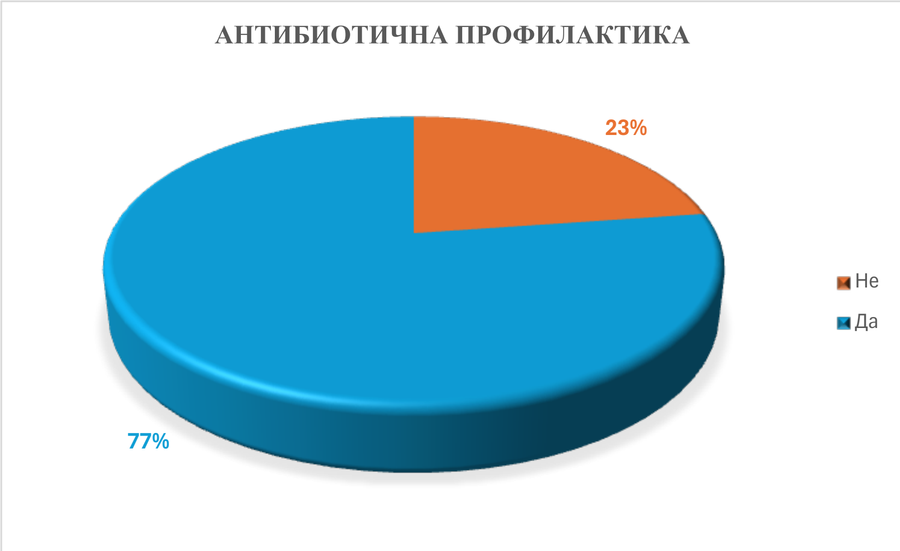

Figure 35 *- Distribution according to the implementation of AB prophylaxis.*

In more than half (59%) of cases of antibiotic prophylaxis, the drug of choice was first-generation cephalosporin – Cefazolin, which was administered in combination with Metronidazole in 18.3% (n=50) of patients. The next AB with the highest relative share of use was Lifurox – 18.49% (n=39), and it was more often used in combination with Metronidazole (10.43%), unlike Cefazolin, which was prescribed twice less often in combination than as monotherapy. The other AB drugs were used much less frequently, mainly during simultaneous surgical intervention (Fig. 36).

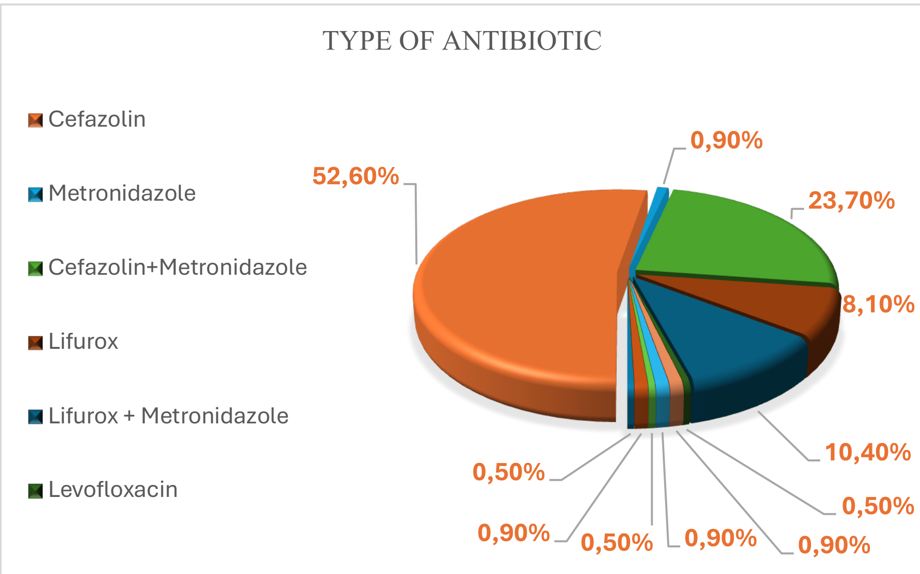

Figure 36 *- Distribution of antibiotics used as prophylaxis.*

Prophylaxis against thrombotic complications – MI, IMI, and PTE was performed in 78% of the studied patients with low molecular weight Heparin drugs – Fraxiparin 3800 IU/0.4 ml. and 7600 IU/0.8 ml, as well as Clexane 6000 IU/0.6 ml, in accordance with the recommendations for dosage per kg of body weight (Fig. 37).

Figure 37 *- Distribution of patients receiving NHA prophylaxis.*

The average duration of NMH prophylaxis was 2.89 days, i.e. 3 days with a standard deviation of 2.23 days – the majority of patients received prophylaxis between 3 and 5 days (Fig. 38). Only one patient received NMH therapy for more than 10 days – 11 days. In the presence of additional indications, therapy to prevent thrombotic complications was prescribed to a selected group of patients for the period after discharge with various drugs that do not require laboratory monitoring of INR and aPTT.

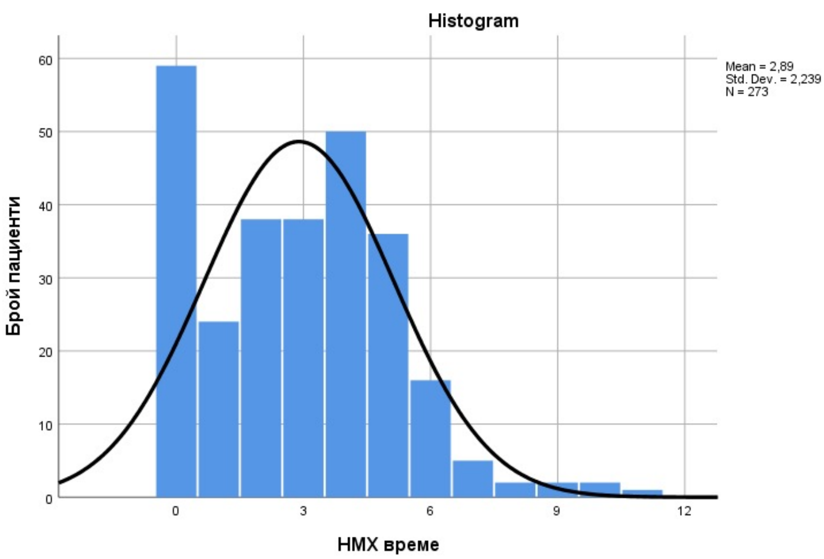

Figure 38 *- Duration of NHA prophylaxis.*

4.3. Description of postoperative results from conventional surgical treatment of incisional hernias for the period 2017-2021 in the Second Clinic of Surgery

In our cohort of 273 patients operated for incisional hernias , a total of 64 complications were recorded, which we assessed using the internationally accepted Dindo-Clavien classification of postoperative complications [103].

Table 4. *Dindo-Clavien classification of complications [103].*

DEGREE	DEFINITION
Grade I	Any deviation from the normal postoperative course without the need for pharmacological treatment after surgical, endoscopic, or radiological intervention. The use of antiemetics, antipyretics, analgesics, diuretics, electrolyte solutions, and physiotherapy is permitted. This grade also includes mild wound infections.
Grade II	Complications requiring pharmacological treatment with drugs other than those listed for grade I. Need for parenteral nutrition and blood transfusions.
Grade III	Need for surgical, endoscopic, or radiological intervention
Grade III-a	Intervention under local anesthesia
Grade III-b	Intervention under general anesthesia
Grade IV	Life-threatening complications (including those affecting the central nervous system) requiring intensive care
Grade IV-a	Single organ dysfunction (including hemodialysis)
Grade IV-b	Multiple organ failure
Grade V	Exitus letalis

No complications of grade III according to the classification were found. Mild complications (Grade I and II) prevailed (71.1%), while severe complications (Grade IV) were observed in patients who underwent simultaneous intervention for another reason with accompanying incisional hernia repair (Table 5).

Table 5. *Distribution of complications according to the Dindo-Clavien classification.*

	Grade I	Grade II	Grade III-a	Grade III-b	Grade IV-a	Grade IV-b
Patients	11	35	-	-	17	1
Percentage	17.1	54.6	0	0	26.5	1.5

A total of 7 wound complications (10.9% of all complications) were recorded – suppuration of the surgical wound in five patients and hematoma of the abdominal wall in two patients. Adverse events occurred in the following systems: CNS – 29.6% (n=19), cardiovascular system – 29.6% (n=19), respiratory system – 26.5% (n=17), and urinary system – 1.5% (n=1). One patient developed sepsis as a postoperative complication.

The average length of hospital stay was 6.24 days with a standard deviation of 3.25 days. The shortest length of stay was 2 days – 5.5% (n=15), and the longest – 29 days – 0.4% (n=1) (Fig. 39).

An economic analysis was performed on the 273 patients studied who underwent conventional

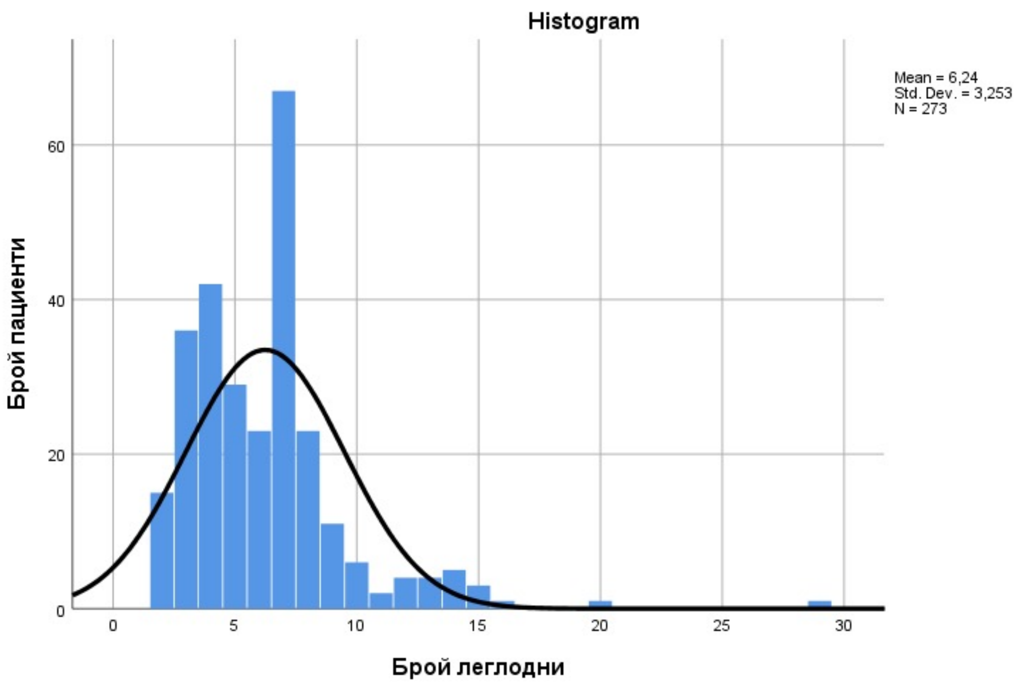

Figure 39 *- Distribution of patients according to the duration of hospital treatment.*

surgery for incisional hernias , calculating the direct and total costs associated with hospital treatment and the early postoperative period. Direct costs are those generated during the hospital treatment and were calculated in the current study using the following formula:

Figure 40 *- Calculation of direct hospital costs.*

The reported average value of direct costs for our cohort of patients was BGN 2041.27± 1530. The minimum value of direct costs calculated was BGN 568.38, and the maximum was BGN 8241.51 (Fig. 41). The main factor found to affect the cost of direct expenses was the length of hospital stay, and during the course of the study – changes in the cost of bed days and additional medical supplies.

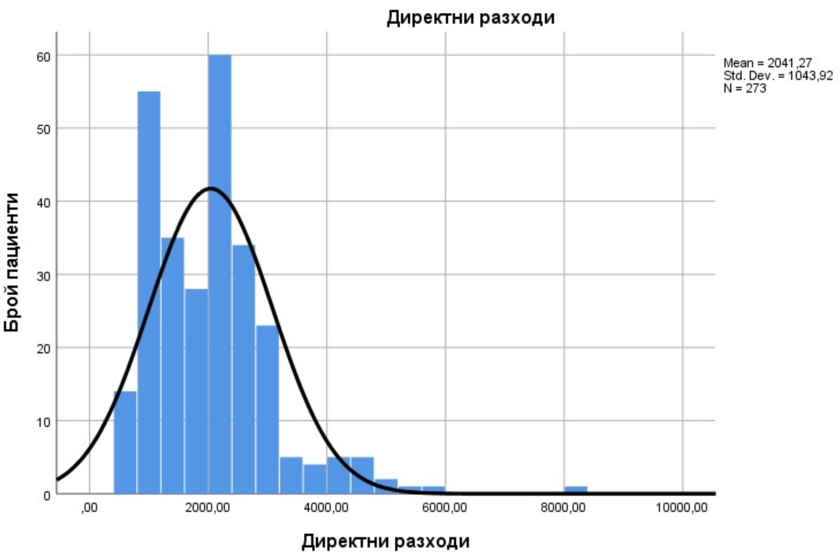

Figure 41 *- Distribution of the value of direct costs.*

Total costs represent the sum of direct and indirect costs, which were calculated based on the sick leave days used in the early postoperative period. Retired patients, those on leave (maternity, paid and unpaid annual leave), unemployed and those in employment who declined sick leave were not included in this calculation. Due to the lack of data on the monthly remuneration of individual working patients, the value of the sick leave was calculated as 80% of the average gross salary for the respective month and year of the study according to data from the National Statistical Institute. Complete information on subsequent sick leave certificates was not available, as some of them were issued in structures outside the scope of the diagnostic and consultation center of UMHAT "Sveta Marina", some of which were in other locations.

The average total cost was calculated to be BGN 2,249.24.± BGN 1,369. (Fig. 42)

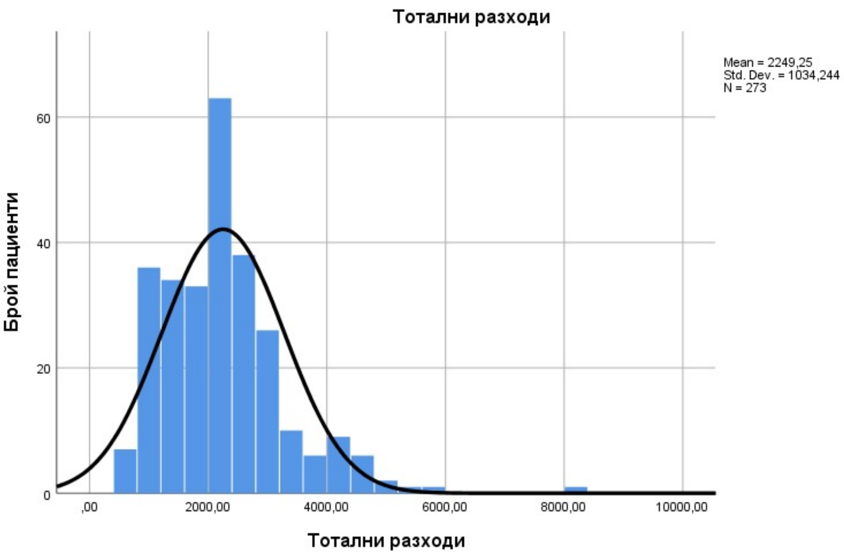

Figure 42 *- Distribution of total costs.*

4.4. Correlation dependencies between the reported variables

Correlation analysis is a statistical method that measures the strength and direction of the correlation between two or more variables. When developing a correlation model, it is essential to correctly define the independent variable X (factor) and the dependent variable Y (effect). The main measure of the strength of the relationship is the correlation coefficient r. Its value is interpreted according to the scale presented below (Table 5).

Table 5. *Correlation coefficient values and their interpretation.*

Correlation coefficient value r	**Interpretation of the strength of the dependence**
0	No relationship
0	Weak correlation
0.3	Moderate connection
0.5	Significant relationship
0.7	Strong correlation
0.9	Very strong correlation
1	Functional relationship

When the correlation coefficient r has a positive value, it can be said that the relationship between the variables is direct. When the correlation coefficient r has a negative sign, it can be said that the relationship is inverse.

For a correlation analysis to be done correctly, the following steps must be followed:

1. Determine the independent variables (factors) X and the dependent variable Y (consequence).
2. Select an appropriate correlation coefficient according to the statistical scale to which the studied variables belong.
3. Assess the strength of the correlation.
4. Assess the statistical significance of the coefficient obtained.
5. Interpret the results obtained.

It is essential to assess whether the obtained correlation coefficient is statistically significant. When using modern statistical and econometric software products, science allows a decision to be made in an alternative way, which boils down to comparing the accepted benchmark level of significance (risk of error α) and the calculated threshold level of significance (p). This method has been applied in the present study to test the statistical significance of the obtained correlation coefficient r.

If the level of significance (p) calculated on the basis of the sample data is less than the accepted standard level of significance (α), the correlation coefficient obtained is considered to be statistically significant and reliable. If the calculated significance level (Sig) is greater than the accepted standard significance level (α), the obtained correlation coefficient is considered not statistically significant.

The emphasis is on the non-parametric contingency correlation coefficient, which is applicable when studying dependencies with variables located on a nominal scale (qualitative variables).

4.4.1. Correlations between studied parameters and recurrence of the hernia and identification of risk factors for the reherniation process

- **Comparative analysis between patient gender and recurrence** – $r = 0.52$, $p=0.392 > \alpha = 0.05$ – there is **a significant positive correlation between patient gender and recurrence**, which, however, is not statistically significant. Female gender is more frequently affected – 17.2%.

- **Comparative analysis between age (represented as age decade) and recurrence -** $r = 0.146$, $p=0.432 > \alpha = 0.05$ - there is **a weak positive correlation between the patient's age group and recurrence.** The highest frequency of recurrent incisional hernias is in the seventh decade – 8.4% (n=23) and the sixth decade – 8.1% (n=22).

- **Comparative analysis between BMI and the number of reported recurrences** – no correlation was found between the two indicators.

- **Comparative analysis between smoking and recurrence** – r = 0.039, p=0.520 >α =0.05 – **a weak positive correlation** was found **between smoking and recurrence.** The use of nicotine products is not a statistically significant predictive factor for recurrence (Fig. 43).

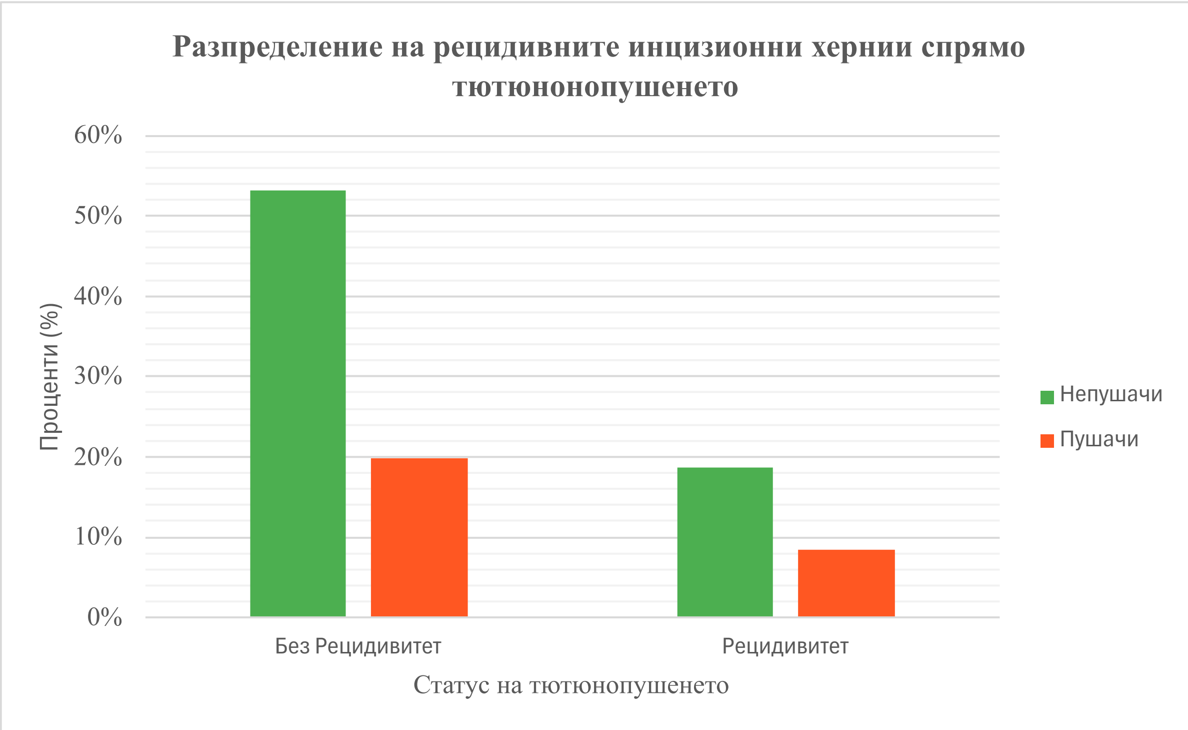

Figure 43 *- Distribution of recurrent incisional hernias in relation to smoking.*

- **Comparative analysis between diabetes mellitus and recurrence** – r = 0.054, p = 0.368 >α =0.05 – **a weak positive correlation** was found **between diabetes mellitus as a concomitant disease and recurrence**. Analysis of patients with poor diabetes control again revealed **a weak positive correlation with reherniation** – r = 0.105, p=0.082 >α =0.05 (Fig. 44). In summary, diabetes mellitus is not a statistically significant risk factor for subsequent recurrence in our series of patients.

Figure 44 *- Distribution of recurrent incisional hernias among patients with poor diabetes control*

- **Comparative analysis between the presence of accompanying respiratory diseases leading to bronchial obstruction (chronic bronchitis, bronchial asthma, and COPD) and** recurrence - r = 0.045, p = 0.908 >α = 0.05 - **weak positive correlation between the two variables**. Such a correlation was also found between episodes of persistent cough in the postoperative period and subsequent recurrence- r = 0.065, p=0.285 >α =0.05—diseases causing paroxysmal, extensive coughing episodes after the initial surgery were not validated as a statistically significant risk factor for reherniation in the studied patient group.
- **Comparative analysis between concomitant connective tissue diseases and recurrence** – r = 0.083, p=0.171 >α =0.05 – there is **a weak positive correlation between concomitant connective tissue pathology and recurrence,** which**,** however, is not statistically significant.
- **Comparative analysis between the type of the prevous incision and recurrence of the hernia** – r = 0.248, p=0.163 >α =0.05 – there is **a weak positive correlation between the**

type of previous laparotomy and recurrence. The most common recurrent incisional hernias are in the area of a previous midline laparotomy scar – 20.1% (Fig. 45).

Figure 45 - Distribution of recurrent incisional hernias according to the type of previous laparotomy

- **Comparative analysis between the number of previous operations and the number of documented recurrences of incisional hernias** - r=0.179, p=0.003<α =0.05 – presence of **a statistically significant, weak positive correlation between the number of previous interventions and the number of described recurrences** of incisional hernias **to date** (Table 6).

Table 6. *Relationship between the number of previous interventions and the number of recurrences*

	Number of previous operations	Number of recurrences
	Pearson Correlation	Pearson Correlation
Number of previous operations	1	0.179
	Sig. (2-tailed)	Sig. (2-tailed)
		0.003
	N	N
	273	273
Number of relapses	Pearson Correlation	Pearson Correlation
	0.179	1
	Sig. (2-tailed)	Sig. (2-tailed)
	0.003	
	N	N
	273	273

- **Comparative analysis between increased bleeding during the previous intervention and** recurrence - r=0.213, p=0.000 <α =0.05 - presence of **a statistically significant weak positive correlation** (Fig. 46). Increased blood loss during the previous operation was found to be a statistically significant risk factor for recurrence in the studied cohort.

Figure 46 *- Distribution of recurrent incisional hernias in patients with increased bleeding during the previous intervention*

- **Comparative analysis between surgical wound infection after previous surgery and recurrence** – r=0.031, p=0.607 >α =0.05 – **a weak positive correlation** is established **between the processes of incision infection after previous surgery and recurrence**, without this being confirmed as a statistically significant risk factor (Fig. 47).
- **Comparative analysis between extreme physical exertion in the postoperative period and recurrence** - r=0.129, p=0.031 <α =0.05 - **a statistically significant weak positive correlation** was established **between heavy lifting in the postoperative period and recurrence** (Fig. 48), i.e., this is a statistically significant predictive factor for recurrence in our group.

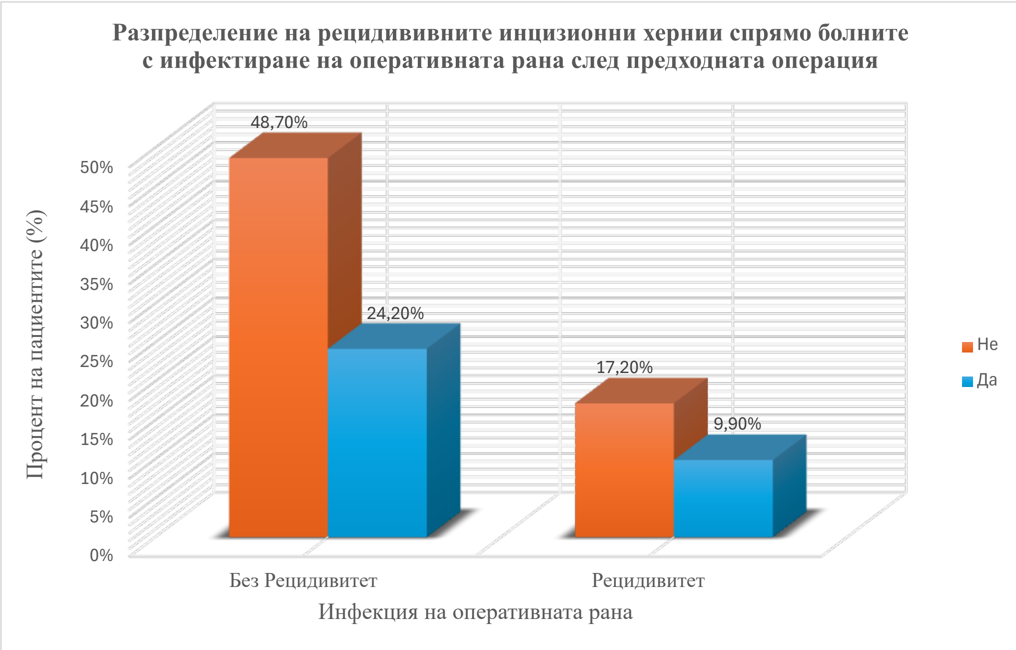

Figure 47 *- Distribution of recurrent incisional hernias among patients with surgical wound infection after previous surgery*

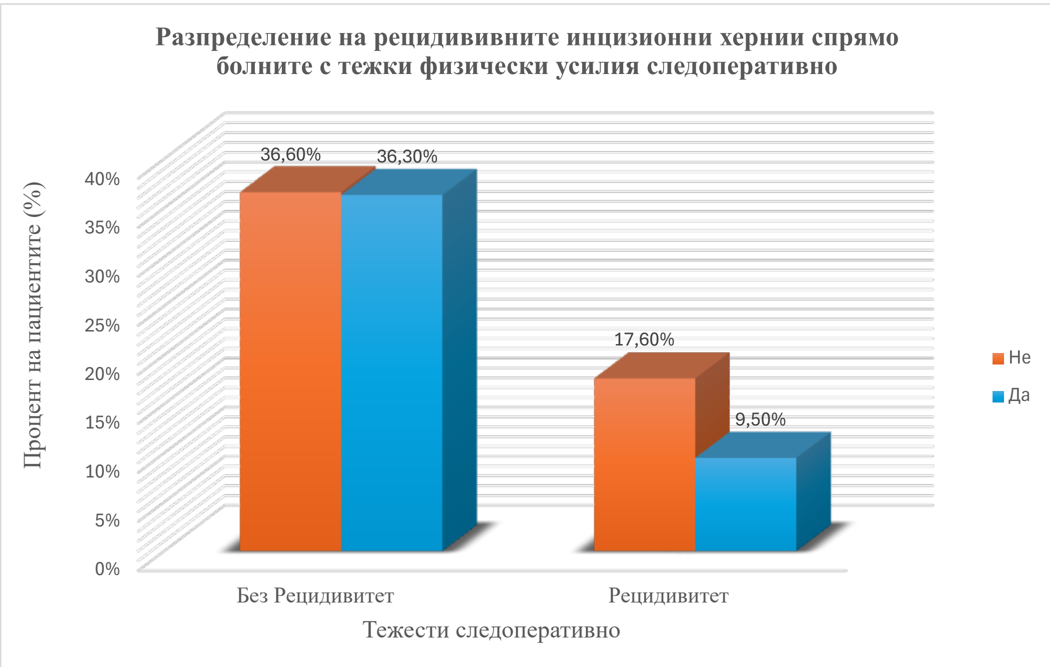

Figure 48 *- Distribution of recurrent incisional hernias in patients with heavy physical exertion postoperatively*

- A weak positive correlation was established, which, however, was not proven to be statistically significant for any of the conditions studied:

-increased IA pressure due to ileus/recurrence - $r = 0.037$, $p=0.538 > \alpha = 0.05$

-increased IA pressure due to ascites/recurrence - $r = 0.050$, $p=0.409 > \alpha = 0.05$

-increased IA pressure due to BPH/recurrence - $r = 0.091$, $p=0.130 > \alpha = 0.05$

-increased IA pressure due to chronic constipation/recurrence - $r = 0.073$, $p=0.223 > \alpha = 0.05$

- **Comparative analysis between chemotherapy after initial surgery and** recurrence - $r = 0.030$, $p=0.615 > \alpha = 0.05$ – there is a weak positive correlation, without chemotherapy treatment being established as a statistically significant risk factor for herniation (Fig. 49)

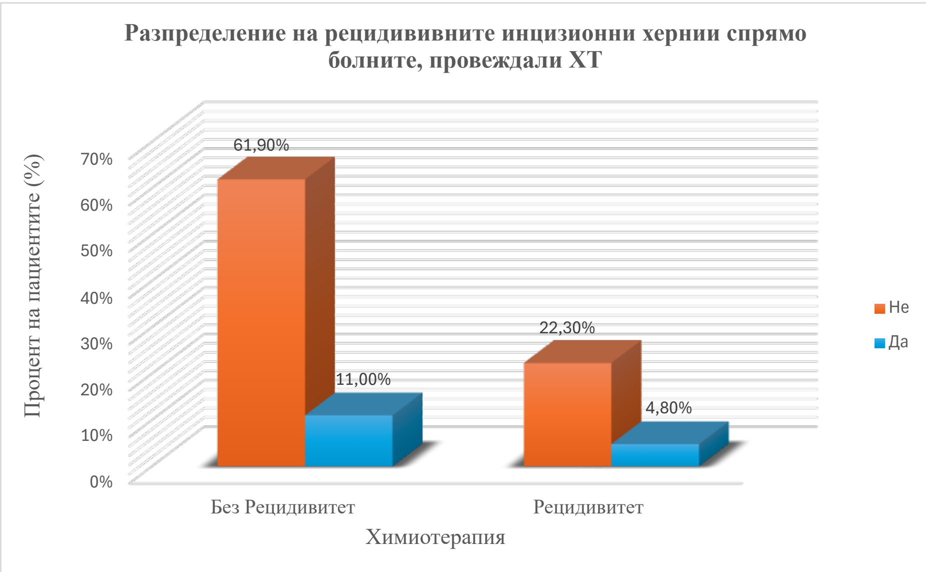

Figure 49 *- Distribution of recurrent incisional hernias among patients who underwent chemotherapy*

- **Comparative analysis between the type of previous repair and** recurrence - $r = 0.697$, $p=0.000 < \alpha = 0.05$ - there is **a statistically significant, strong positive correlation between the type of previous repair and recurrence.** The relative share of recurrent incisional hernias after previous mesh repair is highest – 16.1% (n=44) (Table 7).

Table 7. *Distribution of recurrent incisional hernias depending on the type of previous repair*

Type of previous plastic surgery		**Recurrence**		**Total**
		No	Yes	
Facial adaptation	Number N	0	26	26
	Percentage	0	9.50	9.50
With canvas	Number N	0	44	44
	Percentage	0	16.10	16.10
Facial duplication + canvas	Number N	0	1	1

	Percentage	0	0.40	0.40
Facial adaptation +Vetrofil	Number N	0	3	3
	Percentage	0	1.10	1.10
Total	Number N	199	74	273
	Percentage	72.90	27.10	100

4.4.2. Correlation between perioperative indicators

- **Comparative analysis between the number of previous interventions and the age of patients -** r=0.120, p=0.048 – **a statistically significant, weak positive correlation** was established **between the number of previous operations and the age of patients** in the cohort – older patients had a higher number of previous surgical interventions (Table 8).

Table 8. *Relationship between the number of previous interventions and the age of patients*

	Number of previous operations	Years
Number of previous operations	Pearson Correlation	Pearson Correlation
	1	,120*
	Sig. (2-tailed)	Sig. (2-tailed)
		0.048
	N	N
	273	273
Years	Pearson Correlation	Pearson Correlation
	,120*	1
	Sig. (2-tailed)	Sig. (2-tailed)
	0.048	
	N	N
	273	27

- **Comparative analysis between the type of incision from the previous intervention and the age of the patients (by age groups)** - r=0.520, p=0.041 - there is **a statistically significant, significant positive correlation between the type of incision and the age of the patients by decades**.
- **Comparative analysis between the type of incision from the previous intervention and the time of occurrence of the incisional hernia** - r=0.491, p=0.039 - there is **a statistically significant, moderate positive correlation between the type of incision and the time of occurrence in months.**

- **Comparative analysis between the type of incision from the previous intervention and the gender of the patients - r=0.288, p=0.025 - statistically significant, weak positive correlation between the type of scar and the gender of the patients**
- **Comparative analysis between the gender of the patient and the width of the current defect**

  A non-parametric contingency coefficient is calculated given that the two variables (factor and result) between which a relationship is sought are categorical, located on a nominal scale. The calculated contingency coefficient of 0.112 indicates an **extremely weak positive relationship** between the two variables. The coefficient cannot be considered statistically reliable ($p=0.325>\alpha=0.05$), given that the calculated significance level /p/ is greater than the accepted risk of error of 5%.
- **A comparative analysis between the type of incision from the previous intervention and the need for drainage of the repair**- r=0.439, p=0.005 – we established **a statistically significant, moderate linear relationship between the type of incision and the usage of drainage after the repair.**
- **Comparative analysis between the size of the defect in cm² and the need of drainage -** since the two variables are located on different statistical measurement scales, a non-parametric correlation coefficient Eta is applied. In the hypothesis, we take "use of drainage" as the dependent variable, which proves that **it is significantly influenced by the defect area** r=0.628 (Table 9).
-

Table 9. *Dependence of antibiotic prophylaxis on the area of the defect*

Variable	Type	Eta
Defect area (cm²)	Dependent	0.2
Antibiotic prophylaxis	Dependent	0.59

- **Comparative analysis between the size of the defect and duration of antibiotic** prophylaxis - r=0.267, p=0.000—**a statistically significant, weak positive correlation** was established **between the size of the defect area and the duration of antibiotic prophylaxis in** days—at the discretion of the operating surgeon, longer antibiotic prophylaxis was performed for larger incisional hernias .

- **Comparative analysis between the type of incision from the previous operation and the need for thrombotic prophylaxis** - r=0.297, p=0.015 - there is **a statistically significant, weak positive correlation between the type of incision and NMH prophylaxis.**

4.4.3. Correlations between postoperative indicators

- **Comparative analysis between patient age and the number of recorded** complications - r=0.129, p=0.033 - there is **a statistically significant, weak positive correlation between the number of complications and age** - more adverse events were found in elderly patients.
- **Comparative analysis between the calculated anesthetic risk (ASA score) and the number of complications** - r=0.241, p=0.000 – there is **a statistically significant, weak positive correlation between the number of complications and** the ASA score – more complications were documented in patients with increased anaesthesiological risk.
- Comparative analysis between the number of complications and the duration of antibiotic prophylaxis - r=0.521, p=0.000 - **statistically significant, significant, positive correlation between the number of documented complications and the duration of antibiotic prophylaxis in days** (Fig. 50).

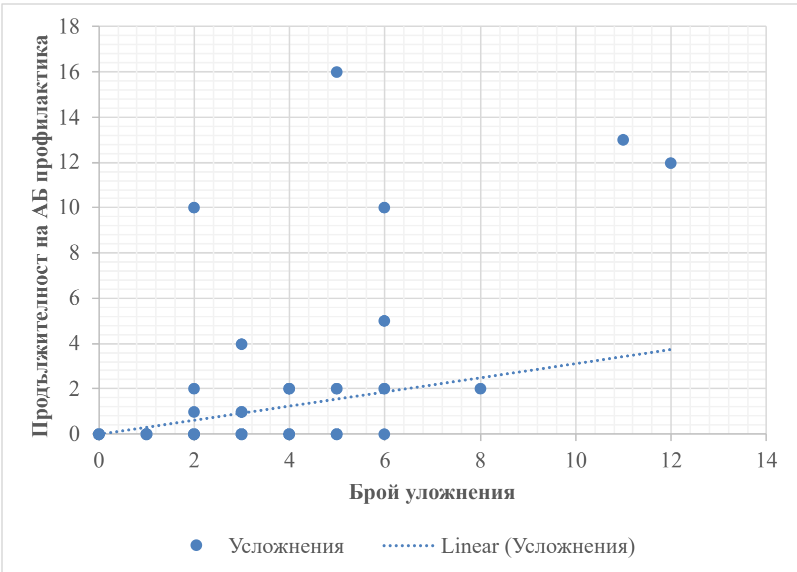

Figure 50 *- Dependence of the number of complications and the duration of AB prophylaxis in days*

- **A comparative analysis between the number of complications and the duration of hospital treatment** – r=0.505, p=0.000 – we established **a statistically significant, significant positive correlation between the number of recorded complications and the duration of the hospital treatment** (Fig. 51). As complications increase, the duration of the hospitalization is prolonged.

- **Comparative analysis between the duration of hospital treatment and the age of** the

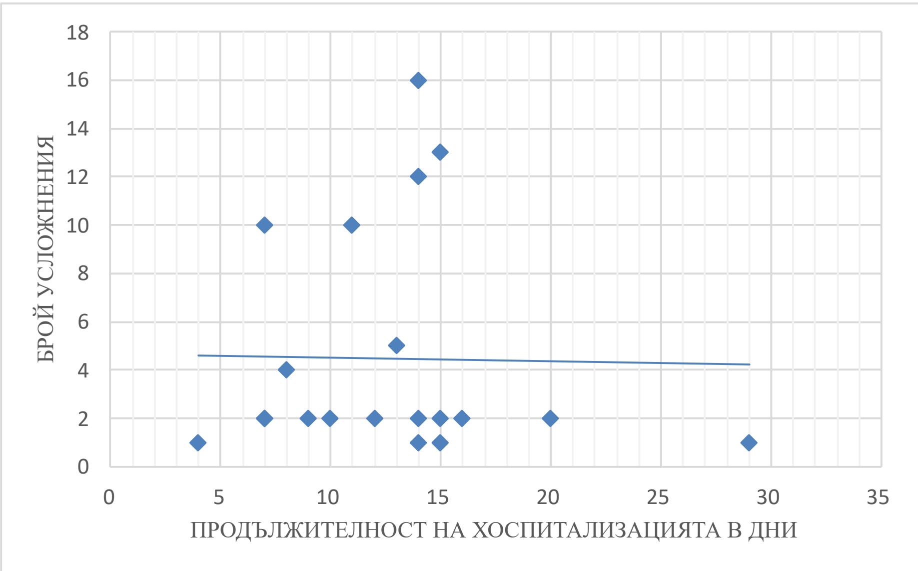

Figure 51 *- Relationship between the number of complications and the length of hospitalization*

patient - r=0.260, p=0.000 - **a statistically significant, weak positive correlation** was found **between the number of the days hospital treatment and the age of the patients** - older patients spent more days in hospital during their hospitalization.

- **Comparative analysis between the duration of hospital treatment and the order of the current surgical treatment** (elective, emergency) – the number of days spent in hospital during treatment **does not depend** on whether the reconstructive surgery was performed on an emergency basis – r-0.22.

- **A comparative analysis between the defect area in cm² and the number of** days **spent** in **hospital** using Brave's correlation coefficient showed **a statistically significant weak linear relationship** r=0.222; p=0.000<α=0.05 (Fig. 52)**.**

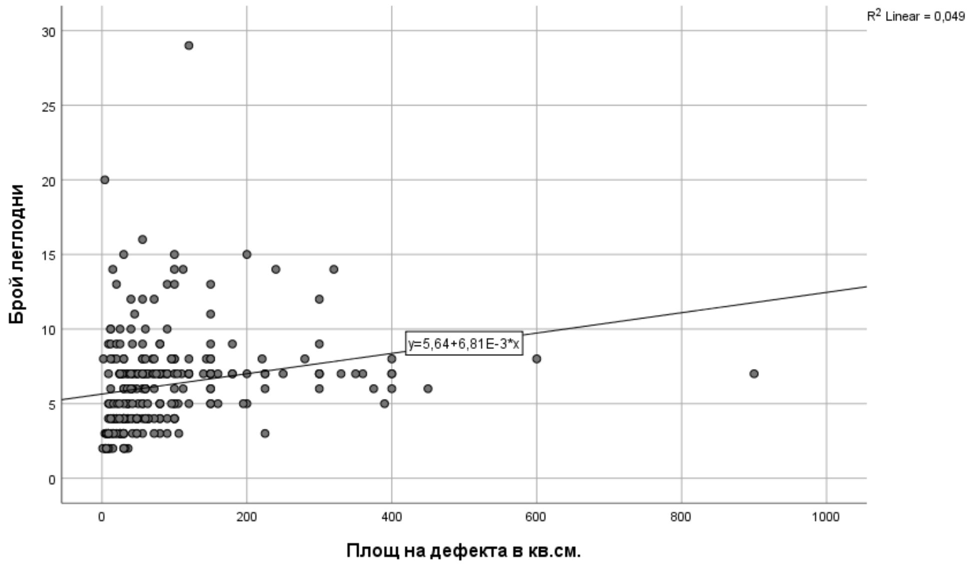

Figure 52 *- Dependence of the number of bed days on the defect area*

- **Comparative analysis between the type of current repair and the length of hospital treatment**– r= 0.428 - there is **a moderate linear correlation between the type of current reconstructive technique and the number of bed days**. In our series, the longest hospitalization was in patients who underwent component separation in its various forms.
- **Comparative analysis between the duration of the hospital treatment and the days on which** the drains **were removed** - r=0.164; p=0.006; r=0.204; p=0.001**—statistically significant, weak direct correlations** were established **between the number of hospital days and the days on which the first and second Redon drains were removed, respectively** (Fig. 53)**.**

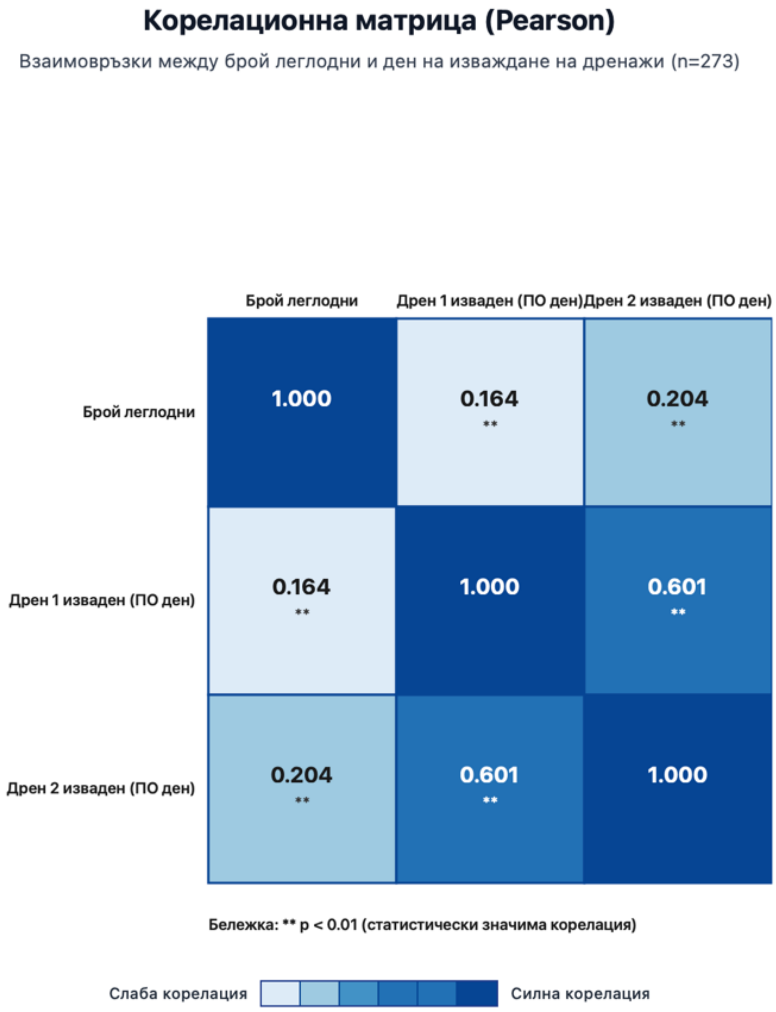

Figure 53 *- Relationship between bed days and the days on which the Redon drains were removed*

4.4.4. Correlation between economic indicators and other variables

- **Comparative analysis between the value of direct/total costs and the gender of patients** - using the non-parametric Eta coefficient, **no relationship was found between costs and gender** in the cohort studied, as the relationships are extremely weak.

- **Comparative analysis between the value of costs and the age of patients** – r=0.265; p=0.000 – there is **a statistically significant, weak positive correlation between the age of patients and the cost of direct expenses**. The higher costs of hospital treatment in the older age groups are mainly related to the higher proportion of comorbidities that require perioperative control and may exacerbate during hospitalization, as well as the higher percentage of complications documented in these patients.

- **Comparative analysis between the value of direct/total costs and anesthesiological risk** – confirming the already stated finding that a greater number of serious accompanying pathologies affects the costs generated during hospitalization, the following dependencies were also found:
  - ⇒ **Statistically significant, moderate positive correlation between "ASA" and "direct costs" – r=0.327; p=0.000**
  - ⇒ **A statistically significant, weak positive correlation between "ASA" and "total costs" – r=0.215; p=0.000**

- **Comparative analysis between the value of direct/total costs and the area of the defect in square centimeters** – a correlation was found between the costs incurred both during and after hospitalization and the size of the hernia in relation to factors such as: higher cost of medical devices and consumables used, need for longer drug prophylaxis, longer hospital stay, and need for more comprehensive medical care to prevent adverse events, longer recovery period, and temporary disability.
  - ⇒ **Statistically significant, weak positive correlation between "defect area" and "direct costs" – r=0.284; p=0.000**
  - ⇒ **Statistically significant, weak positive correlation between "defect area" and "total costs" – r=0.236; p=0.000** (Fig. 54)

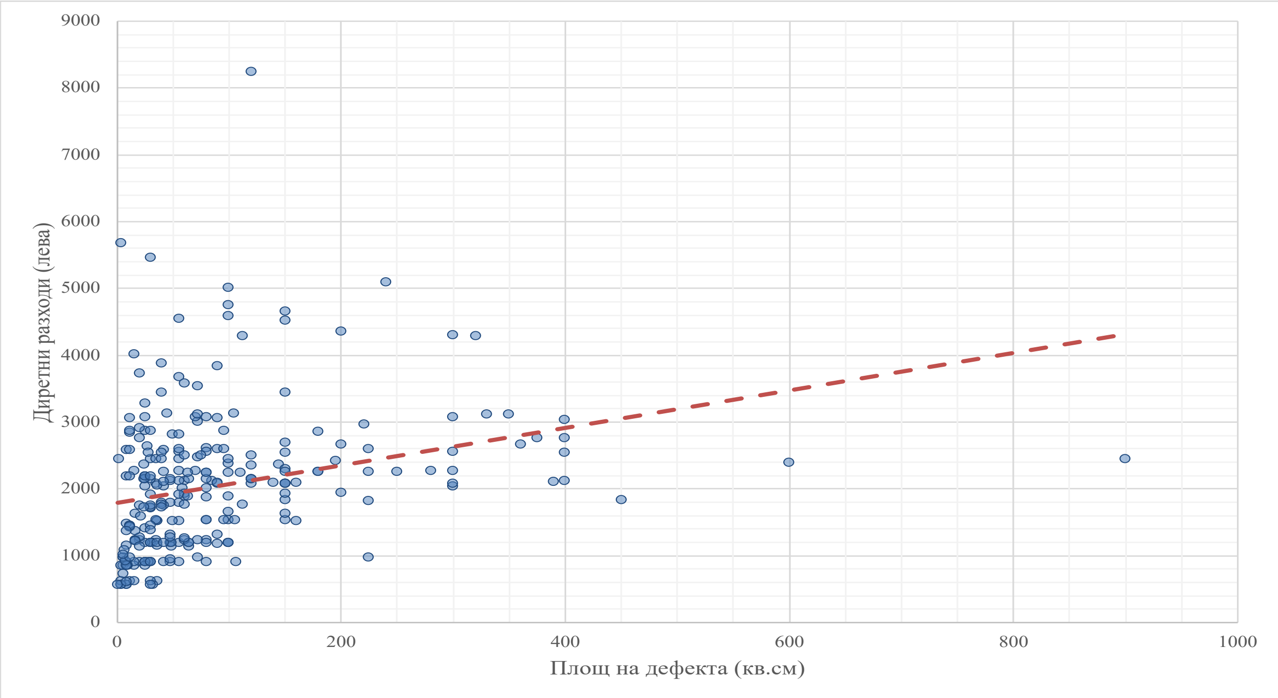

Figure 54 *- Correlation between defect area and direct costs*

- Comparative analysis between the value of direct/total costs and the duration of antibiotic prophylaxis – the need for longer antibiotic prophylaxis significantly increases costs not only during hospital stay but also after it (possible additional costs related to events caused by oral, vaginal, or intestinal dysbiosis):
  - ⇒ **Statistically significant, strong positive correlation between "duration of antibiotic therapy in days" and "direct costs" – r=0.760; p=0.000**
  - ⇒ **Statistically significant, strong positive correlation between "duration of antibiotic therapy in days" and "total costs" – r=0.684; p=0.000** (Fig. 55)

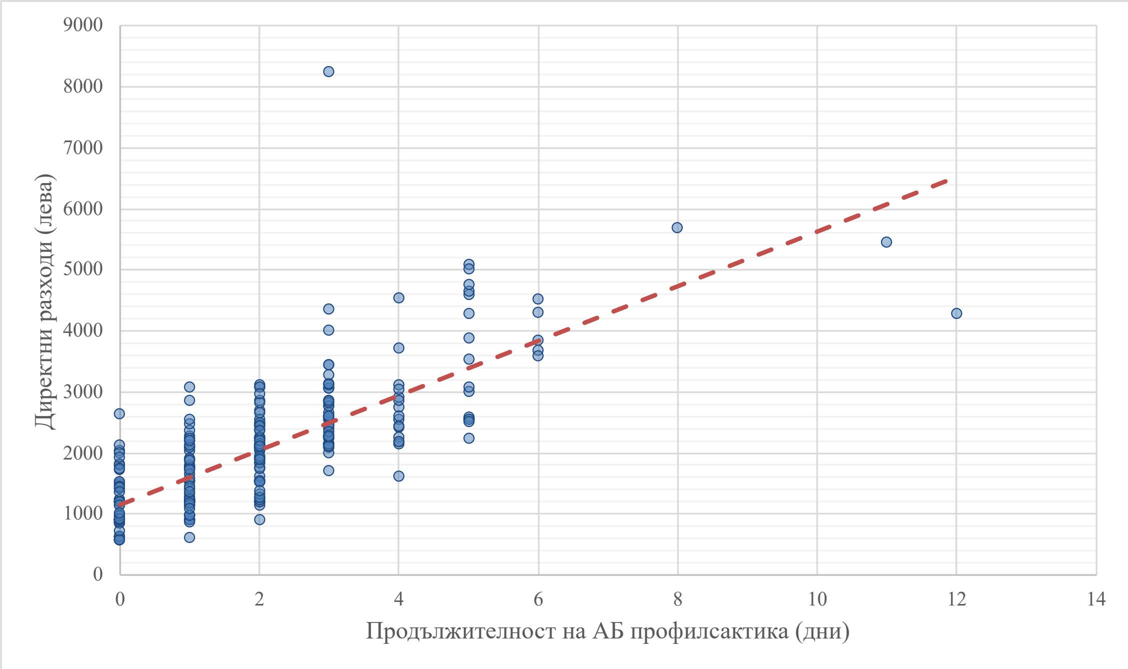

Figure 55 *- Correlation between duration of AB prophylaxis and direct costs*

- Comparative analysis between the value of direct/total costs and the duration of antithrombotic prophylaxis:
  - ⇒ Statistically significant, significant positive correlation between "NMH time" and "direct costs" – r=0.652; p=0.000
  - ⇒ Statistically significant, significant positive correlation between "NMH time" and "total costs" – r=0.561; p=0.000

  Antithrombotic prophylaxis with LMWH for a longer period of time increases hospital treatment costs and total costs.

- **Comparative analysis between the value of direct/total costs and the number of complications**:
  - ⇒ **Statistically significant, moderate positive correlation between "number of complications" and "direct costs" r=0.489, p=0.000**
  - ⇒ **Statistically significant, moderate positive correlation between "number of complications" and "total costs" r=0.440, p=0.000**

  With the increase in documented adverse events, an increase in the cost price was also found**.**

- A comparative analysis between the value of direct/total costs and the length of hospital stay– after running models based on Brave's parametric coefficient – revealed the following:

⇒ **statistically significant, very strong positive correlation between "duration of hospital treatment" and "direct costs" r=0.954, p=0.000**

⇒ **statistically significant, very strong positive correlation between "" duration of hospital treatment and "total costs" r=0.880, p=0.000** (Table 10)

Table 10. *Relationship between length of hospital stay and cost*

	Number of days hospital treatment	**Direct costs**	**Total costs**
Duration of hospital treatment	Pearson Correlation	Pearson Correlation	Pearson Correlation
	1	0.954	0.880
	Sig. (2-tailed)	Sig. (2-tailed)	Sig. (2-tailed)
	0	0	0
	N	N	N
	273	273	273

***. Correlation is significant at the 0.01 level (2-tailed).*

4.5. Regression analysis

A regression analysis was performed on the 273 patients studied, with direct costs selected as **the dependent variable (**or outcome variable) in the current model, while **the following** were selected as **independent (factor) variables**:

- Length of hospital stay (number of bed days)
- Duration of antibiotic therapy in days
- Area of the hernial defect in cm^2.

Table 11 presents the descriptive characteristics of the indicators included in the model, namely their mean values and variations for the respective number of patients in the cohort.

Table 11. *Descriptive characteristics of the variables in the regression analysis*

	Mean	Standard deviation	Number of patients
Direct costs	2041.2 7	1043.91952	273
Length of hospital stay in days	6.24	3.25	27
Duration of antibiotic prophylaxis in days	1.97	1.77	27
Area of the hernial defect in cm²	87.25	106.092	273

On average, the patients in the study stayed in the hospital for about 6 days, with an average antibiotic therapy duration of 2 days and an average defect area of 87.25 cm².

A summary of the regression model is presented graphically in Table 12.

Table 12. *Summary of the regression model*

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.963[a]	0.927	0.926	283.67045

a. Predictors: (Constant), Area of defect in cm², Number of bed days, Duration of antibiotic prophylaxis in days

- **Multiple correlation coefficient - R=0.963** - demonstrates an extremely strong positive correlation between the factor variables in the model and the outcome variable.
- **Coefficient of determination R Square** – obtained by raising the correlation coefficient R to the second power and showing what percentage of the dependent variable is determined by the independent variables in the model – in this case, 92.7% of the value of direct costs depends on the listed independent (factor) variables. **The coefficient of indeterminacy** is calculated additionally by subtracting the coefficient of determination from 100% and shows what percentage of the change in the outcome depends on other factors not included in the model – in this case, 100% - 92.4% = 7.3% of the change in direct costs depends on other factors.

The ANOVA table (Table 13) includes summary characteristics for the sources of variation in the dependent variable, including the F-ratio, which is one of the options when selecting a hypothesis for the adequacy of the regression model.

The hypothesis for the adequacy of the regression model is tested in the following algorithm:

1. The null and alternative hypotheses are defined. The null hypothesis H_0 states that the variation in the dependent variable (the outcome variable) is not caused by the independent variables (factors), i.e., the regression model is not adequate. The alternative hypothesis (H_1) states that the variation in the dependent variable is caused by the independent variables included in the model, i.e., the linear regression model is adequate.
2. A significance level of α=0.05 or a 5% risk of error is accepted.
3. The empirical characteristic F emp. is compared with the tabulated characteristic (from a specialized table) F theor. If it is found that the empirical characteristic is greater than the tabulated one, the null hypothesis is rejected and the alternative is accepted, or it is assumed that the regression model is adequate and the variation in the dependent variable is explained by the independent variables.
4. A decision on whether the model is adequate can be made not only by the comparison described in point 3, but also by the so-called significance threshold (Sig). In this case, the accepted significance level (α=0.05) is compared with the calculated significance level (α=0.00). If it is found that the accepted level of significance is greater than the threshold level of significance (Sig), then the alternative hypothesis that the model is adequate is accepted. In this specific example, Sig=0.00<α=0.05 – therefore, the model is adequate.

Table 13. *ANOVA Summary characteristics for the sources of variation in the dependent variable*

Model	Sum of squares	df	Mean Square	F	Sig.
Regression	274770748.054	3	91590249.351	1138.206	0[b]
Residual	21646140.253	269	80468.923		
Total	296,416,888.308	27			

a. Dependent Variable: Direct costs

b. Predictors: (Constant): Area of defect in cm², Number of bed days, Duration of antibiotic prophylaxis in days

Table 14 presents the regression coefficients, their standard errors, t characteristics, and significance levels (Sig).

Table 14. *Coefficients*

Coefficientsa							
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Bound	Upper Bound
(Constant)	146,772	38,536		3,809	0	70,901	222,643
Number of bed days	267,086	7,526	0.832	35,488	0	252,269	281,903
Duration of antibiotic prophylaxis in days	90,147	13,968	0	6,454	0	62,646	117,648
Defect area in cm²	0.578	0.168	0.059	3.431	0.001	0.246	0.909

a. Dependent Variable: Direct Costs

It is mandatory to perform reliability checks on the individual regression coefficients separately for each in the following algorithm:

1. The null hypothesis is defined as stating that the estimated regression coefficient is statistically insignificant, and the alternative hypothesis states that the regression coefficient is statistically significant.
2. A significance level of $\alpha=0.05$ is accepted.
3. The statistical significance of the individual regression coefficient is tested by comparing the accepted benchmark significance level $\alpha=0.05$ with the threshold significance level for each coefficient (Sig).
4. A decision is made for each regression coefficient based on the following rule: if $Sig=0.00<\alpha=0.05$, then the regression coefficient is statistically significant.

In this specific regression model, we can accept the following independent variables as statistically significant: number of bed days ($Sig=0.000<\alpha=0.05$), duration of antibiotic therapy in days ($Sig=0.000<\alpha=0.05$); area of the defect ($Sig=0.001<\alpha=0.05$).

The multivariate linear regression model has the following form:

$$ДР = 268{,}335 \times ЛД + 97{,}734 \times АБ + 0{,}578 \times ПД$$

Equation1 - Multifactorial linear regression model

Where:

- DC – Direct costs in BGN
- LD – Number of bed days

- AT – Duration of antibiotic therapy in days
- DE – Defect area in cm^2

Based on the estimated multifactorial linear regression model, the following conclusions can be drawn:

1. **Each additional increase in the lenght of hospital stay with one day leads to an increase in direct costs by BGN 268.34.**
2. **Each additional increase in the duration of antibiotic therapy by one day leads to an increase in direct costs of BGN 97.74.**
3. **Each additional increase in the defect area by 1 cm^2 leads to an increase in direct costs by BGN 0.578.**

V. Discussion

Incisional hernias are a common late complication of conventional abdominal surgery, which, despite continuous progress in the field, remains a costly, multidisciplinary surgical challenge, associated with high morbidity and impaired quality of life.

Over a 20-year period (2001-2021) in Australia, according to AIHW (Australian Institute of Health and Welfare) data, 175,369 operations were performed for incisional hernias, accounting for 21.6% of all interventions for anterior abdominal wall hernias [139]. The prevalence in Europe is many times higher, with a comparable number of cases reported in Italy in just a 5-year period (2015-2020) – 154,546 [55]. Statistics show even more worrying trends in Germany – over 700,000 laparotomies are performed annually, which, with an average incidence of incisional hernias of 9-20%, leads to the development of 140,000 new cases each year [100,356]. The United States remains unmatched in terms of the absolute annual number of reconstructive operations on the anterior abdominal wall for incisional hernias, with 350,000 interventions per year, leading to an accumulation of over $3.2 billion in healthcare costs for the same period [58,323]. From everything said so far, we can conclude that although long known, the problem of incisional hernias is far from being solved at this stage.

The answer to the question regarding the frequency of incisional hernias remains ambiguous. While most authors agree on an average frequency of 2-20%, various studies report extreme values ranging from 0 to 91%, depending on the type of the initial surgery performed that led to a hernia formation. [67,117,248]. In his review of 11 studies of incisional hernias involving more than 50 patients and mandatory follow-up of more than 6 months, Le Huu Nho concludes that the overall incidence of incisional hernias is 11.3% [231] (Table 43). In a retrospective cohort study, Rhemtulla et al. followed patients from five US states (Florida (FL), Iowa (IA), Nebraska (NE), New York (NY), Utah (UT)). These patients underwent surgery in six different surgical specialties—colorectal surgery, general/bariatric surgery, hepatobiliary surgery, obstetrics and gynecology, urology, and vascular surgery using conventional methods. The primary objective of the study was to determine the incidence of primary and recurrent incisional hernias . After an average follow-up period of 4.3 years, 3.1% (n=16,169) of 529,108 patients who underwent initial laparotomy developed incisional hernias requiring surgical repair, 20% (n=3,176) of these patients required repeat reconstruction, and

23% (n=723) underwent a third plastic surgery on the anterior abdominal wall due to an incisional hernia [324].

Table 15. *Frequency of incisional hernias according to various studies [309]*

Authors	Year	Type of study	Initial surgery	Follow-up (months)	Number of patients	Frequency of incisional hernias
Gomez et. al [146]	2002	Retrospective	Liver transplantation	42	465	11.6% (n=54)
Piazzese et al. [309]	2004	retrospective	Liver transplantation	29	623	4.9% (n=31)
Sorensen et al. [363]	2005	Cohort	GIT	45	310	26% (n=81)
Burger et al. [66]	2005	retrospective	GIT	12	53	47.1% (n=25)
Vardanian et al. [391]	2006	retrospective	Liver transplantation	-	959	4.6% (n=44)
Heisterkamp et al. [160]	2008	Cohort prospective	Liver transplantation	38	118	15% (n=18)
Engledow et al. [114]	2008	Cohort prospective	GIT	25	80	7.5% (n=6)
Veljkovic et al. [393]	2010	Cohort prospective	GIT	6	603	13.4% (n=81)
Gastaca et al. [130]	2010	retrospective	liver transplantation	-	626	1.7% (n=11)
Moussavian et al. [270]	2010	retrospective	Secondary peritonitis	72	92	54.3% (n=50)
Al-Azzawi et al. [15]	2010	Retrospective	Acute pancreatitis	29	149	42% (n=63)
Total					4078	11.3

Similar observations to those cited in the study have been made by a number of other authors, who conclude that up to two-thirds of patients with incisional hernias enter the self-perpetuating cycle familiar to every surgeon, which leads to a fourfold increase in treatment costs [65,120,171,247] :

Figure 56 - Cycle of evolution of incisional hernias

With each subsequent unsuccessful reconstruction of the anterior abdominal wall, i.e., after each subsequent complete cycle of hernia—the associated morbidity—hernia, complications, and costs increase exponentially [397]. The pronounced cyclical nature of the development of incisional hernias emphasizes the chronic nature of the disease and its role as a growing epidemiological challenge. Even when the prosthesis is implanted in the most optimal position—retrorectal— with or without combining it with new techniques to overcome extreme loss of anterior abdominal wall tissue, such as various types of component separations, the reported incidence of incisional hernias in various studies remains within the range of 1-5% [49,284]. This fact leads to the conclusion that the best strategy for reducing the incidence of incisional hernias and, respectively, reducing the costs associated with them, is to identify the risk factors for their initial development and interrupt the cycle before the patient enters it. The concept of disease prevention is not new; on the contrary, the development and implementation of preventive strategies targeting specific groups of at-risk patients (based on specific modifiable risk factors) have been reported to have good results in other conditions such as myocardial infarction [351], diabetes mellitus [209], and breast cancer [261]. It is essential in this case to identify precisely those risk factors whose modification would have the most beneficial effect for the patient—in this case, it would greatly reduce the incidence of incisional hernias .

Regarding the risk factors associated with the initial surgical intervention, in the guidelines for the treatment of midline incisional hernias published by the EHS (European Hernia Society) at the end of 2023 [341], the society recommends the use of midline laparotomy as a surgical approach with caution, as it carries an increased risk of developing incisional hernias.

The first step in planning any surgical intervention, with a view to achieving the most favorable outcome, is to select the type and location of surgical access. The characteristics of a well-chosen incision are: relatively quick technical execution, ensuring the best exposure of the intra-abdominal contents while maintaining good visibility of the organs of interest throughout the entire intervention, easily expandable if necessary, it has few postoperative complications, it ensures the greatest strength of the abdominal wall in the postoperative period (fewer dehiscences of the surgical wound, eviscerations, and incisional hernias), and it has a satisfactory cosmetic result for the patient [150]. Median laparotomy meets many of these conditions, as it is easy and quick to perform, with minimal blood loss due to the avascular nature of the linea alba, and good visibility of the abdominal organs is achieved within minutes. It is particularly preferred in emergency and exploratory surgery, where maximum exposure of the entire contents of the abdominal cavity is achieved extremely quickly. These facts explain the continued widespread use of midline laparotomy as the preferred surgical approach, despite the surprisingly high incidence of incisional hernias after it [167,169,235,271,372]. The reported high recurrence rates after reconstructive surgery for incisional hernias further emphasize that, in addition to the above-mentioned characteristics, the choice of a specific approach should also be based on reducing the incidence of incisional hernias . When deciding which type of surgical incision would be more appropriate in this regard, certain anatomical, physiological, and dynamic characteristics of the anterior abdominal wall must be taken into account.

The fascial fibers of the anterior abdominal wall are arranged transversely. When using a midline laparotomy, these fibers are separated and, when the surgical wound is closed, the suture material is placed between the fibers. Contraction of the abdominal wall causes lateral tension along the suture line, which can lead to cutting of the suture material by separating the transversely oriented fibers. In transversely oriented incisions, the fascial tissue is incised along the fibers so that when the surgical wound is closed, the suture material is placed around the fascial fibers . When the abdominal wall contracts, the fibers do not separate but come closer together, and the suture material causes minimal lateral tension [322,342]. The advantage of transverse incisions in reducing the formation of incisional hernias is also confirmed by the results of testing on cadaver tissue, which show that the average force required to break the sutures placed 5 mm. from the cut edges of the anterior sheath of the rectus muscles is 0.93 kg when the separation is in the vertical direction (median incisions), compared to 1.78 kg when it is in the transverse direction [152]. Similarly, animal experiments show that transverse incisions are more resistant to tearing than longitudinal incisions during the first 28 days of wound healing [282].

The anatomical and physiological characteristics described above and the experimental observations are supported by a number of studies that favor transverse incisions as more optimal than midline incisions in terms of the formation of incisional hernias . Fassiadis (2005) reported the results of a prospective randomized study of 69 patients who underwent abdominal aortic aneurysm (AAA) repair with a mean follow-up period of 4.4 years (midline laparotomy -n=37, transverse laparotomy - n=32). Of the patients available for analysis at the end of the observation period, 40% of those with a transverse incision and 91% of those with a median laparotomy had an incisional hernia [117]. The high incidence of incisional hernias even in the transverse incision group is not surprising and should be considered in the context of the overall average incidence of the condition after AAA surgery, which is similar – 35% [32,173,190,244]. After multivariate logistic regression analysis, the author proves that in the studied series, only the type of surgical incision is a statistically significant risk factor affecting the incidence of incisional hernias (p=0.010) [117]. Similar results were obtained in a prospective randomized study by Halm et al. (2009) of patients who underwent conventional cholecystectomy, in whom, after a 1-year follow-up period, 2% (n=1/60) of patients with transverse laparotomy versus 14% (n=9/63) with median laparotomy presented with an incisional hernia (95% confidence interval, p=0.017) [154]. Lee et al. (2018), in a one-year follow-up of 165 patients with laparoscopic colectomy and randomization according to the type of access for specimen extraction (transverse incision n = 79 and midline incision n = 86), reported a more frequent development of incisional hernias in the area of the midline incision scar - 15% versus 2% (P = . 0.013) [233]. Similar conclusions were reached in the study by De Souza et al. (2011), in which the authors reported the occurrence of incisional hernias in 16% of patients after midline laparotomy versus 0% in the group with Pfannenstiel incision (p < 0.001) [96]. In contrast to these studies, Seiler et al. reported in 2009 the results of the POVATI study, which included a total of 200 patients (midline laparotomy n=101, transverse incision n=99) who underwent conventional high-volume abdominal surgery and found no significant difference in the incidence of incisional hernias depending on the type of surgical access (transverse incision – 11.5%, midline incision – 16.4%) [348]. Greenwall et al. (1980) also reached the same conclusion. After a 6-month follow-up period of 579 patients who underwent various types of abdominal surgery, they reported a similar incidence of incisional hernias (6.4% in the transverse laparotomy group and 7.3% in the midline laparotomy group) [152]. Two other studies also found no difference in the incidence of incisional hernias when comparing transverse and midline incisions, but in general, incisional hernia was not presented as a late complication in any of the patients studied – Inaba et al. (2004) [178] and Salonia (2005) [337].

Based on these seemingly contradictory studies, one indisputable conclusion can be drawn: in none of these randomized studies did midline laparotomy prove superior to transverse incisions in terms of preventing incisional hernias . The results from our series of patients are consistent with this finding – the predominant location of incisional hernias was in the midline incision area in 77.9% of cases (midline laparotomy n=199, transverse incision around the navel n=19), while **the frequency of occurrence in the transverse/oblique incision area** (including combined laparotomies that also have a midline component) **was observed 4 times less frequently.** The main reason for this uneven distribution according to the type of surgical access is due to the continuing predominant use of midline laparotomies in conventional abdominal interventions in the Bulgarian surgical community, despite the recommendations set out in the BHS consensus statement, which serves as a guideline, adopted at the 16th National Congress of Surgery in 2018 [6]. A contributing factor could also be the finding by Singh et al., who, when comparing midline and transverse incisions, suggests that thethe lower incidence of incisional hernias in the cicatrix area outside the midline is due to the fact that two separate fascial layers are restored during closure, as well as a muscle layer that further protects the wound [357].

In the cohort of 273 patients we studied, a total of 422 previous interventions were reported, performed both at the medical facility where the study was conducted and at other university, municipal, and private medical facilities. The highest incidence of incisional hernias was recorded after oncological surgeries—17.8% (n=75), gynecological surgeries – 14.7% (n=62), appendectomies – 8.5% (n=36), upper GI tract surgeries – 7.8% (n=33), and biliary surgery – 7.3% (n=31). Our results differ significantly from those presented by other authors. For example, a study by Biswas (1973) reports a much lower incidence of incisional hernias after gynecological interventions – only 3% [48]. A much more recent study by Aabakke (2014) describing a cohort of all caesarean deliveries performed in Denmark over a 10-year period reports an even lower cumulative incidence of incisional hernias – 0.197% or 2 per 1000 deliveries [10]. A retrospective study by Smith et al. (2024) covering 297,134 patients operated on over a 3-year period in England after a mean follow-up period of 6.5 years reports the incidence of incisional hernias by subspecialty as follows: colorectal interventions - 10.0%, hepatobiliary - 8.2%, transplants - 6.8%, urological operations - 4.0%, bariatric - 3.5%, vascular - 3.2%, and gynecological surgery - 2.6% [360]. Although our study found similar frequencies after colorectal and biliary surgery, in our group after gynecological surgery, the recorded frequency was almost 7 times higher. Since none of the studies available in the literature found even an approximate frequency of incisional hernias after gynecological surgery, the only logical reason can be found in surgery-related factors in the units where these initial operations were performed.

A large retrospective longitudinal study by Basta et al. from 2019 [38], covering 29,739 patients with general surgical, urological, and gynecological interventions and a follow-up period of 57.9 months, reports the highest incidence of incisional hernias after colorectal (7.7%), vascular (5.2%), bariatric (4.8%), and transplant surgery (4.5%). The results of our series overlap with those of Basta et al. in terms of the percentage of incisional hernias after colorectal surgery (6.9%), but this is not the most common type of initial intervention in our study. Similar to our results regarding the frequency of incisional hernias after conventional colorectal interventions, Ihedioha (2008) reported a frequency of 10% after a 22-month follow-up period [176]. An additional difference between our study and that of Basta et al. is in the occurrence of incisional hernias after vascular surgery—in our study, the total number of all previous vascular interventions was only 1.2%, even though the university center where the study was conducted has a vascular clinic with a long history. A more than fourfold difference in frequency could most likely be explained by the different volume and profile of surgical activity in these vascular centers.

A study by Andersen et al. (2008), which followed 143 patients for an average of 4.9 years after open sigmoid resections, reported a frequency twice as high as that in our series—14.7% [24]. Adel-Carceller et al. (2006) reached approximately the same frequency of 14.5% when observing 295 patients for 37.5 months after colorectal resections for colon cancer [14]. It is noteworthy that the results of these two studies are closer to the 17.8% incidence of incisional hernias after oncological interventions recorded by us, a fact that is related to the general surgical profile of the clinic where the study was conducted. Undoubtedly, a significant proportion of oncological operations were performed for colon neoplasms, but these patients were not included in the group of lower GI tract operations due to the specifics arising from the accompanying oncological disease. In summary of the above studies, it can be concluded that patients with initial lower GI tract surgery, especially for malignant neoplasms, are at higher risk of developing incisional hernias and should be considered for prophylactic anterior abdominal wall reconstruction. This conclusion is also confirmed by the national retrospective study by Ortega-Deballon et al. (2023), in which a cohort of 710,074 patients who underwent conventional abdominal surgery in France over a year after a follow-up of 4.6 years, a 48.6% (n=15,876) incidence of incisional hernias was found in the group of patients with colorectal surgery [290].

In our study, increased bleeding during the initial operation was reported in 22.3% (n=61) of patients with primary postoperative hernia. After univariate and multivariate regression analysis of 329 patients who underwent infrarenal aortic reconstruction, Lord et al. [244] demonstrated that intraoperative blood loss exceeding 1000 ml is a risk factor for the formation of incisional hernias, with the risk increasing by a factor of 3.07. In a recent meta-analysis by Mahajan et al. (2024), including 10 studies with a total of 1,806 patients who underwent conventional AAA reconstruction, the author also points to increased blood loss as a factor influencing the increased incidence of incisional hernias in this type of patient (Mean Differences 429.8 ml, CI [234.8-624.8], $P < 0.01$) [251]. Other studies, such as those by Fassiadis (2005) (p=0.663) [117], Iida (2021) (p=0.779) [177], and Endo (2023) (p=0.137) [113] did not find increased blood loss to be a statistically significant risk factor. In our series of patients, we did not report increased blood loss as an independent risk factor for the occurrence of incisional hernias , which is not surprising because all studies available in the literature that indicate it as such examine patients after AAA reconstructions, and in our cohort, the percentage of patients with incisional hernias after vascular reconstructions is extremely low. In addition, the data on intraoperative bleeding during the initial surgery of another type are in most cases well below the 1000 ml indicated by Lord. Therefore, we reported a weak statistically significant association between increased bleeding during the previous intervention and recurrence (p=0.000).

The development of an inflammatory process in the area of the surgical wound undoubtedly worsens and prolongs the process of restoring the integrity of the abdominal wall in the area of the incision. Short-term complications associated with surgical site infections (SSIs) reported in the literature include: increased risk of mortality, reduced health-related quality of life, increased length of hospital stay, and increased hospital costs [59,102,183,375].

Many authors point to the different degrees of SSI as an independent risk factor for the development of postoperative hernia. After multivariate analysis of 208 patients who underwent conventional and laparoscopic colon resection, Llaguna et al. (2010) [241] demonstrated that surgical wound infection is a statistically significant independent factor for the development of incisional hernia (p= 0.027). Sadava et al. (2014) [335] reached the same conclusion in a retrospective analysis of 1051 patients who underwent laparoscopic colon resection with a mean follow-up period of 54 months ($p<0.01$ OR: 6.5 (3.4–12.5)). Similar results were obtained in a retrospective cohort study by Benlice et al. in 2016 [44] with a mean follow-up period of 5.9± 3 years in 2148 patients after laparoscopic colon surgery. In their analysis of independent risk factors for postoperative hernia in the extraction area, the authors confirm the role of superficial surgical wound infections as such (HR = 2.11; $p < 0.001$). A logistic regression model in the study by Murray et al. (2011), involving 443 patients with transabdominal colon resection and a 12-month follow-up period, also demonstrates the association of SSIs with the development of incisional hernias (OR= 2.23, p=0.003; CI 95% 1.3–3.8). In the study, the authors report that patients after colorectal surgery and existing superficial infection of the surgical wound have a twofold higher risk of developing postoperative hernia, and those with organ infection or deep space infection have a fourfold increase in the likelihood of hernia formation [273].

In our series, we found reliable data for surgical wound infection after the initial surgery in 24.2% (n=66) and in 9.9% (n=27) after the previous plastic surgery in recurrent cases. When examining the correlations, a weak positive correlation was found between the processes of incision infection after the previous surgery and recurrence, without this being confirmed as a statistically significant risk factor ($r=0.031$, $p=0.607 > \alpha = 0.05$). Our results are similar to those obtained by Morita et al. (2015), who, in observing 186 patients after laparoscopic anterior resection of the rectum, did not confirm surgical wound infection as a statistically significant risk factor ($p=0.35$) [269]. Pares et al. (2016) [295], studying 292 patients with laparoscopic right hemicolectomy, also found no statistical difference in SSI rates in patients with or without incisional hernia formation, i.e., this is not a risk factor for hernia formation. Similar results were obtained in a study by Samia et al. (2013) [338], which included 480 patients who had laparoscopic large bowel surgery and were followed up for 3.5 years. Using the Fischer test, they didn't find a statistically significant link between surgical wound infection and herniation ($p=0.235$). In contrast to our results regarding the correlation between recurrence and surgical wound infections are those reported by Juvany et al. (2018) from the follow-up of 101 patients with elective plastic surgery for incisional hernias [196]. The authors demonstrate the statistical significance of SSIs as a risk factor for the development of incisional hernia recurrence after a one-year follow-up period ($p=0.047$).

The development of surgical wound infection is a surgical complication that leads to prolonged and costly treatment, which in most cases includes daily local surgical treatment, the use of antibiotics, and in some cases the need for negative pressure wound therapy or removal of the prosthesis [47]. Although not all studies identify it as a statistically significant risk factor for the occurrence or recurrence of incisional hernias , it continues to pose a significant challenge in the surgical treatment of incisional hernias, and all preventive measures should be taken to limit it.

With a view to implementing preventive measures to minimize the incidence of postoperative infection of surgical wounds, those factors and conditions in patients that are modifiable and whose modification would have the greatest effect in reducing SSIsand, respectively, incisional hernias. Obesity plays a central role in this group of factors, which, according to the World Health Organization classification, is divided into: pre-obesity (overweight) -$25 \leq BMI < 30$, obesity class I - $30 \leq BMI < 35$, obesity class II -$35 \leq BMI < 40$, and obesity class III -$BMI \geq 40$ [51]. The proven link between obesity and serious medical conditions such as diabetes mellitus, hypertension, and even cancer [308] makes it a major global public health threat. International statistics show an increase in the proportion of overweight adults between 1980 and 2013 - from 29.8% to 38.0% for women and from 28.8% to 36.9% for men [280]. According to Eurostat data for 2022, the proportion of the population in Bulgaria aged over 16 who are overweight is 52.9%. The global obesity epidemic, which is also severely affecting our country, is becoming increasingly important in surgery. The constantly increasing incidence of diseases caused by overweight and requiring surgical intervention leads to an increase in the number of obese patients undergoing surgical treatment with the resulting specific risks [157].

The mechanism by which obesity affects the incidence of wound infections and the formation of incisional hernias is not fully understood, with a multifactorial genesis being suggested [116]. One possible explanation is related to reduced tissue oxygenation of the subcutaneous adipose tissue in obese patients [198], as limited perfusion in the area of the surgical incision leads to a deterioration in the normal wound healing process with the potential for wound infection and incisional hernia. Another contributing factor may be increased local tissue trauma caused by retraction during surgery due to the increased volume of subcutaneous fat deposits. A third reason may be the prolongation of the surgical time, typical in obese patients, due to the inability to ensure good visualization of the surgical field and the increase in the time needed to restore the integrity of the abdominal wall in the incision area. The increased duration of the surgical intervention leads to an increased risk of wound infection, which, as previously stated, can lead to an increase in the incidence of incisional hernias [73]. The latest hypothesis on the correlation between obesity and the development of incisional hernias is based on Laplace's law. Increased abdominal circumference and intra-abdominal pressure due to excess weight [223,226] lead to increased distension of the abdominal wall, which is a predisposing factor for wound dehiscence and hernia formation. The metabolic activity of visceral adipose tissue (increased volume in obese patients), which is thought to alter normal immune function [122,297], may also play a complementary role.

In the series of patients we studied, the average reported BMI was 29.57 with a standard deviation of 6.017, which shows that the majority of the patient cohort was overweight, as well as obese (grade I and II). Our results are consistent with those published in the literature by other authors. In the prospective study by Baker et al. (2024), based on data from the Danish Ventral Hernia Database for the period 2007-2022 and covering 13,722 patients who underwent anterior abdominal wall repair for incisional hernia, the authors report a mean BMI of 27.8 (25.0-31.4) [34]. In the study by Gignoux et al. (2021) [138], based on the French national database - French Programme de Médicalisation des Systèmes d'Informations (PMSI), according to which 20,088 patients with incisional hernias were operated on between 2010 and 2015, the team reported similar results, finding obesity (BMI ≥ 30) in 31% of the population (n=8,732). In the same study, looking at 431,619 patients who had undergone laparotomy, the authors reported a relative risk of incisional hernia due to obesity of 2.06 (1.99–2.14) (CI 95%, p <0.0001). Other studies have published similar results. In a study by Navaratnam et al. (2015) on patients undergoing laparoscopic large bowel resection, high BMI was reported to be one of two independent factors for the development of incisional hernias (p < 0.02) [277]. A meta-analysis by Ne et al. (2017) summarises 20 studies from the period 2001-2015 and concludes that there is a significant correlation between high BMI in overweight patients and the incidence of wound infections (OR 1.56; 95% CI, 1.36–1.78; p < 0.001) and between high BMI and the incidence of incisional hernias (OR 6.59; 95% CI, 2.00–21.67; p < 0.001) [159]. These findings are confirmed by the study by Robinson et al. (2020) [327] covering a population of 736,726 individuals, which indicates that overweight or obese patients (BMI≥ 25 kg/m2) have an increased risk of developing postoperative hernia (OR 1.7–5.5, $p < 3.1 \times 10^{-20}$), and those with a BMI≥ 30 kg/m2 have an increased risk of developing SSIs (OR 1.2–2.3, p<2.5 x 10-5). The results of the cited studies differ dramatically from those obtained in our cohort of patients. In a comparative analysis of BMI and the number of recurrences in patients with recurrent incisional hernias , we found no correlation between the two indicators, i.e., obesity was not found to be a risk factor for herniation in our group of patients. A study by Giordano et al. (2017) [141] also indicates that increased BMI correlates with an increased incidence of wound infections, but not with recurrence after plastic surgery for incisional hernias. Our results are also similar to those in the retrospective cohort study by Aquina et al. (2015), which looked at 193 patients who had undergone colon resection for carcinoma and found no association between obesity (BMI≥ 30 kg/m2) and the development of incisional hernias [28]. A possible explanation for this similarity is the similarity in the patients covered in both studies – in our study, most of the patients had also undergone previous oncological surgery, and the frequency of initial lower GI tract surgeries was 6.9%. Another possible reason for the lack of correlation between elevated BMI and the development of incisional hernias, according to the authors, is the inability of BMI to take into account the type of adipose tissue and its distribution in the abdominal cavity. Rothman [331] and Deurenberg et al. [97] also suggest that BMI, despite its ease of calculation, which requires only the patient's height and weight, is not an adequate indicator of obesity, and that studies focusing on overweight should determine the amount of body fat. Previous studies have also used waist circumference (WC), waist-to-hip ratio (WHR), hip ratio, abdominal ultrasound, and even MRI. Current trends are toward the use of computed tomography (CT) to assess body fat, as it provides accurate measurements of visceral and subcutaneous adipose tissue and is more affordable than MRI [414].

In contrast to the results obtained in the present study, as well as the studies cited above, a number of authors point to obesity, as measured by BMI values, as a major risk factor for postoperative infection of surgical wounds, the formation of incisional hernias , and subsequent recurrence after reconstructive repair [141,184,343]. In a retrospective analysis by Owei et al. (2017) [291] covering 102,191 patients, 58.5% of whom were obese, after stratification by body mass index class, the authors even demonstrate a linear increase in all postoperative complications with increasing BMI class. The exponentially increasing prevalence of obesity on a global scale and the associated deterioration in surgical outcomes, including hernia surgery, places a strong emphasis on well-developed strategies for preoperative rehabilitation of these patients.

BMI values below 30 kg/m2 are considered acceptable in terms of postoperative outcomes and do not require prior preparation of patients to reduce weight [236,343]. Patients with a BMI between 30 and 40 kg/m2 are subject to recommended preoperative weight rehabilitation, which includes lifestyle changes, consultation with a nutritionist and dietitian, fitness instructor, or physical therapist [380]. The active participation of the patient and good collaboration with the participating medical and non-medical specialists has been shown to lead to preoperative and long-term weight loss [330]. However, not every patient can achieve a BMI below 30 kg/m2, with a special case being those with significant loss of abdominal wall tissue, for whom weight loss brings both benefits and the risk of exacerbating the LOD problem while it lasts. In patients with a BMI above 40 kg/m2, it is recommended to postpone elective reconstruction of the anterior abdominal wall for incisional or ventral hernia until weight correction is achieved, due to the increased risk of complications. Thus, in a study of 922 patients from the NSQIP (American College of Surgeons National Surgical Quality Improvement Program) database, Pernar et al. demonstrated that patients with a BMI > 40 kg/m2 had a 2.89 times higher risk of postoperative complications (16.5%) compared to those of normal weight (5.6%). The same study also found a strong correlation between high degrees of obesity and hernia recurrence – hernia recurrence was observed in 28.7% of patients with a BMI > 40 kg/m2 compared to 14% of those with a BMI≤ 25 kg/m2 (p = 0.03) [303]. Therefore, the authors advise against scheduling correction of postoperative hernia until BMI values are reduced. To achieve this goal, bariatric surgery may be used as a means in a selected group of patients. With BMI values above 50 kg/m2, reconstruction of the anterior abdominal wall should not be performed due to the extremely high risk of early and late postoperative complications. with the exception of patients with progressive loss of abdominal wall tissue or rapidly worsening symptoms (frequent recurrent episodes of intestinal obstruction, symptoms of progressive intestinal ischemia, strangulation, etc.). For patients with extreme obesity, elective surgical treatment of postoperative hernia should be considered an option only after significant weight loss, almost always after bariatric surgery [193,236]. Recently, there has been a further lowering of this threshold for elective surgery, with some authors setting it at a BMI < 42 kg/m2 [256,412].

Another frequently studied patient-related risk factor for the occurrence and recurrence of incisional hernias is diabetes mellitus. In the study by De Souza et al. (2011) [96], which included 512 patients undergoing conventional, laparoscopic, and laparoscopic-assisted colorectal resections, the authors identified diabetes mellitus as a statistically significant risk factor for the development of incisional hernias (OR 2.225; CI 95% (1.168–4.237); p=0.013). Murray et al. (2011) [273] reached the same conclusion in a similarly designed study of 443 patients undergoing transabdominal colorectal surgery ( ) – diabetes mellitus is an independent risk factor for the occurrence of incisional hernias (p <0.01). Univariate Cox regression analysis of risk factors for incisional hernia formation in the study by Itatsu et al. (2014) [184] also demonstrates a statistically significant correlation between diabetes mellitus and the occurrence of hernia (HR 1.34 (1.04, 1.74); p= 0.024). The study by Smith et al. [360], published in 2024 and including 297,134 patients after conventional abdominal surgery, confirms the results of the previously cited authors by classifying DM as an independent factor influencing the occurrence of incisional hernias (HR 1.31; CI 95% (1.25 -1.37); p<0.001).

In the 273 patients with incisional hernias examined in this study, the reported incidence of diabetes mellitus as a concomitant pathology was 22% (n=60) - in 15% of primary incisional hernias and in 7% of recurrent hernias. The majority of patients with diabetes mellitus had poor control of the disease, namely 70% (n=42). The fact that poor glycemic control in the perioperative period (up to the 60th postoperative day) leads to an increase in the frequency of wound infections, which in turn is a risk factor for the formation of incisional hernias [107,256,316,412], suggests that in our cohort there was also an association between the disease and the occurrence of incisional hernias , although this was not statistically proven. Similar to our study, other studies have also observed a correlation between diabetes mellitus and the formation of incisional hernias, without the authors being able to prove the statistical significance of this relationship. Thus, in the study by Aquina et al. (2015)[28], which followed 193 patients after colorectal resection for carcinoma, Cox's proportional hazards model did not differentiate diabetes mellitus as a statistically significant risk factor for the development of postoperative hernia (HR 1.03 (0.48–2.21); 95% CI; p= 0.94). The same conclusion was reached in the study by Navartnam et al. (2015) [277] covering 224 patients who underwent laparoscopic colon surgery only – there is no statistically proven correlation between diabetes mellitus and incisional hernias (OR 3.55 (0.89–14.10); 95% CI; p= 0.07)A univariate analysis of risk factors for postoperative hernia in a similarly designed study, but involving 2148 patients, by Benlice et al. (2016) [44] also did not statistically confirm the role of diabetes mellitus as an independent risk factor (p=0.07). When observing another type of patients – those after kidney transplantation (n=1564) – Ooms et al. (2016) [289] also did not prove a statistically significant correlation between ZD and the formation of incisional hernias in a univariate analysis (p =0.446). A retrospective cohort study by Walming et al. (2017) [398] on 1621 patients with vascular interventions, as well as those affecting the small and large intestines, also did not prove diabetes mellitus to be a statistically significant risk factor (HR 1.08 (0.63–1.87); 95% CI; p= 0.779). Based on the above, it can be concluded that diabetes mellitus is a factor that plays a role in worsening early and late postoperative outcomes after conventional and laparoscopic abdominal interventions, but since many studies, including ours, fail to prove it as an independent risk factor, its role is overestimated and it has rather a complementary significance in the multifactorial genesis of incisional hernias .

A comparative analysis between diabetes mellitus and recurrence (r = 0.054, p = 0.368) and poor disease control and recurrence (r = 0.105, p = 0.082) revealed weak positive correlations. The results obtained are similar to those of a retrospective study by Young et al. (2019) involving 263 patients who underwent conventional plastic surgery for incisional hernias. The authors also did not consider diabetes mellitus to be a statistically significant risk factor for recurrence in a stepwise regression model and in Cox's multivariate analysis when the parameter was combined with a hernia size > 10 cm [415]. Another recent study by Abdellah Ahmed et al. (published in June 2025) also assesses the effect of diabetes on early and late postoperative outcomes after elective anterior abdominal wall reconstruction. Although the diabetic group had a longer duration of surgery (p=0.01), prolonged wound healing (17.2±3.4 vs. 12.5±2.7 days for non-diabetics, p <0.001) and more frequent surgical wound infections (21.7% vs. 6.7%, p = 0.015), the authors also failed to prove diabetes mellitus as an independent risk factor for herniation (p=0.085) [11]. However, they observed an increased incidence of recurrent hernias after a six-month follow-up period in the group of patients with diabetes (11.7% vs. 3.3%). The results of the study by Abdellah Ahmed et al. highlight the significant impact of diabetes mellitus on all postoperative outcomes in patients who have undergone anterior abdominal wall reconstruction, leading to the conclusion that in order to reduce adverse events and optimize the outcome of surgical treatment of incisional hernias , it is necessary to apply personalized strategies for preoperative rehabilitation of patients at risk.

Glycated hemoglobin (HbA1c) is a marker for controlling blood sugar levels during the half-life of red blood cells (120 days), which is why it is often used to monitor diabetes therapy. While some authors recommend levels <7.0% (153 mg/dl), measured 30-60 days preoperatively, as optimal in terms of the outcome of planned surgical treatment of incisional hernias, others set the limit even lower— —below 6.5%. This explains the difference in the maximum permissible HbA1c levels above which elective abdominal wall repair for postoperative hernia is not recommended – according to some, 7.5%, according to others, up to 8.0% (185 mg/dl) [107,236].In order to optimize preoperative control of diabetes mellitus, it is advisable to conduct intensive training on how to maintain acceptable blood sugar levels, conducted by medical specialists – general practitioners, nurses specializing in working with diabetic patients, and endocrinologists. Programs focused on weight loss—and, respectively, on peripheral insulin resistance and the resulting need for oral or insulin therapy—also have a beneficial effect.

Target blood glucose levels of 120–160 mg/dl in the perioperative period are considered most favorable in terms of reducing the risk of surgical wound infection and other postoperative complications [31,118,316,389]. A meta-analysis by De Vries et al. (2017), including 15 randomized studies, confirms that intensive perioperative blood glucose control significantly reduces the risk of SSI's, both for patients with diabetes mellitus and for those without this comorbid condition [88]. Endara et al. (2013) [112] report in their study that even a single increase in blood sugar above 200 mg/dl in the pre- or postoperative period significantly increases the risk of surgical wound dehiscence. In conclusion, intensive control of diabetes mellitus in the perioperative period, expressed by stable, acceptable serum blood sugar levels, would lead to a reduction in the incidence of wound infections and, consequently, a reduction in the incidence of incisional hernias .

Smoking is another patient-related factor which, together with obesity and diabetes mellitus, has been reported in the literature to be associated with the incidence of surgical wound infection and the development of incisional hernias . Its adverse effect on the healing of surgical incisions occurs through several mechanisms. The use of nicotine products leads to a decrease in partial oxygen pressure in peripheral blood, as well as tissue hypoxia and acidosis, which, by reducing the oxidative mechanism of neutrophil killing, leads to an increased risk of infection and dehiscence of the surgical wound [19,188,364,409]. Smoking also leads to reduced collagen synthesis and deposition in surgical wounds, as established in experimental models by Jorgensen et al.[192], with Knuutinen et al. [210] proving that type I collagen formation decreases by 18% and type III collagen formation by 22% in smokers. In the same study, the authors report a 100% increase in the activity of matrix metalloproteinase- (MMP-8), which breaks down type I collagen many times faster than type III, leading to an imbalance in the type I/type III collagen ratio and, respectively, to a reduction in the strength of the newly formed connective tissue in the area of the surgical scar. Identical to this mechanism in smokers, associated with an imbalance between proteases and their inhibitors, causes tissue-destructive disorders in the formation of abdominal aortic aneurysms and emphysematous bullae in the lungs [25,69,185,239,392]. The above mechanisms underlie the results of the study by Sorensen et al. (2005) [363], which, in observing 310 patients after conventional surgery for GI tract disease for 33-57 months, indicates a 4-fold increased risk of developing postoperative hernia in smokers (OR 3.93 (1.82-8.49); 95% CI).

In the present study, smokers represent 28.2% (n=77) of the sample of operated patients – 19.8% (n=54) are in the group of patients with primary incisional hernia, 8.4% (n=23) – with recurrent hernia. Our results regarding the frequency of smoking as a potential risk factor are similar to those of the recent study by Baker et al. (2024) [34], which reported a frequency of 15.6% in a sample of 13,722 patients with primary postoperative hernia (n=568).

Of the studies available in the literature, only two have statistically proven the link between the use of nicotine products and the herniation process in incisional hernias , with the exception of that by Sorensen et al., but it is based on a much smaller sample. The study by Rhemtulla et al. (2021) [324], covering 529,108 patients after abdominal surgery in 6 surgical specialties, uses a multivariate mixed-effects logistic regression model to prove the role of smoking as an independent risk factor for the formation of incisional hernias in all directions, except in patients with hepatobiliary interventions ($p< 0.001$, for biliary-hepatic surgery - $p=0.927$). The study by Smith et al. (2024) [360] examined 297,134 patients who underwent conventional abdominal surgery, of whom 5.1% (n = 15,138) had subsequent anterior abdominal wall repair for postoperative hernia – smoking was reported as a statistically significant risk factor for herniation (HR 1.38 (1.33-1.44) 95% CI; $p <0.001$). In contrast to this study, in a comparative analysis between smoking and recurrence, we found a weak, linear correlation, but without statistical significance ($r=0.039$, $p=0.520$). Our results are similar to those reported by a number of other studies investigating smoking as a risk factor for the formation of incisional hernias . Interestingly, the marginal levels of significance obtained in those studies are almost identical to those calculated by us. A study by Chen-Xu et al. (2019) [72] covering 654 patients after conventional hepatobiliary and pancreatic interventions does not prove the use of nicotine products as an independent risk factor for incisional hernias ($p=0.575$). A retrospective study conducted by Aquina et al. (2015) [28], involving 193 patients who underwent colorectal resection for carcinoma, further subdivides the cohort into non-smokers, former and current smokers, but again fails to prove the statistical significance of the correlation between smoking and the formation of incisional hernias ($p=0.580$). Regression analysis of risk factors for the development of incisional hernias in the study by Walming et al. (2017) [398] also fails to prove smoking as an independent risk factor (HR 1.15 (0.77–1.71; 95% CI; p= 0.506; n=1370). The study by Benlice et al. (2016) [44] reached the same conclusion in a single-factor analysis of 2148 patients with laparoscopic colorectal resections (p=0.72).

Despite the ambiguous results regarding the exact effect of smoking on the processes of occurrence and recurrence of incisional hernias , reconstructive surgery on the anterior abdominal wall carries additional risks of infection and dehiscence of surgical wounds (formation of wide skin-subcutaneous flaps, use of prosthetic meshes, reduction of chronically incarcerated hernias, or concomitant gastrointestinal surgery—excision of fistula tracts, the need for additional displacement of stomas due to the surgical technique used, or newly formed geometry of the abdominal wall). Therefore, in order to minimize the risk of adverse effects that may additionally result from the use of nicotine products, it is recommended to restrict smoking for a period of at least 4 weeks. Sorensen et al. [364] demonstrated in a study of patients after general surgery and orthopedic interventions that this is the minimum effective period that leads to a reduction in the risk of complications in the first 30 days after surgery. At the same time, there is a linear relationship between the duration of smoking cessation and the benefits to the patient [265]. For patients who are heavily nicotine-dependent and find it challenging to comply with these preoperative recommendations, nicotine replacement therapy in the form of tablets or patches may be used, as several studies have demonstrated their safe use without any negative effects on postoperative surgical outcomes [188,240].

Smoking is associated with another potential risk factor for the occurrence and recurrence of incisional hernias , namely respiratory diseases with the development of bronchial obstruction and leading to persistent coughing fits. In addition to chronic obstructive pulmonary disease, described in the literature as a probable cause, we monitored the study cohort for the presence of other accompanying pathologies with similar clinical course – chronic bronchitis and bronchial asthma. Of the 273 patients we studied who underwent plastic surgery for incisional hernia, 36 (13.1%) had one of the aforementioned respiratory diseases – 47.22% had documented COPD, 22.2% had chronic bronchitis, and 30.5% had bronchial asthma. The frequency of chronic lung diseases reported by us is similar to that reported in other studies published in the literature, such as that by Pereira et al. (2018), which examined the risk factors for complications and recurrence after reconstructive interventions for incisional hernias . Using data from the Spanish national registry for incisional hernias—EVEREG—for a two-year period, the team reported a frequency of 15.4% (n=206) [302]. A similar incidence was found in another large national retrospective study conducted in France covering 32,633 patients with incisional hernias , by Ortega-Deballon (2023) [290] – 11.1%. In the same study, the authors conducted a multivariate analysis of risk factors for the development of incisional hernias and concluded that patients with COPD have a 1.3 times higher risk of developing a hernia after conventional abdominal surgery compared to those without this comorbid condition. Two other studies report a similar risk value – Smith et al. (2024) [360] – 1.91 times (HR: 1.91 (1.80–2.02); 95% CI, $p < 0.001$) and Gignoux et al. (2021)[138] - 1.21 times (RR 1.21(1.14–1.28); 95 % CI; $p<0.0001$). However, this predisposition is ambiguous with regard to the type of surgical intervention performed. In the study by Rhemtulla et al. (2021) [324], which included 529,108 patients who underwent surgery in 6 different surgical specialties, the authors were able to prove the presence of chronic lung disease as an independent risk factor for postoperative hernia in only half of the areas – colorectal, general/bariatric surgery, and obstetrics and gynecology – $p<0.001$, while no such data were available for the others (hepatobiliary – $p=0.598$, urology – $p=0.964$, vascular surgery – $p=0.835$). The heterogeneity of the patient cohort we studied is the reason why no statistically significant correlation between chronic lung diseases and the development of incisional hernias could be proven. 19.85% of the initial surgeries in our patients are related to vascular, urological, or biliary-hepatic pathology, not including previous oncological interventions focused on these specialties, which suggests that the actual percentage is between 25 and 30%, and our results correspond to those obtained by Rhemtulla et al.

When examining the relationship between chronic lung disease and recurrence, we found a weak positive correlation between the two variables ($r=0.045$, $p=0.908$). A similar correlation was found between episodes of persistent cough in the postoperative period and recurrence – $r=0.065$, $p=0.285$, i.e. neither of the two factors carries a statistically significant risk for recurrence after incisional hernia repair. Our results coincide with those reported by Vidovic et al. (2006), who, following a cohort of patients with incisional hernias (n=297) of almost the same size, found no statistically significant correlation between chronic lung disease and reherniation (OR 2.098 [0.734–5.998]; 95% CI; $p= 0.1662$) [396]. The study by Pereira et al. (2018) [302], looking at a four times larger group of patients with incisional hernias (n=1336), also did not report COPD as an independent risk factor for recurrence ($p=0.74$). Unlike our study and the two studies cited above, a recent study by Gomez-Menchero et al. (2022) [147] manages to prove a statistically significant correlation between COPD and recurrence, although it includes patients after laparoscopic repairs for ventral, rather than postoperative, hernias. A recently published study by Lin et al. (2024) [238] examining the predisposing factors for recurrence after conventional preperitoneal repair of incisional hernias demonstrates in a univariate and multivariate analysis that impaired pulmonary ventilation is an independent risk factor for recurrence. In view of these results, although they do not correspond to those obtained in the present study, and the fact that of the conventional surgical techniques used for incisional hernias , preperitoneal/retromuscular prosthetics is recommended as the most favorable, it is advisable for all patients with COPD or other chronic lung disease to have a preoperative consultation with a pulmonologist. After determining the current severity of the condition through functional tests, pulmonary rehabilitation should be performed if necessary, which is a controlled program that includes health education, breathing exercises, and training to increase lung capacity and mandatory smoking cessation (if they are smokers), lasting six to eight weeks [380].

Immunosuppressive therapy is another potential risk factor for the occurrence and recurrence of incisional hernias, widely discussed in the literature due to the adverse effects of immunosuppressive drugs on the healing of surgical wounds. Thus, in an analysis of 465 patients after liver transplantation, Gomez et al. (2001) [146] demonstrated a statistically significant association between prolonged steroid use and the development of incisional hernias . The study by Janssen et al. (2002) [186] , focusing on the same type of patients (n=290), reached a similar conclusion – acute transplant rejection requiring bolus administration of intravenous steroids is an independent risk factor for the formation of incisional hernias ($p = 0.025$). Kahn et al. (2007) [199] demonstrate a statistically significant correlation between the development of incisional hernias and the administration of immunosuppressive agents other than steroids, such as sirolimus and mycophenolate mofetil (MMF) ($p=0.018$). A recently published study by Kim et al. (2024) [201] challenges the significance of immunosuppression as an independent risk factor for incisional hernias, as it found no such association when observing patients after liver transplantation induced postoperatively with methylprednisolone and basiliximab for a period of 5 years. This is consistent with the present study, which found no association between immunosuppressive drug therapy and the occurrence of incisional hernias . In our series, 8.1% (n=22) of patients had a concomitant autoimmune disease, four had two autoimmune comorbidities, and 16% had undergone immunosuppressive therapy for cancer.

The importance of immunosuppression in the process of reherniation after anterior abdominal wall repair for incisional hernia has been the subject of interest in numerous studies. A study by Bueno-Lledó et al.(2021)[63] analyzed 381 patients who underwent component separation and identified immunosuppressive treatment as an independent risk factor for recurrence (OR 1.06[1.48-2.75] 95% CI, $p = 0.003$). A study by Lee et al. (2020) [234] on the effect of immunocompetence on the results of mesh repairs for variations of anterior abdominal wall hernias found a statistically higher rate of postoperative hernia recurrence in patients receiving immunosuppressive therapy (including glucocorticoids, biological agents, chemotherapy, and combined chemo-radiotherapy) ($p=0.017$). A recent study by Saidy et al. (2025) [336] involving 732 patients with reconstructive surgery for incisional hernias reported a significant correlation between treatment with more than two immunosuppressive agents and hernia recurrence (p=0.049). When performing a comparative analysis between immunosuppressive therapy and recurrence in the present study, we found a weak positive correlation, which, however, is not statistically significant (r = 0.030, p=0.615). Our results are similar to those of another recent study by Wasielewski et al. (2025) [400], which did not find immunosuppressive therapy to be a statistically significant risk factor for the recurrence of incisional hernias , even in patients administered more than two drug agents.

The importance of the patient-related risk factors discussed so far, not only in the process of occurrence but also in the recurrence of incisional hernias , is emphasized by their use in various systems for assessing the risk of adverse events after reconstructive surgery for incisional hernias (infection of surgical wounds and recurrence). Created in 2010 and subsequently modified by Kanters et al. (2012), is widely used in decision-making regarding prosthetic material in plastic surgery of the anterior abdominal wall, depending on the stratification of patients into classes according to the possibility of complications. [200,395]. In this classification, the presence of one of the above-mentioned comorbidities – obesity, diabetes mellitus, smoking, COPD, or immunosuppression—places patients in class II "comorbidity," who are at increased risk of SSIs and, respectively, recurrence, and prosthetics with synthetic meshes should be performed with increased caution, taking into account other types of expantoplasty (Table 16).

Table 16. *Modified classification of the Ventral Hernia Working Group [162]*

Modified classification of the Ventral Hernia Working Group for predicting complications after incisional hernia surgery		
Class I – low risk	Class II – comorbidity	Class III – contaminated wounds
No history of previous infection of the surgical wound	• Smoking • Obesity • Diabetes • COPD • Immunosuppressive therapy	A-clean-contaminated B-contaminated C- active infection

Another stratification system for postoperative complications and recurrence in incisional hernias , in which the above-mentioned comorbidities are used, is the Hernia-Patient-Wound (HPW) classification, created by Petro and Novitsky in 2016. similar to the TNM classification for oncological diseases [304]. The presence of morbid obesity (BMI > 35 kg/m2), diabetes mellitus, smoking, and/or immunosuppressive therapy places the patient in at least stage II, in which the risk of adverse events is 12.6%, and for recurrence – 9.7% compared to the first stage, where the probability of hernia recurrence is twice as low – only 4.7% (Table 17). For each subsequent stage, depending on the width of the hernial defect and the condition of the surgical wound, the risk increases accordingly.

Table 17. HPW classification by Petro and Novitsky (2016)[304]

Hernia-Patient-Wound classification system for predicting early and late complications after incisional hernia surgery						
Stage	**Hernia (Hernia)**	**Patient (Patient)**	**Wound (Wound)**	**HPW stage**	**Risk of wound complications (**	**Risk of recurrence (**
1	1	0	0	H1 P0 W0	5.8	4.7
2	1 or 2	Each	0	H1 P1 W0 H2 each PW0	12.6	9.7
3	Each	Each	Each	H1 each PW1 H2 each PW1 H3 each PW0	20.2	13.2
4	3	Each	Each	H3 P1 W0 H3 eachP W0	38.9	31.1

Legend: Width of the hernial defect: H 1 <10 cm, H2- 10-20 cm, and H3 >20 cm; In the absence of comorbidities on the part of the patient – P0, in the presence of morbid obesity, diabetes mellitus, smoking, and/or immunosuppression – P1; Condition of the surgical wound: clean – W0, contaminated – W1.

Given the high and unabated incidence of socially significant conditions such as obesity, diabetes mellitus, and COPD, and the fact that, according to WHO data, in 2025, 1/5 (20.9%) of the world's population over the age of 15 will be smokers [408], in light of the above classification systems, it is clear that recurrent incisional hernias will continue to be a pressing issue for herniologists. According to Herniamed-Registry data, 21.85% (n = 5,328) of all reported incisional hernias (n = 24,385) in which anterior abdominal wall reconstruction was performed are recurrent [213]. Similar statistics are presented by the Danish Hernia Database: of 3,258 elective hernioplasties performed for incisional hernias, 18.2% (n = 593) were related to recurrent hernias [161]. In the present study, an even higher frequency of recurrent incisional hernias was reported—27.1% (n = 74), with the majority of the included patients—74.3% (n = 55)—experiencing a first recurrence, 20.3% (n=15) underwent reconstructive surgery of the anterior abdominal wall due to a second recurrence, and for 5.5% (n=4) it was a third or fourth recurrence of the hernia. , a comparative analysis between the various risk factors and recurrence in our cohort statistically validated the following variables as influencing the recurrence of incisional hernia: number of previous operations, increased bleeding during the initial operation, non-compliance with the postoperative exercise regimen involving heavy lifting, and the type of previous plastic surgery, which was found to have a strong positive correlation and deserves special attention. The role of previous reconstructive surgery as a leading factor in the development of recurrence in incisional hernias is also confirmed in the study by Pereira et al. (2018) [302], which included a multivariate analysis of factors in 1336 patients from EVEREG – OR 2.031 [1.47–2.80] 95% CI; $p<.0001$. Similar to our study, Vidovic et al. (2006) [388] also found a statistically significant correlation between the type of previous repair and recurrence ($p=0.0058$). In a study of 22,895 patients undergoing elective anterior abdominal wall repair for primary postoperative hernia, Köckerling et al. (2020) [211] again found a strong association between the type of technique used and the occurrence of subsequent recurrence ($p < 0.001$).

Of the reported 27.1% recurrent incisional hernias, 39.3% (n=29) were after plastic surgery on the anterior abdominal wall without prosthetic material, and the majority – 60.7% – were after reconstructive surgery with expantoplast placement. Our results are comparable to those of Hoffmann et al. (2021) [170], whose team, reviewing 4015 patients with recurrent incisional hernias from the Herniamed registry, reported a recurrence rate after non-mesh repair of 49.4% and 50.6% after prosthetic repair (35% after conventional techniques and 15.6% after laparoscopic surgery with mesh integration). Three other studies report almost identical results to ours in terms of recurrence after reconstructive interventions without the use of expantoplast, comparing them with techniques involving the use of mesh. The study by Clark et al. (2001) reports a recurrence rate after surgery without mesh placement of 38% [76], while that of Schumpelick et al. [347] reports 33% after a follow-up period of 64 months, and Vidovic et al. (2006) [388] reported the same frequency as in our cohort – 39.4%.

The medical records of the patients included in this study did not always contain accurate information about the type of previous autologous tissue repair performed – whether it was a fascial adaptation technique or a type of fascial doubling. We do not consider this a serious drawback of the study, as a number of authors report a frequency similar to ours, both when reporting the results after reconstruction with aponeurotic suture and with fascial duplication ( ). In a period comparable to our follow-up period, Manninen et al. (1991) [254] report 34%, Hesselink et al. (1993) [165] report 36% recurrence after fascial adaptation techniques, and Weber et al. (2002) [394] report 27% after fascial doubling. The 30-60% reherniation of incisional hernias after anterior abdominal wall reconstruction without mesh reported by Bauer et al. (2002) [37] also demonstrate the similarity of the results obtained in the present study with those published in the literature.

This is not the case with the 60.7% recurrence rate we recorded after plastic surgery using prosthetic material. This result is in sharp contrast to a number of well-known studies and meta-analyses, as well as our initial hypothesis that the rate of recurrent incisional hernias after reconstructive interventions with mesh should be lower. An international prospective study by the French Society of Surgery (AFC) from 2020, involving 61 participating centers in France, Belgium, Switzerland, Morocco, Algeria, and Tunisia, reported a significant correlation between the use of prosthetic materials in incisional hernia repairs and a reduction in recurrence after a 2-year follow-up period ($p<0.001$). In this study, Romain et al. [329] found an average of only 23.3% reherniation regardless of the position of the mesh. A meta-analysis by Lopez–Cano et al. (2018) [243], summarizing the results of five randomized studies, also demonstrated the role of prosthetic material in reducing the reported recurrence rate (RR 0.44, 95% CI 0.31±0.62; $p< 0.00001$), with the average frequency of postoperative hernia recurrence in these studies being only 15.8%. Burger et al. (2004) [65], in an analysis of 181 patients with initial incisional hernias or first recurrence, reported a ten-year cumulative recurrence rate after mesh repair of 32% - almost half that recorded by us after a 5-year follow-up period. The study by de Vries Reilingh et al. (2007) [90] found a 23.5% recurrence rate in the study group of patients with prosthetic reconstructions, comparing the method with the technique of separating the components of the anterior abdominal wall, while Korenkov et al. (2002) [215] found one of the lowest recurrence rates in mesh repair—8.6% when comparing the technique with fascial adaptation and the use of autologous grafts. The main shortcomings of these two studies, which should be taken into account when comparing their conclusions with those in our cohort, are the much smaller observed patient group and the lack of statistical significance of the results obtained. In contrast, a meta-analysis by Mathes et al. (2016) [258], summarizing 10 randomized controlled trials, proves with a high degree of statistical significance ($p<0.00001$) that the relative risk of recurrence after mesh repair for postoperative hernia is 0.36 ([0.27-0.49]95% CI) and that the method is clearly superior to the aponeurotic suture technique in terms of this indicator. This fact, accepted by the surgical community as universally valid, basic knowledge, was the basis of the initial hypothesis at the start of this study that the expected percentage of registered recurrences after prosthetic reconstruction of the anterior abdominal wall should be lower and is at odds with the results obtained. There are several arguments, supported by data from the literature, that justify this discrepancy.

In modern surgical treatment of incisional hernias, the majority of herniologists adhere to performing plastic restoration of the integrity of the abdominal wall using prosthetic material in all cases where there are no absolute or relative contraindications for this, due to the large amount of published data in its favor. This is confirmed by a study by Pawlak et al. (2020) [301], which indicates that the relative share of mesh repairs in the treatment of incisional hernias in England for the period 2016-2018 (which coincides with the period of the present study) is 81.1-82.3%. The predominant use of mesh in reconstructions logically leads to a higher percentage of reported incisional hernia recurrences after this type of intervention.

A study by Köckerling et al. (2021) (n = 61,627) [212] assessing trends in the surgical treatment of incisional hernias over a 10-year period (2010-2019) suggests the second logical explanation for our results. The authors report that during the specified time interval, the relative share of conventional retro-rectal plasty procedures performed increased significantly (from 32.1% in 2013 to 41.4% in 2019; $p < 0.001$), and, starting in 2015, the relative share of new minimally invasive methods with prosthesis integration (E/MILOS, eTEP, etc.) increased from 4.5% in 2013 to 10% in 2019 ($p < 0.001$).. At the same time, the frequency of reconstructions performed without prosthetic material remains unchanged – around 10%. These trends observed in specialized centers in Germany, Austria, and Switzerland also correspond to current practice in the Bulgarian surgical community. This statement is supported by the publication in 2018 of a consensus statement in the form of guidelines on the treatment of anterior abdominal wall hernias by the BHD. The increasing use of conventional prosthetics in the retro-rectal position at the expense of other techniques, as well as the introduction of new and previously unused methods into daily practice (associated with a natural learning curve for the surgical team and, as a rule, a higher percentage of complications in the initial stage, including in the case of recurrences) would logically lead to a higher recurrence rate after mesh repair.

The third, rather contributing factor to the discrepancy between our results and those in the literature consists in the more noticeable introduction of preventive prosthetics in high-risk patients during other interventions into daily surgical practice. These are often patients with concomitant gastrointestinal cancer, in whom the following are typical: stoma removal, immunosuppressive therapy, changes in collagen synthesis as a result of treatment, and the condition is often associated with significant fluctuations in body weight and loss of muscle mass, including in the abdominal wall – all factors that contribute to the development of postoperative hernia, even against the background of mesh protection. This hypothesis is confirmed by the results of the study by Romain et al. (2020)

[329], which identifies concomitant gastrointestinal surgery as a risk factor for recurrence in the second year after anterior abdominal wall repair (OR 1.97 [1.20-3.22] 95% CI; p = 0.007).

With regard to the position of the prosthesis placed during previous surgery, not all 74 patients with recurrent incisional hernias had accurate information about the exact anatomical plane in the previous medical documentation, therefore it was impossible to perform statistical grouping of the data for this indicator. In most cases where there was documentary evidence of the exact location of the mesh, it was placed in an onlay position – an observation that was also confirmed macroscopically during the interventions. With regard to the literature data on recurrence after prosthetics in this anatomical plane, the randomized study by Venclauskas et al. (2010) [394] reports a 10.5% reherniation rate, but the follow-up period is only 12 months and the cohort consists of 57 patients. Similar in terms of patient numbers (n=50) is the study by Sevinç et al. (2018) [349], which reports a 6% recurrence rate, but its higher reliability is due to a significantly longer follow-up period of 37 months. The study by Natarajan et al. (2017) [275] reports a 7.69% recurrence rate after plastic surgery with the mesh positioned on the anterior vaginal wall of the rectus abdominis, but the sample consists of only 13 patients, and the study design involves follow-up for only 6 months, which casts doubt on the results. However, the sample size was only 13 patients, and the study design included follow-up only until the 6th month, which casts doubt on the actual frequency if it had continued over a period of 2-3 years. Only the study by Demetrashvili et al. (2017) [95] looks at a larger cohort of patients – 78 – and has a satisfactory follow-up time of 4.6 ± 1.0 years, with the authors reporting a 5.1% recurrence rate in the onlay group. It should be noted that although all four randomized studies cited are discussed in the 2023 EHS guidelines for the treatment of midline incisional hernias [341] and form the basis for the strong recommendation for the preferred use of retrorectal positioning of the prosthesis, in none of them did the authors find a statistically significant difference between the onlay and sublay cohorts in terms of recurrence. It is therefore critical to have the competence to place the prosthesis in all possible positions, despite the more favorable characteristics of the retrorectal position, especially in cases of compromised anatomy. Although this is a challenge in conventional surgical treatment of incisional hernias , it is extremely important to ensure a personalized approach to each case in the pursuit of the best medical care.

The highest recurrence rate after plastic reconstruction of the abdominal wall in the onlay position in primary incisional hernias is reported by Wittel (2010) [410] – 6-17%. These values are far from the 60.7% recurrence rate after reconstructive surgery with prostheses reported by us, which shows that our initial thesis of predominant placement of the mesh in previous plastic surgeries in the 74 patients we studied in this plan is not true. A scenario involving the implantation of expantoplasty in other anatomical planes is far more likely, although the data from the medical documentation was incomplete. Placement of the meshes in a retrorectal position in previous interventions is most likely, based on the recommendations of the BHD and the fact that prosthetics in other possible planes are far less popular and are used less frequently. The study by Burger et al. (2004) [65] reports the highest recurrence rate after retro-rectus repair available in the literature, examining a cohort of 84 patients with initial incisional hernias or those with a first recurrence and a defect size of up to 6 cm. (observation period – 6.7 years) – 34%. Even taking these studies, which report the highest rate of reherniation, as a starting point, they cannot explain the 60.7% recurrence rate reported by us, which suggests the presence of other accompanying technical and patient-related factors.

A comparative analysis between extreme physical exertion in the postoperative period and recurrence in our cohort revealed a statistically significant weak positive correlation ($r=0.129$, $p=0.031$). It is widely believed among surgeons that early, heavy postoperative physical exertion can have a negative effect on the restoration of abdominal wall integrity, leading to fascial rupture and wound dehiscence or trauma, which increases the risk of herniation [293]. The pathophysiological mechanism leading to these changes is related to an increase in intra-abdominal pressure caused by lifting weights, but there is evidence that the degree of increase depends on the amount of weight and the way it is lifted. Gerten et al. (2008) in a clinical trial involving 41 women who had to lift loads weighing 0, 2.5, 5, 10, and 15 kg using four different maneuvers, found statistically that intra-abdominal pressure increases significantly when lifting weights over 2.5 kg, regardless of the method ($p<0.001$) [136]. A study by Iqbal et al. (2008) [180] challenges this thesis, as when measuring pressure in vivo by intragastric and intravesicular manometry, they report a slight increase when slowly lifting weights up to 50 kg in the absence of abdominal pressure. This calls into question the role of weight lifting as a risk factor for herniation if it is performed slowly and in a controlled manner in the postoperative period. In addition, a number of authors report a faster and more significant increase in intra-abdominal pressure during involuntary or daily activities such as coughing, wheezing, straining, jumping, or defecation compared to physical activity or weight lifting [78,403].

Regarding the period required for abdominal wall recovery after surgery, experimental studies in rats have shown that 28 days are sufficient for primary, uncomplicated wound healing to reach baseline tensile strength [168]. Lau and Pomahac (2014) [227] also conclude that the fascia heals in approximately 30 days. According to other authors, it is even possible for the muscle-aponeurotic layer to recover earlier than the skin incision under conditions of moderate physical activity, as fascial fibroblasts can then be activated [108,125]. Reinforcing the abdominal wall with prosthetic material further modifies its physical and mechanical properties. For example, a study by Buhck et al. (2012)

[64] demonstrates physiological stability of the anterior abdominal wall immediately after inguinal canal repair with a mesh.

The available literature lacks data showing that limiting physical activity for more than 30 days could reduce the incidence of recurrent incisional hernias , or conversely, that an early return to normal physical activity could increase it. This is precisely why the results of the present study are so significant, as no other study has demonstrated that non-compliance with the postoperative exercise regimen involving heavy lifting is a statistically significant risk factor. In order to improve the results of surgical treatment of incisional hernias, the question arises as to how to minimize the possibility of recurrence with regard to this factor – how long should physical activity be restricted, and whether and for how long auxiliary devices such as abdominal elastic belts or compression bandages should be used.

There is a lack of a standardized approach in postoperative recommendations to patients regarding physical activity after abdominal surgery, particularly after reconstructive surgery of the anterior abdominal wall. This is confirmed by a large national study by Güsgen et al. (2020)[153], covering 386 surgical clinics in Germany, which shows significant variation in guidelines for restricting increased physical activity after conventional abdominal surgery with a maximum duration of up to 6 months: average period of activity restriction after median laparotomy -5.79 weeks (5.57-6.11), after transverse laparotomy -5.42 weeks (5.08-5.75), 34.4% of the surgeons surveyed set the maximum permissible weight limit at 10 kg, while the same proportion – 34.1% – set it twice as low – 5 kg. In addition, the authors found that 78% of the recommendations were based solely on the surgeon's personal experience, and only 10.5% on scientific evidence from the literature. Similar ambiguity regarding postoperative recommendations on physical activity was also observed by Paasch et al. (2018) [292], analyzing the results of a questionnaire on the postoperative treatment of patients after conventional hernia repair, completed by 44 surgical clinics in Germany. The majority of centers (34%) agree on a maximum permissible weight of 5 kg, 2.27% recommend a maximum of 15 kg, while 9.09% do not restrict the load in terms of permissible kilograms at all. With regard to physical activity, 20.5% advise their patients to reduce it for a period of 4 weeks, 4.5% for 12 weeks, and 18.2% for 2 weeks. An interesting fact from this study is that the highest recurrence rate was reported in a surgical center that recommends 3 weeks of reduced physical activity and 3 weeks of wearing an elastic abdominal belt. This is close to the common practice in Bulgaria, as well as to the recommendations for postoperative activity after abdominal interventions and reconstructive surgery of the anterior abdominal wall, given by an expert board at the 41st annual international congress of the EHS in 2019. For prosthetic repair of incisional hernias in the retrorectal position, 55.5% of participants recommend 4 weeks of restricted physical activity, and 31.5% recommend a period of 7.0± 1.7 weeks; for onlay placement, 39.4% consider 4 weeks to be an adequate duration, while 37% recommend 7.4± 1.9 weeks; in complex cases, the majority of experts (47.2%) agree on 7.2± 2.3 weeks [292]. Even within a single surgical center—where the present study was conducted—there are differences in recommendations regarding physical activity restriction after anterior abdominal wall reconstruction among individual surgeons, although most recommend a minimum period of 4–8 weeks. The ambiguity in the guidelines provided by an expert board, even within a large surgical forum such as the EHS international congress, further emphasizes the need for a randomized study in this area to clarify the issue once and for all. In the meantime, in light of the results we have obtained, it is advisable that recommendations regarding motor activity and physical activity after conventional treatment of incisional hernias be part of the preoperative consultation with patients, emphasizing that compliance with them is directly related to the most favorable outcome of treatment. At the same time, the period of rest and reduced physical activity should not be too long, as Hoang et al. [166] note in their study, the possibility of an early return to work is recognized by patients themselves as an important indicator of satisfaction with the surgical treatment, immediately after the success of the intervention itself. The length of sick leave after surgery for a post-operative hernia also plays a significant role in the overall socio-economic assessment of the treatment. For example, Bay-Nielsen et al. [41], in their analysis of the costs following inguinal hernioplasty, found that postoperative absence from work was the most expensive component of treatment.

In the cohort of 273 patients who underwent conventional plastic surgery for postoperative hernia, the average direct cost was reported to be BGN 2,041.27± BGN 1,530, ranging from BGN 568.38 to BGN 8,241.51. In the studies available in the literature, there are some differences between authors as to which components should be included in their calculations. The calculation in the present study is similar to that in the study by Gillion et al. (2016)[140], in which direct costs cover the entire consumption of resources during hospitalization and amount to €4731. This is similar to that in the series by Israelsson et al. (2003)[181], in whose economic analysis direct costs summarize those incurred during the intervention (taking into account the operation and time under anesthesia), during the stay in the surgical clinic, and adding the cost of the bed. In contrast, Reynolds et al. (2012)[323] consider direct costs to be a derivative of the cost of medical consumables (prosthetic materials and others) and non-surgical labor costs only. In this regard, the authors report a statistical difference in the amount of direct costs depending on the surgical method used – for plastic surgery without the use of mesh – $5,420 ($3,620−9,400), with synthetic mesh - $7,590 ($5,880−9,540), with biological mesh - $16,970 ($15,070−21,600) (p<0.001).

The main factors found to alter the cost of direct expenses were the size of the hernial defect, the length of hospital stay, and antibiotic therapy, and during the course of the study, changes in the cost of bed days and additional medical supplies. A study by Taha et al. (2021) [374] on the variables affecting the cost of surgical treatment of incisional hernias also found the cost of prosthetic materials to be the second most important factor determining direct costs ($p < 0.001$).

Total costs represent the sum of direct and indirect costs, which were calculated in this study based on the hospital sheets used in the early postoperative period, and their average value was BGN 2249.24± BGN 1369. A study by Rampado et al.(2017)[317] also encountered difficulties in calculating the indirect component due to its complex quantification, which is influenced by a number of biological, social, psychological, and economic factors (different professions, retired or unemployed patients, housewives, etc.). Nevertheless, the team in this Italian study reports total costs of €5,544.25 for patients with synthetic implants and no comorbidities, €5,020.65 in those with the same mesh implant but with accompanying conditions that are risk factors for recurrence, and €16,397€17 for those with a biological prosthesis used in the plastic surgery, taking into account the difference in sick leave used after discharge depending on the type of mesh – those with synthetic expantoplast were absent from work for 21 days, and those with biological expantoplast for 30 days.

Patients of retirement age, those on leave (maternity, paid and unpaid annual leave), those not in employment, and those in employment who refused sick leave were excluded from the calculation of indirect costs in our series. Due to the lack of data on the monthly remuneration of individual working patients, the value of the sick leave was calculated as 80% of the average gross salary for the respective month and year of the study according to data from the National Statistical Institute. In their study, Gillion et al. (2016) [140] report an average sick leave period of 29.4 days for all working patients, calculating the indirect cost component at €5,376, using a calculated average weekly sick leave value for the country of €1,271. The authors thus indicate €10,107 as the average total cost of surgical treatment of incisional hernias in France for the study period, noting that the share of indirect costs was higher than that of direct costs for employed persons.

The magnitude of the economic burden that incisional hernias place on healthcare systems around the world has been confirmed by a number of studies. For example, Shubinets et al. (2011)[186] point out that hospitalizations related to anterior abdominal wall repair for incisional hernias alone cost US taxpayers $6.2 billion annually, or $7.3 billion when hospital treatment for complications of the disease is included. If hospital treatment for complications of the disease is added to this, the cost rises to $7.3 billion. Despite numerous medical innovations and additional knowledge gained about the prevention and treatment of incisional hernias, the study by Rhemtulla et al. (2021)

[324], reported 10 years later, does not show a dramatically different picture. Looking at data from just six US states, the authors report that the costs associated with treating initial incisional hernias amount to $687 million, with surgery for a first recurrence costing $155 million and a second recurrence adding another $33 million to the total. The importance of efforts to reduce the recurrence of incisional hernias is highlighted by the fact that although only 20% of patients with primary hernias experience a subsequent recurrence, this group accounts for 35% of total costs ($307 million). The economic pressure on healthcare systems can be further reduced by cutting costs in a resource-constrained environment through the implementation of targeted strategies to reduce the formation of incisional hernias . A study in France shows that if the incidence of incisional hernias falls by even 5% through the use of preventive measures such as compliance with EHS recommendations for abdominal wall closure in conventional abdominal surgery and prophylactic prosthetics in high-risk patients, this would result in savings of €4 million for the national health budget [140].

Based on the results of this study, we propose a standardized algorithm for conventional surgical treatment of incisional hernias , which we hope will optimize treatment outcomes and thus increase satisfaction for both patients and surgeons (Fig. 57). The most important steps in this algorithm are:The most important steps in this algorithm are:

- Step 1: When performing the initial abdominal surgery, a precise assessment of the risk of developing a postoperative hernia is necessary, and after identifying high-risk patients, their preventive prosthetics
- Step 2: If an incisional hernia is suspected, patients should be diagnosed using the following sequence of methods at the surgeon's discretion: clinical examination – abdominal ultrasound – CT scan of the abdominal organs (with the greatest informative value, it can be an invaluable tool in preoperative planning and deciding which reconstruction technique to use)
- Step 3: Identification of patients at high risk of recurrence and their preoperative rehabilitation: smoking cessation for a minimum period of 4 weeks, weight control with preoperative target BMI values of≤ 30 kg/m2, optimization of blood glucose values, respiratory rehabilitation, etc.
- Step 4: Reconstructive repair of the postoperative hernia using a surgical technique selected in accordance with the recommendations regarding the size of the hernial defect, but it is particularly important to have a good knowledge of the structural anatomy of the abdominal wall and the skills to place the prosthesis in different

anatomical positions, as it may be necessary to change the preliminary plan during the intervention itself.

- Step 5: Since the majority of recurrent incisional hernias present within the first 2 years after surgery, this is the optimal follow-up period in order to detect the highest possible percentage of these patients and perform the reoperation as early as possible before the hernia significantly increases in size and complexity.
- Step 6: Mandatory preoperative optimization of the patient and the surgical wound, if necessary (presence of infection, fistulas, maceration of the skin surface), as well as good planning of the surgical approach with the selection of an uncompromised anatomical plan for the insertion of the prosthetic material, are of paramount importance for ensuring the best possible outcome of surgical treatment with the prevention of subsequent recurrence.

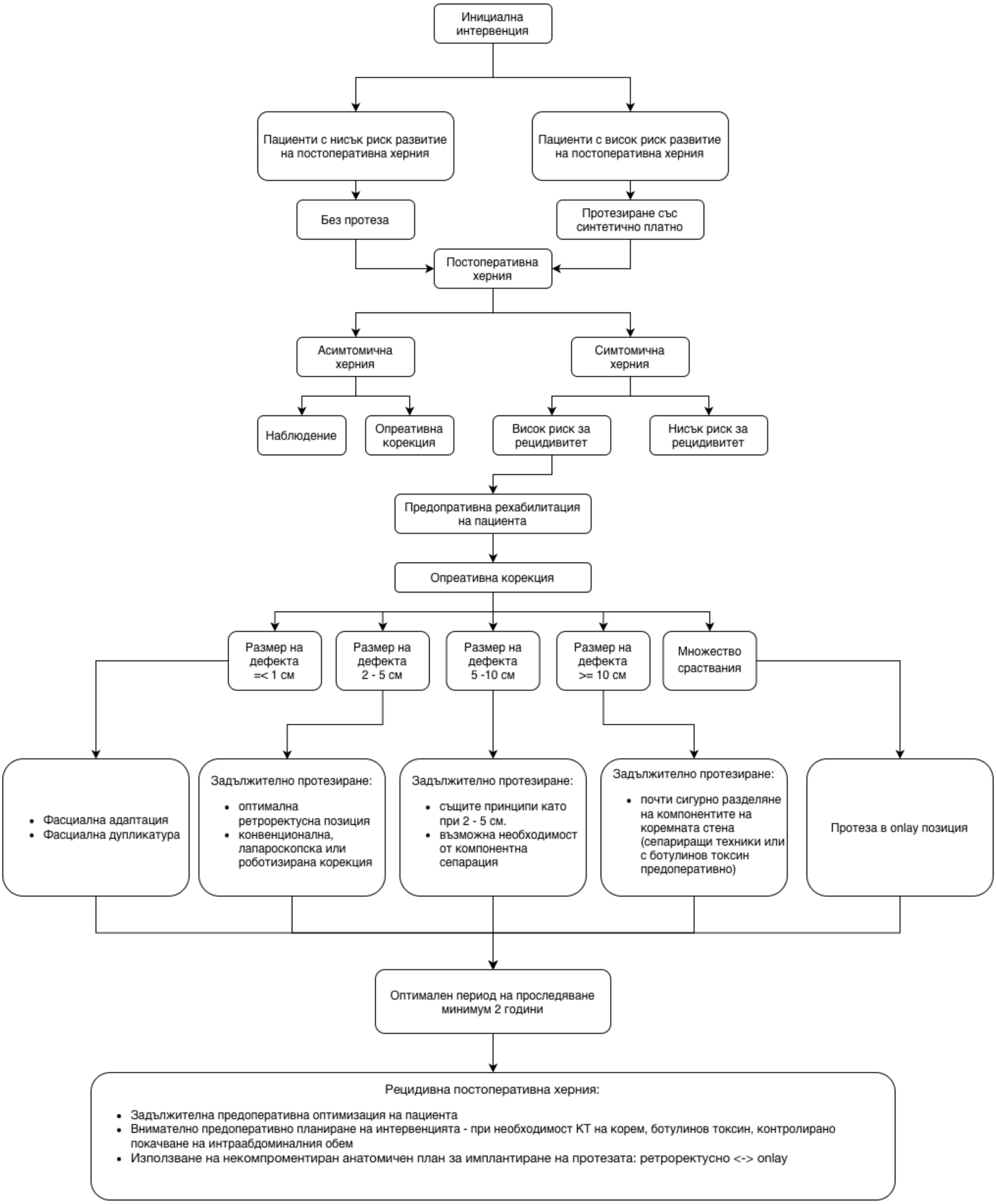

Figure 57 *- Algorithm for management of incisional hernias*

VI. Conclusion

Incisional hernias are a significant problem in surgical practice worldwide, remaining the most common long-term postoperative complication after abdominal surgery, affecting 12.8–30% of patients [54,384]. Advances in medical knowledge and technology have led to increasingly complex surgeries, which in turn have presented new challenges for herniologists—the treatment of complex incisional hernias, often large in size and involving significant loss of abdominal wall tissue. Not only the technical difficulties, but also the reported unacceptably high recurrence rates of up to 32% [361] and mortality rates of up to 1% illustrate the important problems to be solved in the surgical treatment of incisional hernias [38,290].

Although significant progress has been made in recent years in the treatment of incisional hernias through the introduction of new prosthetic materials that reduce patient discomfort and the likelihood of intra-abdominal adhesions, as well as through modern surgical techniques such as component separations and laparoscopic/hybrid techniques [315], the frequency of recurrence has been reduced but not eliminated [247]. The fact that surgical treatment of recurrent incisional hernias is associated with significant morbidity, increased number and duration of hospitalizations, and even mortality [361], necessitated a shift in the approach to reducing the recurrence rate towards the development of strategies aimed at preventing the disease.

A significant step in this direction was the publication in 2022 of the updated guidelines for the repair of abdominal incisions by the EHS and AHS (American Hernia Society), which, with the aim of reducing the incidence of incisional hernias, recommends the maximum use of minimally invasive techniques in abdominal surgery, the use of transverse or oblique incisions in conventional interventions, and the restoration of surgical accesses with sutures.-invasive techniques in abdominal surgery, the use of transverse or oblique incisions in conventional interventions, and the repair of surgical accesses with continuous sutures using slow-resorbable suture material with a small pitch [93]. A further reduction in the number of incisional hernias in the future can be expected through the wider implementation in daily general surgical practice of various stratification systems for patients at high risk of developing the disease. Such is the formula proposed by Veljkovic et al. [393] for assessing the risk of developing incisional hernias - p(%)=32(SIR)+30(SSI)+9(TIME)+2(BMI), which, by including four independent risk factors in a regression model – the ratio of the length of the facial suture to the length of the incision (, SIR – suture incision ratio <4.2 – 0. > 4.2 -1), deep surgical wound infection or infection of a deep space or organ (in the presence of CDC type 2 or 3 SSI -1 , in the absence -0), time to suture removal (TIME > 16 days – 1, < 16 days- 0) and obesity (

BMI>24 kg/m2-1, BMI<24 kg/m2-0), divides patients into four groups – 0-5 points – 1% risk of postoperative hernia, 5-15 points – 9.7% risk, 15-50 points – 30.2% risk, and >50 points – 73.1% risk. Another much simpler alternative is the HERNIA score= 4 (laparotomy) + 3 (manually assisted laparoscopy) + 1 (chronic obstructive pulmonary disease) + 1 (BMI≥ 25 kg/m2)A third option is the Penn Hernia Calculator proposed by Basta et al. which, based on 16 different variables, reliably predicts the risk of developing an incisional hernia (C-statistic = 0.76-0.89) [38,39]. Stratifying patients during the initial surgery would lead to the most accurate selection of those for whom prophylactic anterior abdominal wall repair would be most beneficial. Influencing modifiable patient-related risk factors through the implementation of effective preoperative rehabilitation programs for patients within existing healthcare delivery systems would further optimize outcomes, reducing the socioeconomic and health burden of the disease.

Although conventional surgical techniques remain the cornerstone of operative treatment for incisional hernias , improving treatment outcomes requires a multifaceted approach—integrating surgical precision, therapeutic strategies tailored to individual patient characteristics, and efficient use of healthcare resources. Continuous innovation and research are essential to reducing recurrence, improving quality of life, and addressing the growing global burden of this common postoperative complication.

VII. Publications related to the dissertation

- **V. Grigorova** Factors influencing recurrence after conventional surgical treatment of incisional hernias – a comparative analysis of personal experience and available literature – Varna Medical Forum, vol. 14, 2025.