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RETROMUSCULAR ENDOVIDEOSURGICAL HERNIOPLASTY FOR VENTRAL HERNIA

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INTRODUCTION

Relevance of the research topic and the degree of its development.

The relevance of the problem of surgical treatment of ventral hernias is due to the widespread prevalence of this pathology among the population (3-5%). More than 20 million radical operations for hernias of the anterior abdominal wall are performed annually in the world, which accounts for 10-12% of all surgical interventions [12].

Due to the peculiarities of the etiopathogenesis of the formation of ventral hernias, this pathology mainly affects people of working age. That is why the successful result of hernioplasty is assessed as the absence of relapse and the absence of complications in the postoperative period that could affect the patient's daily life. It is worth noting that if a relapse occurs (10-18%), the probability of a second relapse increases many times (20-60%)[3].

There are currently many methods of hernioplasty of ventral hernias, among which the "gold standard" is open hernioplasty Rives-Stoppa [4]–[9].This technique ensures reliable fixation of the mesh endoprosthesis in the retromuscular space, which leads to a fairly low percentage of relapses (1%-24%). However, like all options for open interventions, the Rives-Stoppa technique is accompanied by significant trauma to soft tissues, which causes severe pain in the postoperative period, increased hospitalization and long-term restoration of the patient's functional capabilities [4].

Thanks to the rapid development of endovideosurgical (EVS) technologies, more and more minimally invasive techniques are appearing in the arsenal of surgeons, including Mini-or Less-Open Sublay (MILOS), Intraperitoneal Onlay Mesh (IPOM), extended Totally Extraperitoneal Plasty (eTEP). When using these methods of hernioplasty, low-intensity pain syndrome is observed in the postoperative period and there are no restrictions on physical activity in the long-term postoperative period. However, these interventions significantly increase the duration and cost of the operation, and are not applicable to all groups of patients [2], [7].

Despite the wide range of surgical techniques, the hernia community is still searching for an ideal, standardized method characterized by minimal invasiveness, low risk of postoperative complications and high quality of life for patients. Surgery using eTEP access is now being performed more and more often, showing promising results[10]. However, there is not enough research to prove the advantages of this technique in comparison with open hernia repair methods. In this regard, comparison of both early and long-term results of traditional Rives-Stoppa repair and surgery using eTEP access for ventral hernias is relevant.

Purpose of the study

To improve the results of retromuscular hernioplasty for ventral hernias.

Research objectives

1. To evaluate the results of treatment after endovideosurgical and open retromuscular hernioplasty of ventral hernias in the early postoperative period.
2. To compare the duration of postoperative recovery of patients and the development of relapses after EVS and open retromuscular hernioplasty of ventral hernias.
3. To develop an intraoperative checklist and analyze the results of implementation into clinical practice as part of the standardization of endovideosurgical retromuscular hernioplasty for ventral hernias.
4. To analyze the possibility of using and the effectiveness of a tumescent solution for local anesthesia of the intracorporeal suture of the white line of the abdomen during the endovideosurgical method of hernioplasty.

Scientific novelty

1. For the first time, standardization of endovideosurgical retromuscular hernioplasty using the eTEP approach was carried out by developing an intraoperative checklist, recommendations were given for performing

individual stages of the operation and overcoming possible technical difficulties.

2. For the first time, a comprehensive comparative analysis of the early and long-term results of treatment after open and endovideosurgical retromuscular hernioplasty in patients with ventral hernias was carried out.
3. For the first time, the method of local anesthesia with a tumescent solution of the intracorporeal suture of the white line of the abdomen was tested and the effectiveness of the technique was assessed in the early postoperative period.

Theoretical and practical significance of the research

A methodology has been formulated for the standardized application and development of endovideosurgical retromuscular hernioplasty using the eTEP approach in patients with primary and postoperative ventral hernias. An intraoperative checklist for endovideosurgical retromuscular hernioplasty using the eTEP approach has been developed and introduced into clinical practice. The technique and procedure for performing each stage of hernioplasty are described in detail.

A method of local anesthesia with a tumescent solution of the intracorporeal suture of the white line of the abdomen was developed and tested, which made it possible to study the possibilities of multimodal anesthesia in the early postoperative period.

Methodology and research methods

The work was performed at the Department of Faculty Surgery, Faculty of Medicine, St. Petersburg State University in 2018–2023.

The research work was based on a prospective principle and included observation of 187 patients with ventral hernia admitted to the 1st surgical department of the Federal State Budgetary Institution "L.G. Sokolov North-Western Regional Scientific and Clinical Center" of the Federal Medical and Biological Agency of Russia. During the research work, two independent clinical studies were performed.

The first study included 122 patients with ventral hernias, which included primary ventral and postoperative ventral hernias. Further, in each of these groups, patients were divided depending on the type of surgical intervention. The second study included 35 patients divided into two groups of patients - those with retromuscular hernioplasty performed using the eTEP approach with the use (study group) and without the use (comparison group) of tumescent anesthesia. The third study was based on the results of treatment of two groups of patients of 30 people each, operated on by two different compositions of the operating team.

Early results were assessed in the first 6 months of the postoperative period. To obtain long-term results, patients were observed from 1 year to 4 years from the date of surgery.

Statistical processing of the data was carried out taking into account the nature of their distribution. The software package “Microsoft Office 2019” and the StatTech v. 3.1.6 program were used as mathematical tools (developer - Stattekh LLC, Russia).

Implementation of research results

The results of the study are used in the practical activities of the first surgical department of the Federal State Budgetary Institution "L.G. Sokolov North-Western Regional Scientific and Clinical Center" of the Federal Medical and Biological Agency of Russia." In addition, the results of the study are used in the educational work of the Department of Faculty Surgery of St. Petersburg State University.

Personal contribution of the applicant

The author searched and analyzed modern scientific literature on the issues under study and substantiated the relevance of the research topic. The author formed and studied clinical groups of patients, participated as an assistant or surgeon in all surgical interventions, carried out postoperative treatment of all patients after endovideosurgical retromuscular hernioplasty and analyzed the results obtained (collection, generalization and statistical processing of data).

Approbation of work

Based on the materials of the dissertation work, 5 scientific works were published, including 3 in publications recommended by the Higher Attestation Commission of the Ministry of Education and Science of the Russian Federation for the publication of the main scientific results of dissertations for the academic degrees of Doctor and Candidate of Medical Sciences. A report was presented, a 2nd degree Diploma was received at the conference “Man and His Health” 2022 and a report with the results of the study at the VI All-Russian Congress of Herniologists “Modern Trends in Herniology 2023”.

Structure and scope of work

The thesis is presented on 109 pages of type written text, consists of an introduction, a literature review, a description of the material and research methods, the results of one’s own research, discussion and conclusions. The work contains 18 tables and 40 drawings. The bibliographic index includes 97 sources.

Main scientific results

The dissertation paper presents the main scientific results of the research in the form of the publication of three scientific papers, co-authored by the applicant. In the publication “First experience of using eTEP hernioplasty for ventral hernias,” co-authored with Lodygin A.V., Akhmetov A.D., Kashchenko V.A. demonstrated the first results of the use of endovideosurgical retromuscular hernioplasty using the ETER approach for ventral hernias, implemented on the basis of the 1st surgical department of the North-West Regional Clinical Center named after. L.G. Sokolova. The technical aspects of implementing the operational manual are analyzed and described in detail.

In the scientific work "Parastomal hernias: current state of the problem (literature review)”, published in the journal “Coloproctology” in collaboration with Ovchinnikov T.S., Lodygin A.V., Bogatikov A.A., Kashchenko V.A. A review of domestic and foreign literature on the treatment of parastomal hernias was

performed. Endosurgical retromuscular hernioplasty using the eTEP approach is one of the main methods used in the treatment of this pathology. The results of the study were used to write a literature review of the dissertation work.

One of the fundamental publications of the researcher is “Comparative assessment of the results of open and endovideosurgical retromuscular hernioplasty of ventral hernias”, published in the journal “Endoscopic Surgery” in collaboration with Ovchinnikov T.S., Lodygin A.V., Kashchenko V.A. This scientific work publishes the main results of the study, highlighted in the dissertation work.

In all three scientific works, the applicant made a personal contribution in the form of developing the concept and design of the study, collecting and processing information material, statistical processing, received data and writing text.

Main provisions submitted for defense

1. Endovideosurgical retromuscular hernioplasty is associated with a faster recovery in the level of physical activity, less pronounced discomfort in the area of postoperative intervention and the absence of relapses in the long-term postoperative period.
2. Patients after retromuscular hernioplasty using the eTEP approach with local use of a tumescent solution for analgesia of the intracorporeal suture of the white line of the abdomen note less pain and require fewer analgesics in the first 5 days of the postoperative period.
3. Standardization of endovideosurgical retromuscular hernioplasty using the eTEP approach is associated with a statically significant increase in the reproducibility of the surgical technique and a decrease in the duration of the learning curve.

CHAPTER I. Ventral hernias. Current state of the problem and methods of surgical treatment (literature review).

1.1 Ventral hernias: definition, epidemiology, classification and pathogenesis of formation.

A ventral hernia is a protrusion of organs or tissues through an opening in the muscular-fascial structures of the anterior abdominal wall. A hernia consists of three components: the hernial orifice, the hernial sac and the contents of the hernial sac [4]–[6], [10], [11].

The prevalence of ventral hernias, according to various authors, is from 3 to 5% of the population. Every year, up to 20 million hernioplasties are performed worldwide for ventral hernias. The great social significance of this pathology is explained by the predominant impact on the working-age population and the high number of relapses. The relapse rate varies widely and, depending on different methods of plastic surgery, can reach 18%. If a relapse occurs, the likelihood of another relapse increases many times (20-60%)[12].

Currently, the most current classification of hernias of the anterior abdominal wall is the classification proposed by the European Herniology Society (EHS) in 2009, dividing into primary and postoperative ventral hernias[12].

Primary ventral hernias are formed due to the formation of a defect in “weak” areas of the anterior abdominal wall. Over time, they increase in size due to constant exposure to intra-abdominal pressure, contraction of the diaphragm and the muscles of the anterolateral abdominal wall. As a result, the abdominal organs move through the abdominal wall defect, expanding the latter and forming a hernial protrusion [13].

Postoperative ventral hernias can develop after any surgical treatment in the abdominal cavity, which involves an incision in the abdominal wall [14]. Unlike primary abdominal wall hernias, postoperative hernias come in different sizes and shapes. Thus, the size of an incisional hernia is not easily determined by just one variable or measurement. To classify in a two-dimensional grid format, it is

necessary to reduce the variable “size of hernia defect” to one quantitative or semi-quantitative indicator. JP Chevrel [15] addressed this issue by selecting the width of the hernia defect as one of the parameters for classification, stating that width is the most important size measurement for determining the difficulty of successfully repairing a hernia [12].

The consensus of the European Hernia Society has determined that width and length should be used to adequately describe the size of a hernia defect. The width of the hernia defect is defined as the greatest horizontal distance between the lateral edges of the hernia defect on both sides. For multiple hernia defects, the width is measured between the most lateral edges of the most lateral defect on that side [12]. Defects in the surgical technique for closing a laparotomy wound, concomitant pathology and postoperative wound infection are considered the fundamental causes of the development of postoperative ventral hernias [16]–[19].

Factors that increase the risk of anterior abdominal wall hernia are: male gender, high body mass index (BMI), old age, diabetes mellitus, smoking, taking various medications (vasopressor, hormonal), chronic obstructive pulmonary disease, ascites [8], [20], [21].

The direct causes of ventral hernias are divided into two groups: predisposing - gender, age, heredity, physique, anatomical weakness of the muscular aponeurotic structures of the anterior abdominal wall, and producing - conditions that contribute to increased intra-abdominal pressure - pregnancy, heavy physical activity, constant constipation, trauma abdomen, presence of fluid in the abdominal cavity, obesity[4], [10], [22].

Impaired collagen metabolism and diastasis recti predispose to the development of anterior abdominal wall hernia at a later date. The reasons for the development of hernias during these periods are often a violation of collagen synthesis due to obesity, cachexia, old age, anemia, hypoproteinemia, cancer, liver diseases, diabetes mellitus [6].

It has been proven that the previously listed risk factors affect the number of relapses [7], [9], [23].When planning a surgical operation, when counseling the

patient regarding the expected course of the postoperative period, as well as the prognosis of relapse in the long-term period, it is necessary to take these risk factors into account. However, the main factors are: unreasonable choice of hernioplasty method during the initial operation, incorrect choice of mesh endoprosthesis size, violation of the surgical technique [24].

The pathogenesis of the formation of hernias of the anterior abdominal wall is inextricably linked with the molecular aspects of collagen synthesis and destruction. According to recent research, scientists have discovered molecular and cellular structures in the fascia and aponeuroses that prevent the formation of hernias. Collagen is the main component of connective tissues, in particular fascia and aponeuroses. The synthesis and destruction of collagen molecules in these tissues is in balance. However, when studying the rate of synthesis and destruction of collagen in the fascia of the transverse abdominal muscles on the side of the hernia formation and on the healthy side, a pattern was found: the rate of collagen destruction on the side of the hernia formation is higher. Based on this, it can be assumed that local changes in the molecular processes of collagen breakdown play an important role in the pathogenesis of hernia formation [25].

In addition, it has been proven that a decrease in the level of hydroxyproline is a predisposing factor to the formation of hernias. Hydroxyproline is an amino acid that is part of collagen. A collagen molecule with a low hydroxyproline content loses its structural properties. In patients with hernias, a low content of hydroxyproline was found in the aponeurotic tissues. This fact once again confirms the direct connection between collagen metabolism and the formation of hernias of the anterior abdominal wall [25].

1.2 Development of hernioplasty for ventral hernias depending on the location of the mesh implant in the anterior abdominal wall.

Hernioplasty using mesh implants has significantly improved long-term results and is the standard treatment for ventral hernias [26-28]. However, the results of many studies demonstrate a high risk of developing wound complications when

installing a mesh implant, including infection, the development of seromas and relapses [29,30]. The risk of these complications depends on the space of the anterior abdominal wall in which the mesh implant is located. For example, contact of a mesh implant with abdominal contents potentially increases the risk of adhesions, intestinal obstruction, and fistula formation [30,31].

However, although repair of ventral hernias using mesh implants is a routine practice in the surgeon's arsenal, there is no consensus on the best placement of the mesh implant. Currently, there are several options for placing the implant in the anterior abdominal wall: onlay, inlay, sublay and IPOM (intraperitoneal onlay mesh) (Figure 1)[32]–[34].

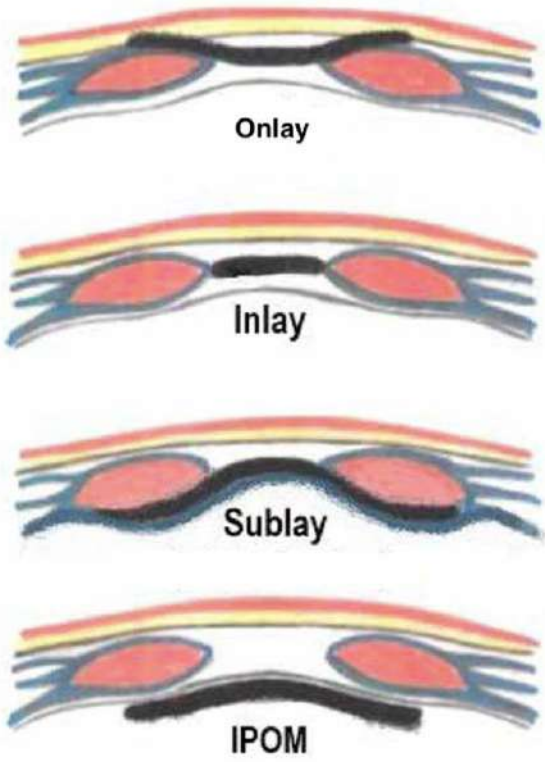


Figure 1 - Options for the location of the mesh implant (black line) in the anterior abdominal wall

The onlay technique involves placing the endoprosthesis in the subcutaneous fat with fixation to the abdominal wall. The size of the mesh implant when choosing this location option is 3-5 cm larger than the hernia defect. After suturing the

aponeurosis defect edge to edge, the mesh is sutured to it to avoid displacement. The advantage of the technique is its technical simplicity. But the mechanically unfavorable location of the mesh leads to a high percentage of relapses and purulent complications [35], [36].A meta-analysis by Holihan et al. (2016), showed that in 17 out of 21 publications. The onlay technique has demonstrated a higher risk of recurrence and surgical site infection (SSI) compared to sublay and IPOM hernia repairs.[37]. In a meta-analysis by Sosin et al. the authors demonstrated that the use of the onlay mesh implant fixation technique in 472 patients was significantly associated with a high risk of relapse and complications in the early postoperative period. The average incidence of hematomas and seromas was 17.4%. Repeated surgical treatment with removal of a previously installed mesh implant accounted for 0.3% of the entire cohort of patients. Recurrence of ventral hernia occurred in 12.9% of patients ($p=0.023$) [38]. Thus, according to the results of meta-analyses of the use of the onlay mesh implant installation technique, it was shown that onlay hernioplasty is one of the least profitable options for placing a mesh implant to achieve the best treatment result ($p<0.001$) [37,38].

The inlay method involves suturing the edges of the implant to the edges of the hernia defect without approximating the muscular aponeurotic structures. The method is not widely used in surgical practice due to the high number of relapses, which mainly occur at the edges of mesh implant fixation. A meta-analysis of 21 studies demonstrated a higher risk of infectious complications [95% CI 1.113 (0.088–3.833)] and relapses [95%CI 3.946 (0.487–13.256)] when installing a mesh implant using the inlay method [38]. According to the results of the study by Sosin et all (2018), it was shown that the use of the inlay technique is associated with a high rate of complications and relapses. The review included 20 retrospective studies involving 821 patients. The average size of the hernia defect was 112.2 ± 5.9 cm^2, the average BMI was 30.3 ± 1.4 kg/m^2, 53.5% of patients were women. The average complication rate was 39.1%, the average postoperative wound infection rate was 12.0%, and the average hematoma/seroma rate was 12.2%. The study demonstrated

the highest relapse rate (21.6%) when using the inlay technique compared to other methods of installing a mesh implant (p=0.023) [32], [38], [39].

The sublay technique is the placement of a mesh endoprosthesis behind the rectus abdominis muscles, but in front of the posterior plate of the rectus abdominis muscle sheath. Below the linea arcuata, the endoprosthesis is located between the rectus muscles and the transverse fascia. Access to the retromuscular space allows the edges of the hernia defect to be aligned and the linea alba to be restored, which reduces pressure on the suture line. Along with this, the retromuscular space is well vascularized, which leads to better integration of the mesh implant into the surrounding tissue. Initially, this technique was performed exclusively in an open manner, but the development of endovideosurgical technologies led to the emergence of extended totally extraperitoneal plasty (eTEP) technique. This access made it possible to achieve a reduction in pain and the incidence of purulent complications [40]–[42]. In a meta-analysis of 14 studies, the authors reported that the use of sublay space for mesh implant placement demonstrated the lowest risk of recurrence [95% CI 0.218 (0.061–0.465)] and SSI [95% CI 0.449 (0.118–1.155)] compared to other methods [38]. Another systematic review of 28 studies analyzed 2234 patients who underwent retromuscular hernia repair for ventral hernia. The average size of the hernia defect was 287.4 ± 26.3 cm2, the average BMI was 32.6 ± 1.8 kg/m2, 55.0% of patients were women. The percentage of hernia recurrence was 5.8% with a mean follow-up period of 18.0 ± 4.8 months [38].

The IPOM technique involves placing the endoprosthesis intraperitoneally and fixing it to the anterior abdominal wall. The main requirement for this type of hernia defect correction is the use of composite non-adhesive mesh prostheses, since the implant is in no way delimited from the internal organs. Unfortunately, the use of this type of mesh implants makes this hernioplasty technique expensive and less accessible to patients [32], [43], [44].A meta-analysis by Holihan et al. (2015), showed that in 15 out of 21 publications. The IPOM technique has demonstrated a low risk of relapse [95% CI 0.59 (0.069–1.504)] and SSI [95% CI 0.878 (0.291–1.985)], as in the group of patients with retromuscular hernioplasty [37,38]. In a

systematic review by Sosin et all (2018), including 2700 patients, the following rates of complications and relapses were observed: the average rate of infection was 17.7%, and the average rate of hematoma/seroma formation was 11.5%, relapse after IPOM hernioplasty was 10.9% with an average follow-up period of 24.1 ± 6.2 months, which was the second lowest indicator after a group of patients with retromuscular hernioplasty [38].

The analysis of the literature showed that the use of mesh implants is safe and effective in hernioplasty of ventral hernias, and the specific anatomical location of the mesh implant in the layers of the anterior abdominal wall affects the results of surgical treatment. Research results have demonstrated that the location of the mesh implant in the sublay or IPOM spaces is preferable. However, the retromuscular space can be assessed as a more advantageous option for placing a mesh implant due to the low likelihood of relapse and wound complications [37,38].

1.3 Evolution of minimally invasive surgery for ventral hernias and the role of standardization in herniology.

1.3.1 History of the development of retromuscular hernioplasty.

The modern history of retromuscular hernioplasty begins with two French surgeons whose names are now synonymous with surgery. They began their surgical careers in Algeria, then a French colony, before moving to France. Both had extensive experience teaching anatomy with overlapping surgical interests beyond ventral hernia repair. Jean Rives became head of the department of surgery at the University of Reims in 1964. His first major contribution concerned the use of a mesh implant in the preperitoneal space for inguinal hernias using a midline approach [45].

Rene Stoppa, another famous Frenchman, became the chief surgeon of the University of Amiens in 1965. In 1968, together with J. Rives, he published his first results of the use of Dacron patches in the preperitoneal space [45]. In 1984, the experience of two highly experienced surgeons and their teams in the repair of inguinal hernias led to the joint publication of a research paper [46]. Jean Rives and

Rene Stoppa's initial work on inguinal hernia repair and their familiarity with the extraperitoneal space likely inspired them to expand their surgical practice to ventral hernias. Jean Rives was not only an experienced anatomist, but also an excellent artist. He himself created most of the illustrations for his articles, which accurately depicted surgical steps and techniques. In one of his early surgical illustrations, Rives demonstrated reconstruction of the posterior fascia using the posterior aponeuroses of the rectus sheath, thus implying that the purpose of this reconstruction was only to isolate the mesh implant and not to strengthen the repair itself, a concept widely accepted today [47].

That is why in modern literature hernioplasty with a retromuscular placement of a mesh endoprosthesis is called the “Rives-Stoppa operation” [45].

However, surgeons still face technical problems when performing the Rives-Stoppa procedure. The most difficult problem in herniology has been and remains the treatment of patients with large and giant ventral hernias. With long-term existence of hernias of this type, a significant part of the internal organs is located in the hernial sac outside the abdominal cavity. After hernioplasty, intra-abdominal pressure increases significantly, which is the main pathogenetic factor in the recurrence of such hernias. In modern literature, this condition is called loss of domain. Trying to solve this problem, A. M. Carbonell and Y. W. Novitsky successfully complemented the Rives-Stoppa operation with their own variants of posterior separation plastics to reduce tissue tension when suturing the hernial orifice and increase the volume of the abdominal cavity [48].

A. Carbonell separated the posterior plate of the aponeurosis of the internal oblique muscle to expand the coverage of the mesh implant on the sides, moving into the space between the transverse abdominis muscle and the internal oblique muscle [49].

In 2006, Y. Novitsky first performed transversus abdominal release (TAR) at the University of Connecticut and first presented this technique at the joint meeting of the American Hernia Society and the European Hernia Society in Berlin in 2009, receiving mixed reactions [50]. Y. Novitsky's team published the technique with

initial results in 42 cases in 2012 and a follow-up paper with 428 cases in 2016 [51,52]. The TAR technique has allowed the closure of very large and complex hernia defects while at the same time providing unprecedented coverage with a mesh implant.

In connection with the development of minimally invasive techniques, retromuscular hernioplasty for ventral hernias began to be performed in the endovideosurgical version. J. Daes in 2012 first described and applied surgery using an extended total extraperitoneal approach (eTEP) for inguinal hernia [53]. Later, this approach was modernized for use in ventral hernias. In 2018, I. Belyansky et al. described a new endovideosurgical approach eTEP, allowing to perform the Rives-Stoppa operation [54]. eTEP access has become widespread worldwide [55]–[59]. In Russia, endovideosurgical access eTEP was successfully introduced into surgical practice among the Russian society of herniologists V.A. Burdakov [60], [61].

1.3.2 Standardization of surgical manuals based on the “Critical View of Safety” concept

The age of minimally invasive surgery brought with it a huge number of new techniques and breakthroughs in surgery, but could not completely solve the problem of complications. Surgery remains one of the riskiest types of medicine, both for patients and doctors. We must now change the direction of the entire surgical approach: safety must become the central ideology and the main criterion for making all decisions. This does not mean that we should forget the importance of calculated risk in surgery, but rather that we need to increase the degree of systematic risk analysis and management.

Surgical safety consists of several components that play an important role in the development of complications. Various factors have a significant impact on the safety of surgery, and the effectiveness of measures used by different participants in the treatment process may differ in real clinical practice. Standardization of surgical procedures is one of the important tasks, and the question of assessing the quality and safety of the operation also arises.

Modern surgical discussion is faced with the following key questions: what components constitute surgical safety, what factors influence the development of complications, what points of application are most effective for all participants in the treatment process, how to standardize the surgical approach and how the quality and safety of the operation can be assessed.

The introduction of the “Critical View of Safety” (CVS) concept and the standardization of operative techniques when performing laparoscopic cholecystectomy brought significant changes to the practice of surgeons, reducing postoperative complications, quickly mastering and developing the technique around the world [62].

The concept of safe cholecystectomy was proposed in 1995 by American surgeon Stephen Strasberg, who examined the risks and complications associated with this operation and also proposed practical recommendations for minimizing them. He developed risk assessment methodology and developed a systematic approach to safe cholecystectomy. Standardization of the operative approach has played an important role in reducing postoperative complications. Protocols and recommendations have been developed to determine the optimal method of performing the operation, standard safety procedures and quality control [62,63].

The introduction of the concept of safe cholecystectomy and standardization of the surgical approach have significantly increased the level of safety and effectiveness of laparoscopic cholecystectomy. The number of complications associated with the operation, such as bleeding, infection, damage to the common bile duct and other important structures, was significantly reduced [63,64].

The fundamental principles of safe cholecystectomy and standardization of the surgical approach can be applied to the treatment of other surgical pathologies, such as ventral hernias. The development of endovideosurgical techniques and the complication of surgical techniques require the introduction of precise and standardized action algorithms. Surgical risks can be reduced and the efficiency and safety of surgery improved by following the standards and protocols established in research conducted in the field of safe cholecystectomy [64-66].

1.3.3 Results of the use of retromuscular hernioplasty in the global community of surgeons

Duration of surgery and hospitalization

A longer operation is characterized by higher costs and longer anesthesia. eTEP access is a high-tech method that requires highly trained surgeons and the use of modern equipment. The operation time using eTEP access is significantly higher than when performing open Rives-Stoppa hernioplasty [35], [41], [55]. However, due to the fact that surgery using eTEP access is less invasive, the time to restore the patient's functional capabilities and, accordingly, the length of hospitalization is significantly shorter [40], [67]–[69].

In a study by A. Addo et all, based on a retrospective analysis of medical records of 65 patients, it was proven that hospitalization time when using eTEP access was significantly lower than when using open sublay plastic surgery (3.6 days vs 5.3 days, $p = 0.03$) [35].

S. J. Zolin et all compare open and endovideosurgical methods for hernioplasty of primary ventral hernias based on data from 186 patients and conclude that hospitalization time is significantly shorter in the group of patients operated on using endovideosurgical access ($p < 0.001$)[70].

Pain syndrome in the early postoperative period

Endovideosurgical approaches are accompanied by less trauma to soft tissues, which causes less severe pain in the postoperative period. A lot of studies show that in the early postoperative period, patients operated on using eTEP access, do not experience significant pain [6], [42], [67], [71]. The lack of fixation of the mesh implant and minimization of skin damage during the eTEP approach may be the reason for the low level of postoperative pain syndrome [72]. According to Kumar N. et al. [68] on the first postoperative day, pain was assessed at 2,8 points, in the study Radu V. G. et al.[56] the mean visual analogue scale (VAS) pain score was 2,55 points. In a retrospective analysis, S. J. Zolin et all assessed the intensity of pain using the PROMIS scale. The average value in the group of patients operated on

using open retromuscular plastic methods is higher (43,5 versus 36,6), but no statistically significant differences were found (p=0.240) [71, 73].

Postoperative complications

According to the recommendations of the European Herniological Society, the Rives-Stoppa technique is the "gold standard" for open hernioplasty. This is explained by the lowest number of relapses, purulent complications, seromas, and hematomas among all other methods of open plastic surgery. There are a large number of studies comparing various open methods. However, there are not many studies comparing the early and long-term results of open and endovideosurgical procedures, which is associated with rapidly developing technologies and the constant emergence of new methods of surgical treatment of hernias of the anterior abdominal wall.

According to a systematic review M. Sosin et al.,[74] including 6227 patients, the following rates of complications were identified (Table 1):

Table 1 - Frequency of complications according to M. Sosin et al. [74]

	Percentage of complications
Open access:	
Seroma/hematoma, (%)	11.0%
Infectious complications, (%)	12.1%
General complications, (%)	37.0%
Endovideosurgical access:	
Seroma/hematoma, (%)	3.3%
Infectious complications, (%)	0.1%
General complications, (%)	6.2%

The reduction in the number of complications when using the endovideosurgical approach is explained rather by the sample size: 94.2% of patients in this study underwent surgery using an open approach, and only 5.8% had an endovideosurgical approach.

In the work of V. A. Burdakov, in a group of 138 patients, seroma occurred in 2.2% of cases, chronic pain syndrome occurred in 4 patients (2.9%), hematoma - in 2 patients (1.45%). This study provides data only on patients operated on using the eTEP approach [67].

In a systematic review by S. Sauerland, the author obtains statistically significant results (RR = 0.26; 95% CI 0.15 to 0.46; I^2 = 0%) and comes to the conclusion that the use of endovideosurgical access is associated with a significantly lower number of infectious complications compared to the use of open access [75].

Occurrence of recurrence

The frequency of hernia recurrence is the most important characteristic of the success of surgical intervention. According to a systematic review by M. Sosin et al, the highest percentage of relapses is observed when using onlay and inlay techniques. Comparing the open Rives-Stoppa technique and eTEP access, the author points to a higher percentage of relapses when using the sublay technique, however, the sample size for the study does not allow us to say this with confidence [74].

Among the studies on eTEP access (V.A. Burdakov et al.: 138 patients - 0 relapses, B.B. Orlov et al.: 202 patients - 1 relapse, E. Chelala et al.: 1101 patients - 52 relapses), the authors report a low relapse rate using this technique [42], [68], [76].

1.4 Use of tumescent solution for local anesthesia of soft tissues

Due to the rapid development of modern technologies, minimally invasive methods of surgical treatment of hernias of the anterior abdominal wall are being increasingly developed. However, despite the minimal invasiveness of the operations, due to the large endoscopic volume of soft tissue dissection and total reconstruction of the anterior abdominal wall, patients experience discomfort and pain in the surgical area. Pain in the early postoperative period significantly reduces the patient’s quality of life, increases rehabilitation time, hospitalization, and the

number of wound complications, which requires additional anesthesia and observation of the patient in a surgical hospital. In recent years, more and more anesthesiologists around the world are implementing the concept of multimodal anesthesia, which implies multi-level antinociception, in which the maximum effect is combined with a minimum of side effects and is achieved through the use of diluted solutions with low dosages of drugs [77].

Unlike conventional local anesthesia (LA), in which the maximum dose of anesthetic is achieved quickly and anesthesia occurs only in small areas of soft tissue, tumescent anesthesia (TA) allows anesthesia to be administered over a larger volume of patient tissue with the development of a long-lasting analgesic and anesthetic effect. Tumescent anesthesia is used in many areas of surgery and is based on the use of a combination of local anesthetic and adrenergic agonist (Klein solution) - lidocaine, adrenaline or their derivatives, which are injected layer by layer into the skin, subcutaneous tissue, muscles and aponeurosis. The essence of the method is the infiltration of soft tissues with a significant amount of tumescent solution. As a result of increased interstitial pressure, the tumescent solution is distributed throughout the soft tissues. As a result, the effect of the so-called “tumescence” develops - an increase in the volume and elasticity of soft tissues, which makes it easier for the surgeon to perform dissection during surgery and helps prevent or reduce the intensity of pain. Ropivocaine in the tumescent solution blocks nociception in a certain area of the body by stabilizing the neuronal membrane and reduces its permeability to sodium ions, which prevents the occurrence of action potentials and the transmission of pain impulses. The TA technique reduces the risk of intraoperative bleeding or in the early postoperative period through the use of adrenaline. Adrenergic agonist causes intense local vasoconstriction due to the activation of alpha receptors, and thereby slows down the systemic absorption of the local anesthetic, which reduces the peak concentrations of lidocaine in the blood serum, reducing the risk of systemic toxicity of the anesthetic and providing a prolonged antinociceptive effect [78].

In 1892, German surgeon C.L. Schleich was the first to describe the TA technique using cocaine as an analgesic [79]. However, due to the advent of ether anesthesia at that time, his ideas were not further developed and were revived only in 1987 by the American plastic surgeon J. Klein, who successfully used lidocaine instead of cocaine for liposuction [80]. Since then, the technique of tumescent anesthesia has gained popularity due to its safety, effectiveness and low number of side effects. Over time, the dosage of local anesthetic was gradually reduced while maintaining the same effect, and automatic pump infiltration systems facilitated the treatment of large soft tissue areas. So, in 1984, the German surgeon Gerhar Sattler introduced the method of liposuction using a roller pump.[81] In 1998, Breuninger developed a modification of the TA technique using infusion devices with controlled flow and volume of injected solution. He used Ringer's solution as the base of the tumescent solution without adding sodium bicarbonate and introduced into the local anesthetic mixture the long-acting anesthetic ropivacaine, which has been on the medical market since 1994. Due to its long-lasting effect, local anesthesia using a modern tumescent solution when used intraoperatively makes it possible to provide a high-quality level of pain relief in the early postoperative period - eliminating the need for analgesics on the 1-2 postoperative day, which contributes to early rehabilitation and recovery of the patient [82]. However, like any other anesthesia technique, tumescent anesthesia has certain advantages and disadvantages. Its main advantage is a high safety indicator for patients, which is associated with the absence of a systemic effect of the tumescent mixture on the cardiovascular system. The disadvantages of the technique are the possibility of using a limited amount of tumescent solution and the likelihood of developing an allergic reaction to the anesthetic [77].

The need and relevance of using a tumescent solution in clinical practice is confirmed by the results of modern research. In 2010 Cepeda M.S. et al. conducted a meta-analysis of 23 studies that compared the intensity of pain during local anesthesia using lidocaine. The patients were divided into two groups - with and without adjustment of the pH of the administered anesthetic mixture in children and

adults. Adjusting pH buffering meant adding sodium bicarbonate solution to the anesthetic mixture. The results of the meta-analysis demonstrated that patients receiving buffered lidocaine reported significantly less pain than those receiving unbuffered lidocaine. The reduction in pain intensity was more pronounced in the group of patients receiving lidocaine with epinephrine (tumescent solution). In the eight crossover studies included in the meta-analysis, patient survey results showed patient preference for buffered lidocaine in tumescent solution ([OR] 3.0, 95% CI 1.2-4.2). The authors noted significant heterogeneity in the results during the analysis, which was not explained by the risk of bias of individual studies, the amount of lidocaine administered, or the type of procedure performed. Therefore, the authors conclude that when using lidocaine for local anesthesia during urgent or non-urgent medical procedures, it is recommended to combine the anesthetic with an adrenergic agonist, buffer the injected solution with sodium bicarbonate, and prewarm the anesthetic mixture to approximately body temperature before injection [83].

The results of international studies in recent years demonstrate the effectiveness of the tumescent solution in infiltrating postoperative wounds in a number of surgical interventions. Thus, in a randomized clinical trial (RCT) Lau et al. (2003) found that postoperative subfascial wound infusion of 0.5% bupivocaine provided superior analgesia compared with oral analgesics after inguinal hernia repair [84]. In another study, Schurr et al. (2004) demonstrated that continuous infusion of local anesthetics after inguinal hernia repair reduced pain intensity and increased functional scores compared with placebo. However, these effects are limited and were observed only on the 1st postoperative day [85]. In a study of 222 patients undergoing anorectal surgery, Lohsiriwat et al. (2007) found that infiltration of the perianal area with a local anesthetic solution allows for safe and effective one-day surgery with a low incidence of urinary retention [86]. In a study by Legeby et al. (2009) results showed that the use of levobupivacaine as a local anesthetic after breast reconstructive surgery every three hours in addition to paracetamol and morphine resulted in improved pain relief at rest and with movement compared with

placebo[87].Thus, the results of systematic reviews and meta-analyses in recent years demonstrate that local anesthetics are effective when administered intraarticularly, intraperitoneally, or perianally for the relief and prevention of pain in the early postoperative period.

1.5 Conclusion

Endovideosurgical operation using eTEP access is a modern and high-tech method, the advantages of which are demonstrated by many studies. However, due to the recent introduction of this method, studies on this topic are few and often contradictory. That is why it is advisable to continue studying this topic, and, in particular, to compare early and long-term postoperative results between open and endovideosurgical methods of retromuscular hernioplasty of ventral hernias.

Chapter 2. Materials and research methods

2.1 General research methodology

Scientific work was carried out at the Department of Faculty Surgery of the Federal State Budgetary Educational Institution "St. Petersburg State University" on the basis of the 1st surgical department of the Federal State Budgetary Institution "L.G. Sokolov North-Western Regional Scientific and Clinical Center" of the Federal Medical and Biological Agency of Russia in 2018–2023. The study included 187 clinical observations of patients with ventral hernias.

The criteria for inclusion of patients in the study were the presence of a clinically and instrumentally confirmed ventral hernia - primary or postoperative, as well as voluntary informed consent of the patients to participate in the study.

Exclusion criteria were: age under 18 years, presence of recurrent ventral hernia, lateral ventral hernia; hospitalization for emergency reasons, including strangulated hernia; planning a simultaneous operation; stay in the intensive care unit after surgical treatment; lack of patient consent to participate in the study; absence of one or both rectus abdominis muscles; lack of surgical space to unite the sheaths of the rectus abdominis muscles (crossover procedure); condition after a previous Rives-Stoppa operation.

All patients received comprehensive information about existing methods of treating patients with ventral hernias, the possible consequences, outcomes and complications of each of them. The risks of refusing surgical treatment were explained to the patients. After the conversation, the patients signed an informed consent for surgical treatment and participation in the study, approved by the Ethics Committee of St. Petersburg State University in accordance with the Declaration of Helsinki (Helsinki, Finland, 1964).

Improving treatment methods for sick ventral hernias remains relevant, and therefore it was decided to introduce a relatively new technology of endovideosurgical retromuscular hernioplasty [55], [56], [59], [69], [70], [72], since existing studies only indirectly show its advantages relative to reliable open Rives-

Stoppa hernioplasty in reconstruction of the anterior abdominal wall [5], [6], [8], [32], [45]. This study was designed on the principle of prospective comparison of the clinical results of using these techniques separately in patients with primary ventral hernias and postoperative ventral hernias. The principles of surgical techniques do not differ from each other, which suggests that the endovideosurgical approach is as effective as with open retromuscular hernioplasty. In addition, the endovideosurgical approach is theoretically accompanied by less trauma than its open counterpart, which made it possible to expect better recovery results for patients both in the early and late postoperative period.

In 2018, the surgical team of the department began recruiting a study group of patients with endovideosurgical hernioplasty using the eTEP approach; in parallel, a control group of patients with traditional open retromuscular Rives-Stoppa hernioplasty was formed. The control and study groups were divided into two groups depending on the disease, namely a group with a primary ventral hernia and a group of patients with a postoperative ventral hernia. From 2018 to 2023, a study group consisting of 66 patients and a control group consisting of 56 patients were formed. Median follow-up in both groups was 24 months (range 12–48 months). The distribution of patients into the control and study groups was performed using block randomization.

2.2 Preoperative examination of patients with ventral hernias.

All patients included in the study were examined on an outpatient basis according to the standard preoperative preparation protocol: general clinical blood and urine tests; biochemical blood test (glucose, total protein, total bilirubin, alanine aminotransferase, aspartate aminotransferase, potassium, sodium, creatinine, urea); coagulogram; blood test for markers of viral hepatitis B and C, human immunodeficiency virus, syphilis; blood type and Rh factor; electrocardiography (ECG); chest x-ray; fibrogastroduodenoscopy, computed tomography of the abdominal and pelvic organs, consultations with a general practitioner, anesthesiologist and resuscitator. The scope of the examination was expanded if it

was necessary to clarify the patient's comorbid status (ECHO-CG, Holter monitoring of ECG, FRP; study of glycated hemoglobin levels; consultations with specialists). In addition to the standard examination, after the operation the quality of life was assessed according to the Quality of Life (EuraHSQoL) scale proposed by the EHS [88], which includes two blocks of questions. The purpose of the questionnaire is to assess the patient's quality of life in the long-term postoperative period, namely the level and duration of pain after discharge, the rate of return of functional abilities, subjective assessment of the level of one's own health and the occurrence of relapse.

All patients underwent computed tomography of the abdominal cavity and pelvis with oral or intravenous contrast in the preoperative period. Computed tomography of the pelvis was an optional study and was used when the hernia defect spreads in the lower abdomen. It was mandatory to evaluate: the localization of the hernia defect; the distance of the hernial orifice relative to the xiphoid process and the pubic symphysis; size of the hernial orifice and protrusion; thickness of the rectus muscles. The obtained research data made it possible to rank the size of the hernia defect according to the EHS classification (2009) and, depending on this, determine the surgical method. In addition, patients undergoing retromuscular hernia repair using the eTEP approach underwent preoperative marking based on the results of computed tomography, which made it possible to accurately localize the trocars to optimal positions (Figure 2).

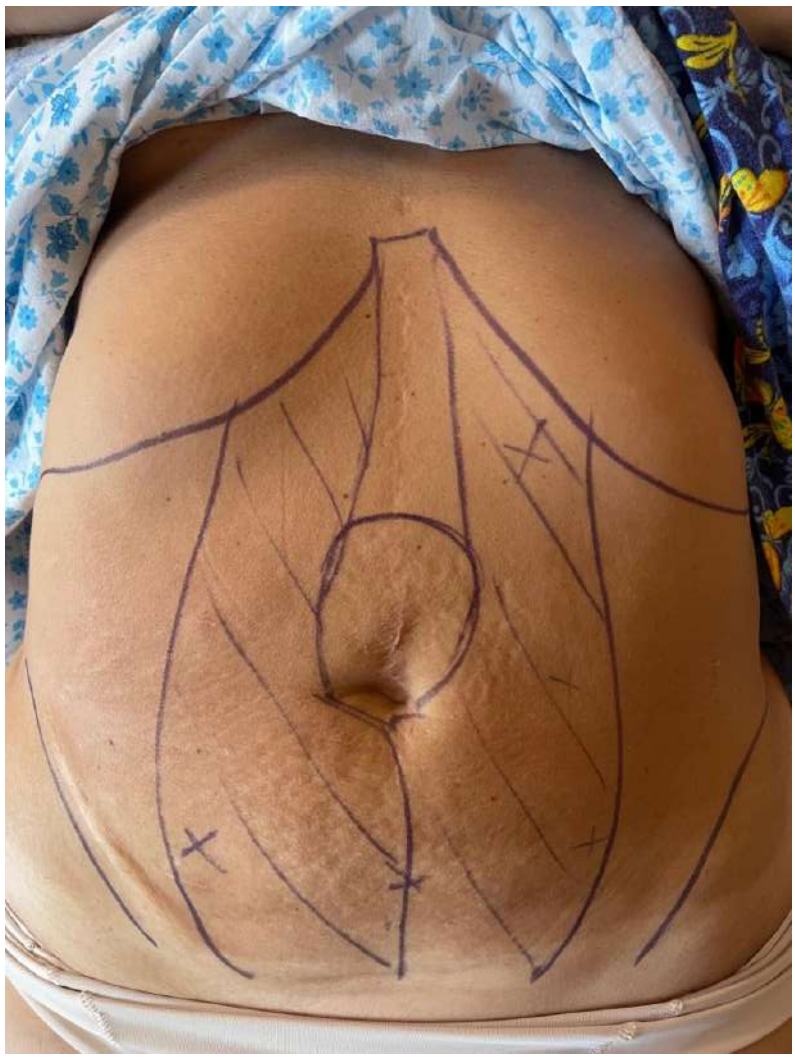


Figure 2 – Preoperative markings for a patient with a postoperative ventral hernia

2.3 Technique for performing open retromuscular hernioplasty for ventral hernia.

Open retromuscular hernioplasty (operation Rives-Stoppa, Sublay hernioplasty) has taken a well-deserved championship both in the surgery of primary ventral hernias and postoperative ventral hernias. The surgical technique has been thoroughly studied and is routinely used by surgeons in hospitals.

The surgical procedure begins with a laparotomy incision through the skin, subcutaneous fat to the anterior wall of the rectus abdominis vagina. The sheaths of the rectus abdominis muscles are opened and the retromuscular space is dissected. The scale of dissection in the upper and lower directions depends on the size and localization of the hernial orifice; lateral dissection is carried out to the edges of the

rectus abdominis muscles in a blunt manner, in order to avoid trauma to the neurovascular bundles located at the lateral edge of the rectus abdominis muscle. Thus, a single retromuscular space is created for the subsequent installation of a mesh implant and maximum coverage of the hernia defect [35].

The mesh endoprosthesis is placed in the retromuscular space and sutured with interrupted sutures to the posterior plates of the sheath of the rectus abdominis muscles along the periphery. Fixation of the mesh is necessary for complete expansion and correct positioning of the mesh implant [32], [89].

The retromuscular space is drained. The anterior layers of the rectus abdominis sheaths are sutured. The anterior abdominal wall is sutured layer by layer [40], (Figure 3).

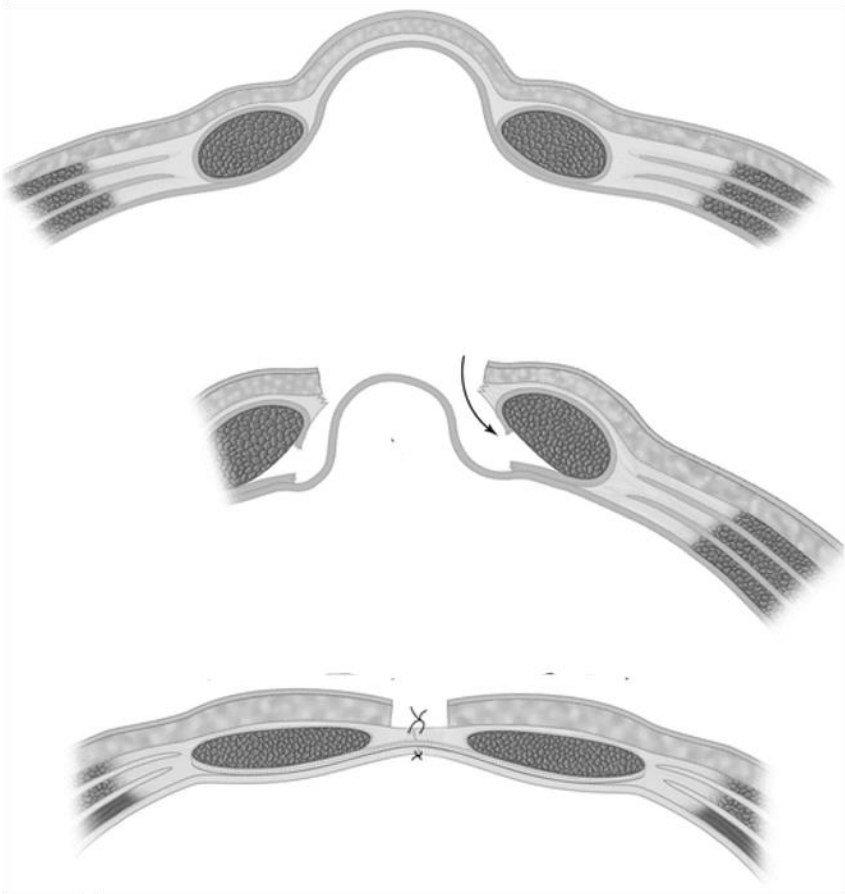


Figure 3 - Sequence of the main stages of Rives-Stoppa hernioplasty.

2.4 Technique for performing endovideosurgical retromuscular hernioplasty using the eTEP approach

To perform retromuscular hernioplasty using the eTEP approach, a 10mm incision is made in the projection of the rectus muscle in the left mesogastrium. Using an optical trocar or an open method, access is made to the left retromuscular space, a 12 mm trocar is installed and CO_2 insufflation is performed at a pressure of 14 mm Hg. Art. [42], [54], [90]. With the inserted laparoscope, optical dissection of the left retromuscular space is performed in a blunt manner to install 5-mm ports (Figure 4) [6], [42], [54], [90].

A clinically significant feature of the anatomical structure of the rectus abdominis muscles is the presence of neurovascular bundles passing laterally along the posterior surface. This feature must be taken into account when performing retromuscular dissection in order to avoid both bleeding in the intraoperative period and disruption of the innervation of this area in the postoperative period [6], [13].

Despite its apparent simplicity, the anterior abdominal wall is a difficult area to perform surgical interventions. The anatomy of this area has a large number of features that must be taken into account for successful surgical treatment.

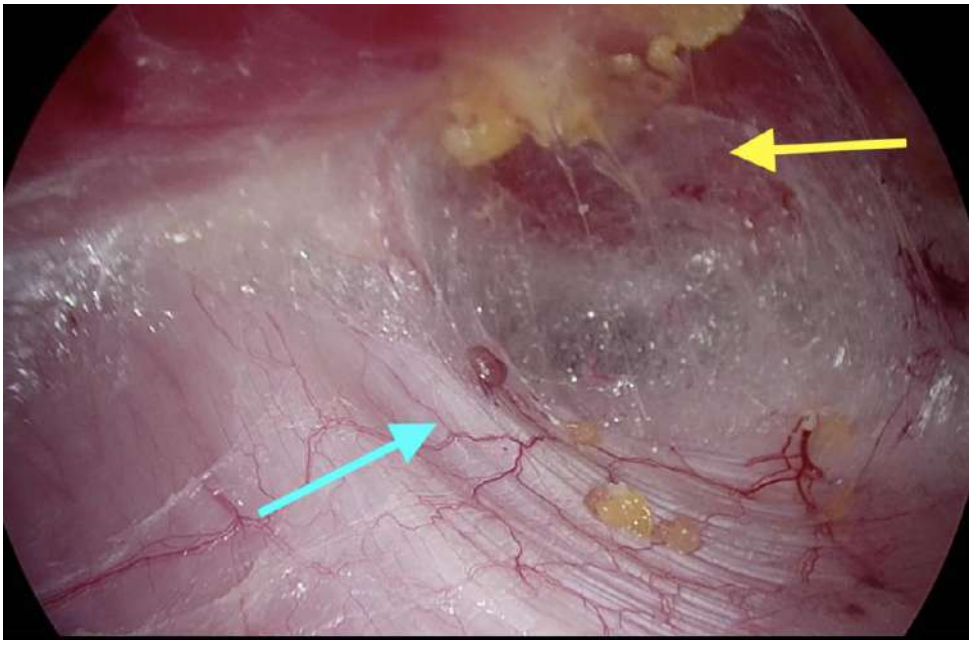


Figure 4 - Formation of the retromuscular space: posterior wall of the rectus sheath (blue arrow), left rectus abdominis muscle (yellow arrow).

Depending on the location of the hernia defect, it is possible to perform 2 options for transition to the opposite retromuscular space (Figure 5, Figure 6):

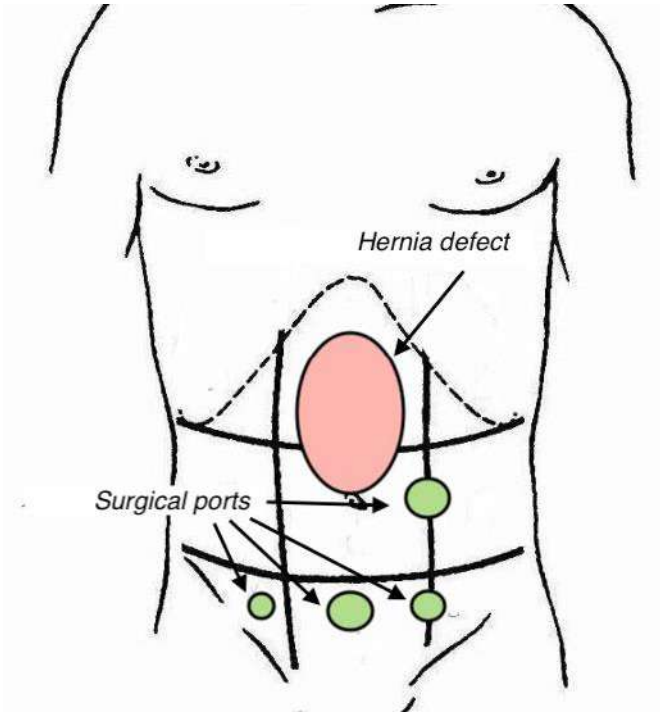


Figure 5 - Option for installing ports with a lower crossover

1. While maintaining the integrity of the abdominal wall and localization of the hernial orifice in the upper part of the anterior abdominal wall, the first 5-mm port is installed in the left iliac region medial to the semilunar line. The dissection continues downwards towards the space of Retzius, where a 10 mm trocar and a 5 mm trocar are placed at a distance of about 2-3 cm above the pubic symphysis and a 5 mm trocar in the right iliac region lateral to the Spigelian line. After the trocar placement has been completed, it is possible to perform a lower crossover, namely, a transition to the left retromuscular space.

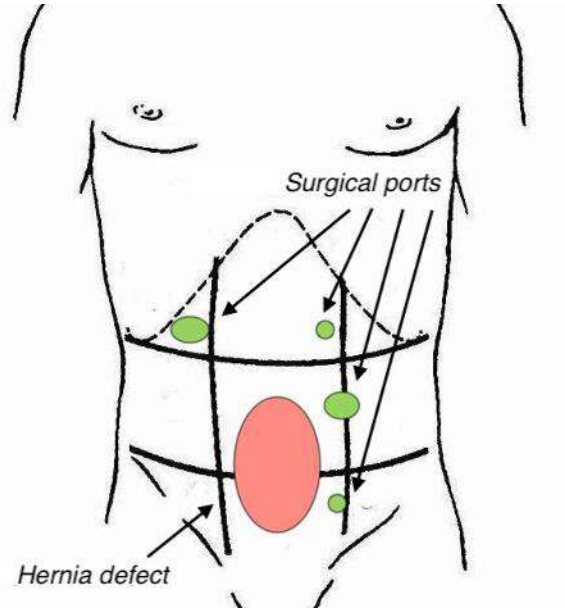


Figure 6 -Port installation option for upper crossover

2. If the integrity of the abdominal wall is compromised below the line of Douglas and the hernia defect is localized at a distance of 7 cm or more from the xiphoid process, an upper crossover is performed. After optical dissection has been performed in the left retromuscular space, a 5-mm trocar is installed in the left hypochondrium. The execution of the upper crossover continues by crossing the posterior plates of the sheaths of the rectus abdominis muscles and moving into the opposite retromuscular space. To continue the formation of a single retromuscular space, a 10 mm trocar is installed in the right hypochondrium [54], [90].

The next stage is the formation of a single retromuscular space with visualization and evacuation of the hernial sac (Figure 7). In the presence of peritoneal defects, suturing is performed with a continuous absorbable suture.

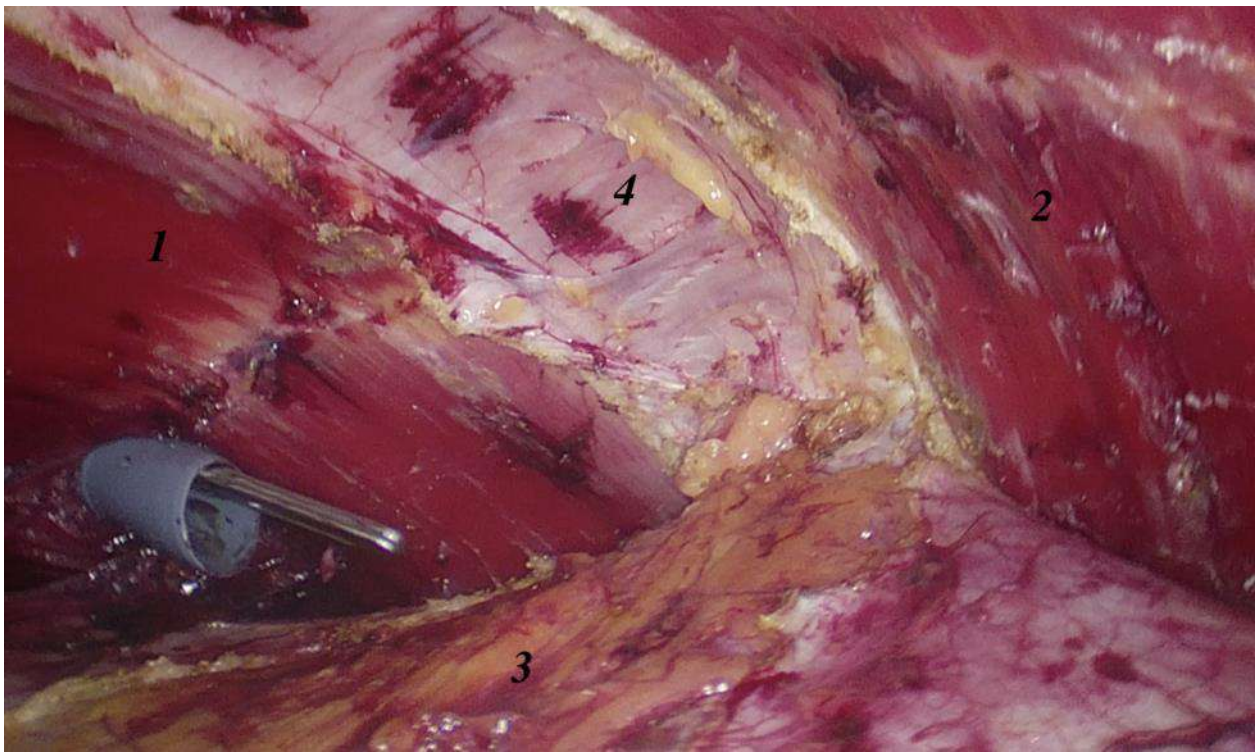


Figure 7 - Anatomy of the retromuscular and preperitoneal spaces (formation of a single space): right (1) and left (2) rectus abdominis muscles, ligamentum falciforme (3), linea alba (4).

The possibility of suturing a defect in the posterior wall without tension is assessed by comparing the fascial sheets. If it is impossible to compare the posterior layers of the sheath of the rectus abdominis muscles, uni- or bilateral posterior separation of the transverse abdominal muscles (transversus abdominis release) is performed. The next step is continuous suturing of the hernia defect of the white line of the abdomen and diastasis of the rectus abdominis muscles using a non-absorbable thread with a notch (Figure 8) [54], [90].

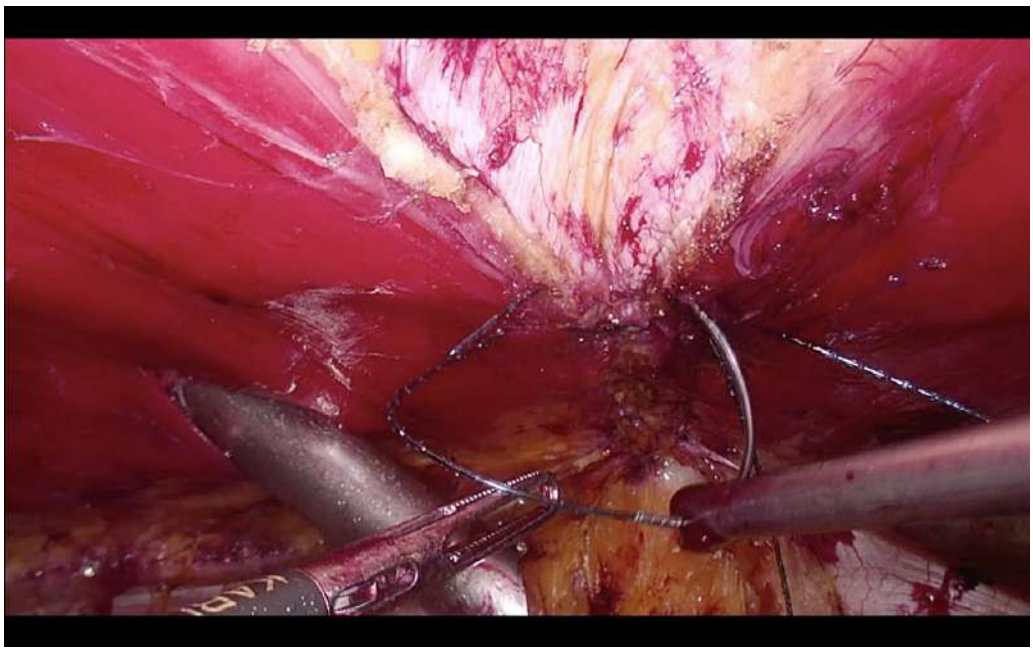


Figure 8 - Restoration of the white line of the abdomen

A sterile measuring tape is inserted through a 12 mm trocar to accurately determine the size of the mesh implant to be installed. Next, the endoprosthesis is inserted and straightened in the retromuscular space (Figure 9). Fixation of the mesh implant is not necessary with this technique. Drainage is installed in this space, desufflation is performed under visual control, and layer-by-layer sutures are applied to the wounds [54], [90].

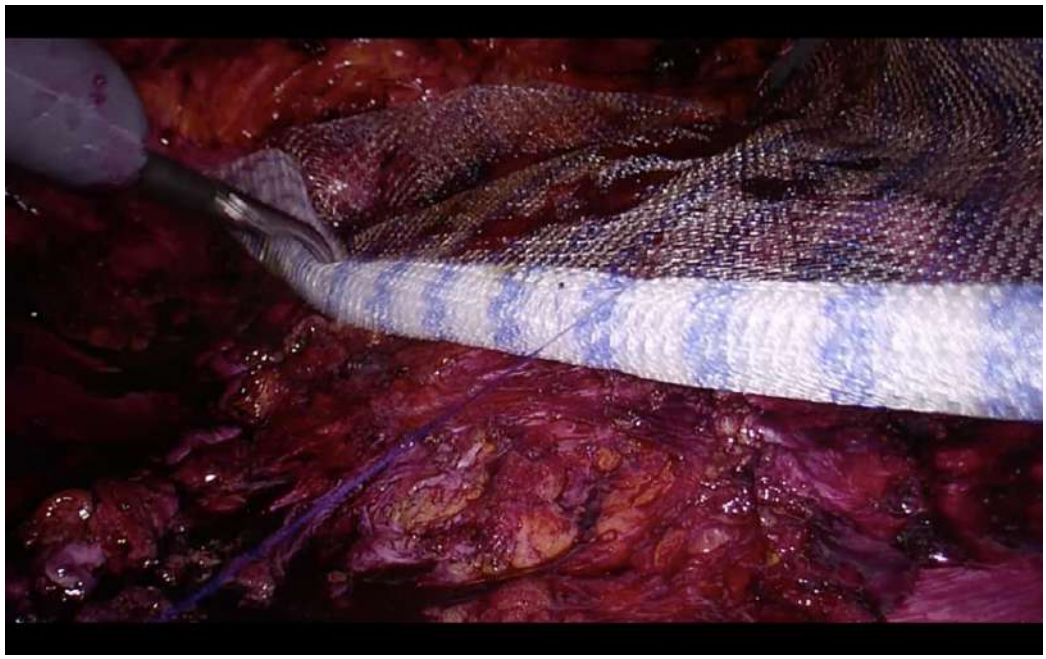


Figure 9 - Installation of a mesh implant in the retromuscular space

2.5 Specific anatomical landmarks in the context of performing endoscopic retromuscular hernioplasty

When performing retromuscular hernioplasty using the eTEP approach, it is necessary to remember specific anatomical landmarks, which can significantly help the operating surgeon.

The “lamppost” sign describes the position of the neurovascular bundles that perforate the rectus abdominis muscle posteriorly along its lateral edge (Figure 10). These bundles first run vertically and then, under the influence of insufflation, bend medially along the posterior surface of the rectus abdominis muscle, resembling lamp posts. Preservation of these bundles during retromuscular dissection is necessary in order to avoid bleeding in the intra- and postoperative period and disruption of the innervation of the rectus abdominis muscle in the postoperative period [58], [90].

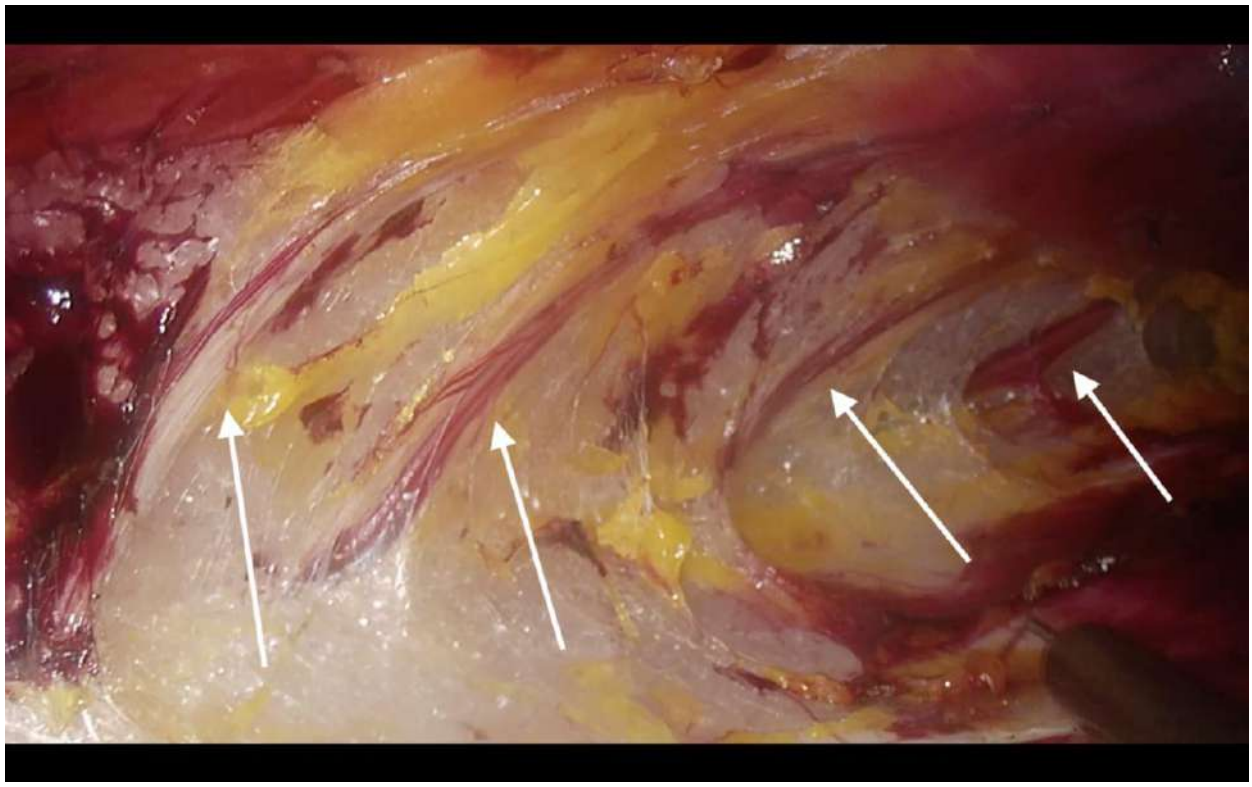


Figure 10 – Left rectus abdominis muscle, perforated by neurovascular bundles (white arrows)

The volcano symptom is a landmark for the localization of the hernia defect (Figure 11). Morphologically, the “volcano” symptom is a hernial sac covered with yellow fat of the falciform ligament, surrounded medially by the cut edges of the posterior aponeurosis of the rectus abdominis muscles. In a technically complex surgical procedure, correct identification of this sign serves as a guide to continue dissection in the preperitoneal plane, minimizing the size of defects in the posterior layer requiring closure, or allowing their formation to be completely avoided [91].

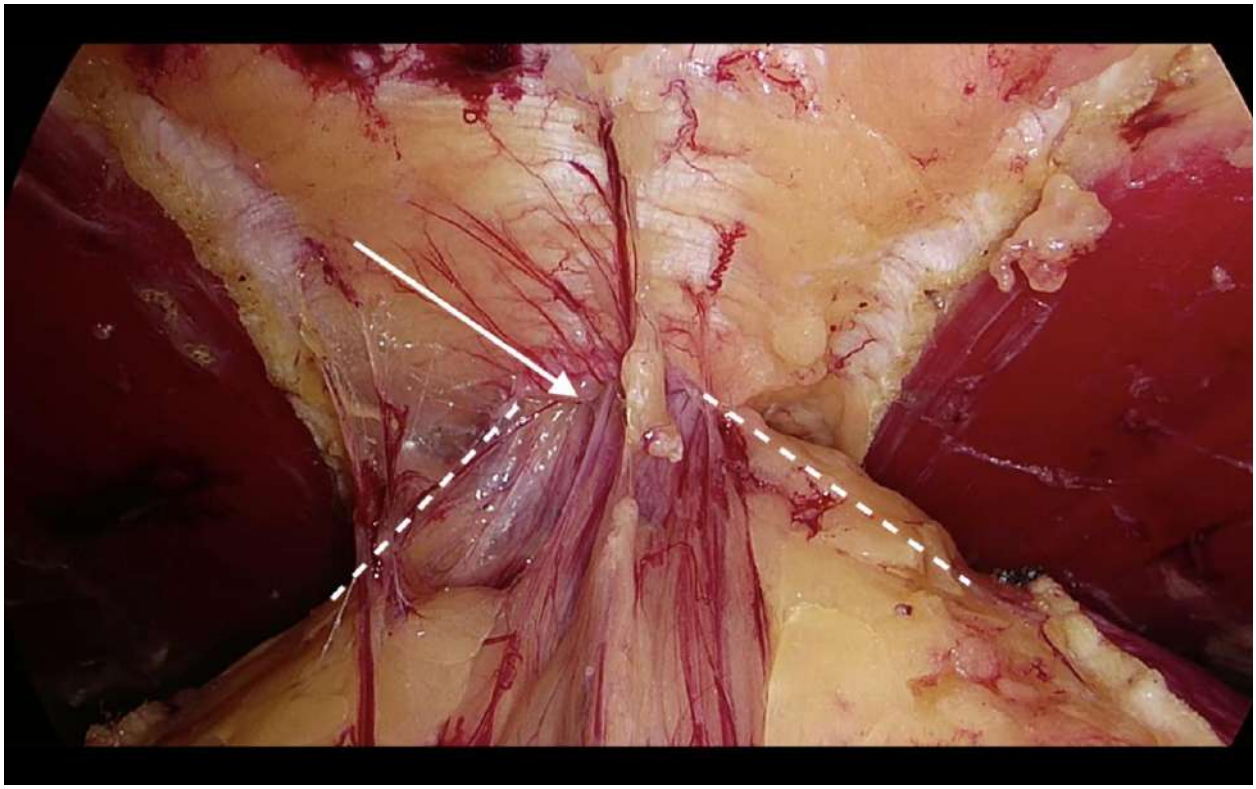


Figure 11 – Volcano symptom: hernial sac (borders – white dotted line), covered with yellow fat of the falciform ligament (arrow)

One way to create more retromuscular space and reduce tension in the posterior layers of the rectus abdominis aponeurosis is to dissection Bogro's space. The complexity of this manipulation lies in the fact that during retromuscular dissection, Bogro's space is limited by the superficial plate of the transverse fascia, and if an incorrect attempt to enter this space is possible, there is a high possibility of perforation of the peritoneum and creating further difficulties for the operator. The safest and most effective entry point into this space is the gap between the

arcuate line (linea arcuata) and the transverse fascia (Figure 12a). When performing dissection between these structures, maximum efficiency, safety and speed of entry into Bogro's space are ensured. The guide to entering Bogro's space is the visualization of the transverse abdominal muscles (Figure 12b) [90].

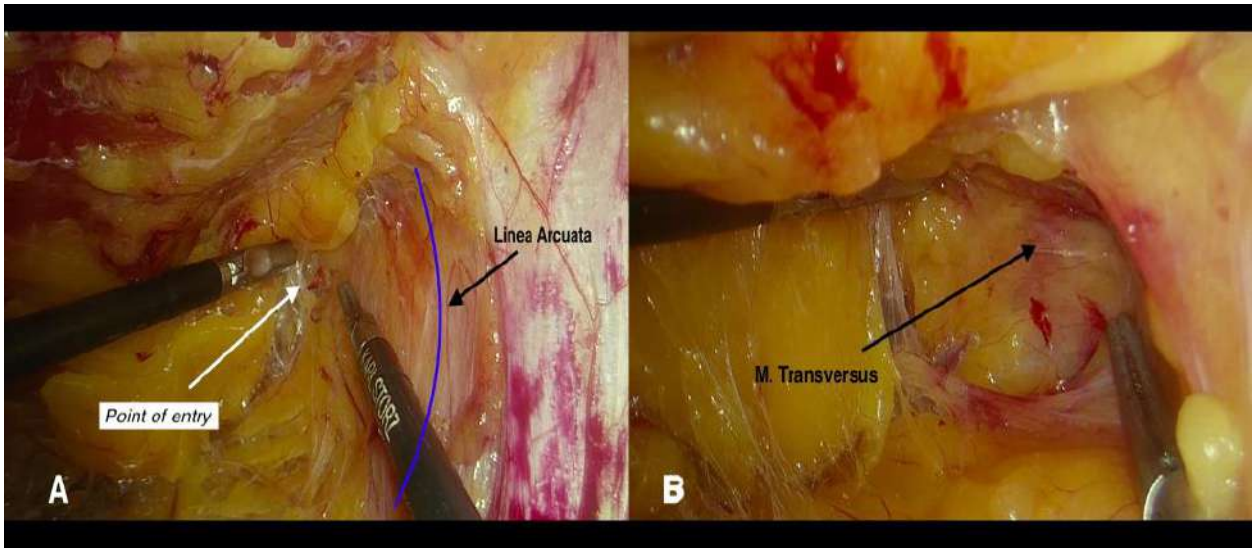


Figure 12 - A - Entry point into Bogro space, B - Indicator of entry into Bogro space (m.transversus)

Retromuscular hernioplasty using the eTEP approach is gaining popularity in the treatment of ventral hernias. Like most new surgical aids, it presents a unique set of technical challenges and complications. Correct identification of anatomical structures from an unfamiliar endoscopic viewpoint is the key to performing it safely. These anatomical landmarks serve as tools for correct orientation and work in the surgical field, avoiding iatrogenic damage to the linea alba and lunate and the development of complications in the early and late postoperative period [92].

2.6 Non-standard situations and methods for solving them when performing endovideosurgical retromuscular hernioplasty

In the process of performing endovideosurgical retromuscular hernioplasty using the ETER approach, non-standard situations may arise associated with deviations from the standard surgical technique. These deviations may be due to

differences in the patient's anatomy (disruption of normal anatomy due to postoperative scarring), inexperience in performing such operations, or technical errors.

The first possible difficulty that all surgeons encounter at the stage of mastering the technique is the installation of the first trocar into the retromuscular space. This stage may be accompanied by the following errors: insertion of a trocar into another anatomical layer and perforation of the parietal peritoneum with the development of carboxyperitoneum. Erroneous installation of the first trocar can occur when the trocar is inserted lateral to the Spigelian line or the surgeon fails to observe the angle of installation of the trocar relative to the anterior abdominal wall. Prevention of the development of the above events is the use of optical trocars. Under visual control, the surgeon must clearly identify the layer-by-layer structures of the anterior abdominal wall - subcutaneous fatty tissue, the anterior layer of the rectus abdominis sheath and the rectus abdominis muscle itself. After visualization of the tissues of the posterior layer of the vagina of the rectus abdominis muscles, insufflation of carbon dioxide begins (pressure 12-14 mm Hg). To prevent trauma to the aponeurosis and the development of carboxyperitoneum, it is recommended to continue inserting the trocar parallel to the layers of the anterior abdominal wall.

The most serious problem when performing endovideosurgical retromuscular hernioplasty is premature carboxyperitoneum. Often this situation occurs due to excessive pressure and rotation of the tool. Therefore, it is important to ensure the correct skin incision, which will not create resistance when inserting the trocar. If premature carboxyperitoneum occurs when installing the first trocar, it is recommended to continue surgical treatment in the opposite retromuscular space. In case of depressurization of the retromuscular space after dissection, attempts to continue the operation in such conditions may lead to difficulty in visualization in a limited space and prolong the operation due to difficulties in differentiating the anatomical structures. In such a situation, it is possible to place an 18G injection needle in the lateral area below the Spigelian line. Next, an air test is performed using a saline syringe to identify the connection of the needle with the abdominal

cavity, after which the needle remains open and acts as a release valve for carbon dioxide (Figure 13). This manipulation is performed to equalize the pressure of carbon dioxide in the retromuscular space and the abdominal cavity, which will increase visualization and continue surgical treatment.

Performing the reconstructive stage of the operation (for example, closing a defect in the peritoneum) may cause excessive tension on the tissues during suturing, which can lead to tissue rupture. It is important to foresee such a situation at the stage of planning the operation and, if necessary, expand the scope of the operation by planning posterior separation plasty or changing the surgical method. To reduce peritoneal tension, the following methods were used: reducing insufflation pressure to 10 mm Hg. Art. and making a seam of the defect not in the longitudinal, but in the transverse direction. Performing dissection in the space of Retzius and in the spaces of Bogro on both sides will create more plastic material in the form of peritoneum and thereby close the defect.

Figure 13 – Installing an 18G injection needle into the abdominal cavity and performing an air test.

If these measures are ineffective, posterior separation can be used to increase the area of the parietal peritoneum flaps. Full posterior separation along its entire length is not always required; after crossing the transverse muscle at the level of the peritoneal defect, it is recommended to check how much the tissue deficiency has been compensated. There were no cases in the study where it was not possible to eliminate the defect of the parietal peritoneum.

Installation of an endoprosthesis is the final stage of plastic surgery, but even with this manipulation, surgeons mastering the technique may encounter difficulties. Before installing a mesh implant, it is mandatory to measure the formed retromuscular space with a sterile ruler to determine the correct size of the future implant. It is recommended to install the planned mesh implant by reducing the

resulting dimensions (length and width) by 15% due to overstretching of the tissues of the anterior abdominal wall due to carbon dioxide insufflation and relaxation of the muscle frame during general anesthesia.

Adequate deployment of a mesh implant at the stage of mastering the technique is not always a simple manipulation. In such a situation, first of all, you should make sure that the endoprosthesis is not rotated 90°, for which preliminary marking is carried out in the center of the upper and lower edges in the form of a triangular notch (Figure 14).

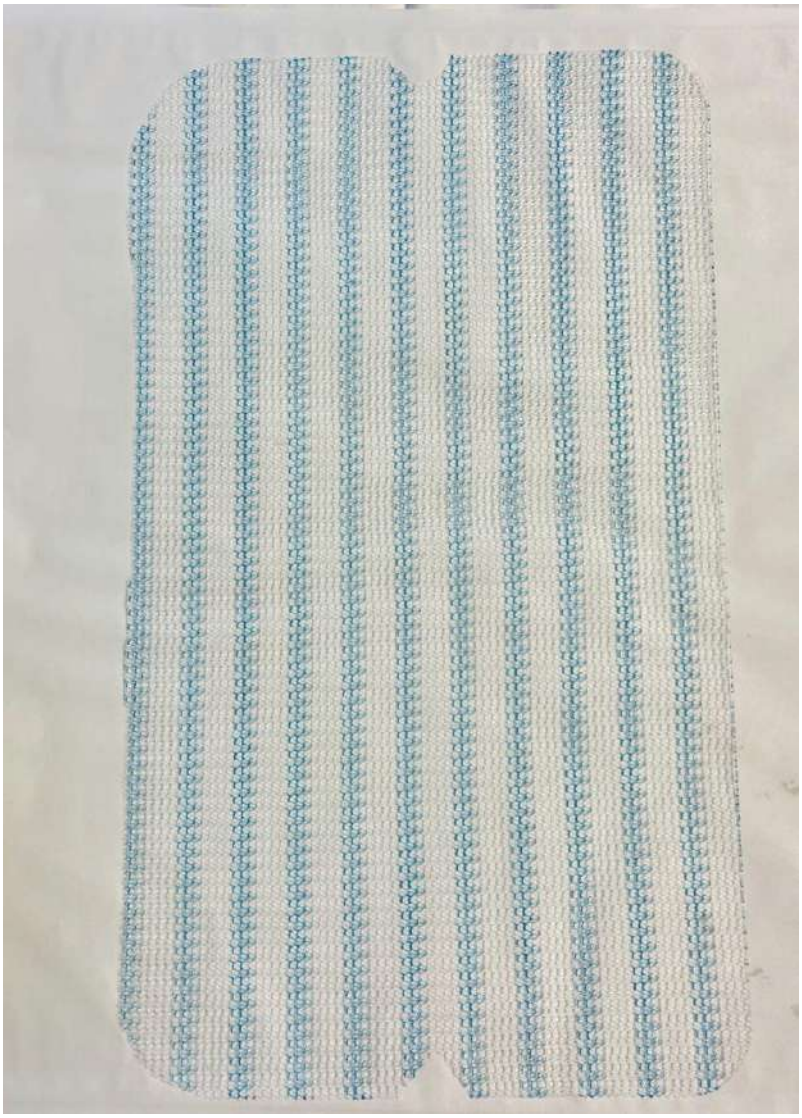


Figure 14 – Mesh implant with cutouts

For the easiest delivery of the mesh implant into the abdominal cavity and subsequent installation in the retromuscular space, the endoprosthesis is twisted on

both sides in a transverse direction towards the center. Both folded edges are fixed in the center with an interrupted suture (Figure 15). Thus, a mesh implant in the form of a “tube” is easily inserted into the retromuscular space through a 12 mm or 10 mm trocar, installed along the midline of the space, and after cutting the fixing unit, it is spread over the entire surface of the posterior layer. Cut-out indicator marks facilitate more precise placement of the mesh implant in the retromuscular space.

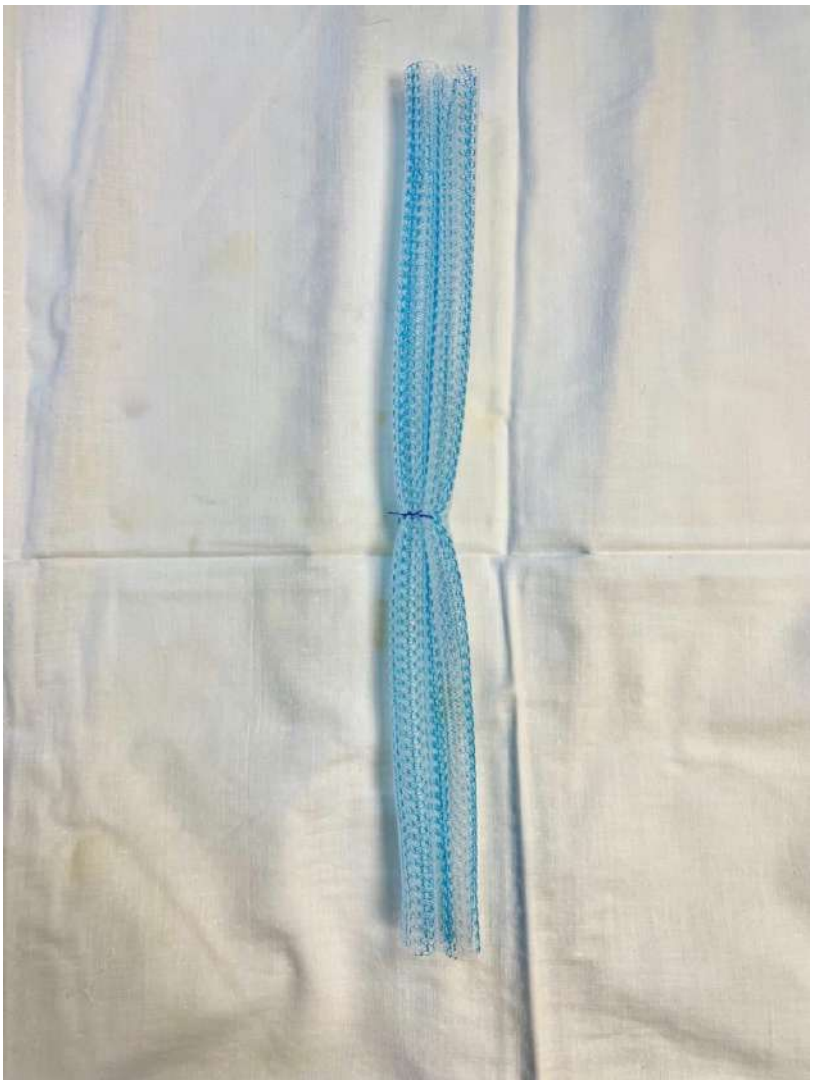


Figure 15 – Mesh implant prepared for insertion into the retromuscular space

2.7 Development and implementation of an intraoperative checklist as part of the standardization of endovideosurgical retromuscular hernioplasty using the eTEP approach

The introduction of an intraoperative checklist into the work of the surgical department is a solution aimed at improving the quality of medical care and reducing

the risk of errors during surgical interventions. A checklist is a structured list of steps and tasks that must be performed during surgery and serves as a reminder and control for the surgical team.

In the process of research, a team of surgeons working as part of the 1st surgical department of the Federal State Budgetary Institution "L.G. Sokolov North-Western Regional Scientific and Clinical Center" of the Federal Medical and Biological Agency of Russia, actively mastered and introduced into practice the technique of endovideosurgical retromuscular hernioplasty using the eTEP approach. In the early stages of learning the new technique, a number of problems arose. Considering the technical complexity of the surgical procedure and the need for in-depth knowledge of the anatomy of the anterior abdominal wall “from the inside,” the first cases of hernioplasty required significant operating time (up to 5-7 hours) and were characterized by early postoperative complications, such as retromuscular hematoma and seromas.

Taking into account the accumulated experience, based on the 1st surgical department of the Federal State Budgetary Institution "L.G. Sokolov North-Western Regional Scientific and Clinical Center" of the Federal Medical and Biological Agency of Russia, an intraoperative checklist for endovideosurgical retromuscular hernioplasty of ventral hernias using the eTEP access was developed and put into practice. This checklist is based on data obtained from the world literature, including works [41], [54]–[56], [68], [73], [90] (table 2).

Table 2 - Intraoperative checklist: eTEP RS (Extented Totally Extrapretonal Plasty Rives-Stoppa)

A. Access		
A1 – Determination of hernia defect. Choosing the appropriate method of transition to the opposite retromuscular space	☐ Yes	☐ No
A2 – Injection of local anesthetic at the sites of trocar insertion	☐ Yes	☐ No
A3 - Installation of the trocar.		
A4 - Access to the retromuscular space under visual control (Visiport or under the "oculus")	☐ Yes	☐ No
A5 - The posterior layer of the sheath of the rectus abdominis muscles is not damaged, the tightness is preserved.	☐ Yes	☐ No
B. Formation of a single retromuscular space.		
B1 – Optical dissection of the retromuscular space is performed and an auxiliary trocar is installed	☐ Yes	☐ No
B2 – Sufficient space has been created to initiate the Crossover maneuver.	☐ Yes	☐ No
B3 – Crossover maneuver was performed without violating the integrity of the peritoneum	☐ Yes	☐ No
B4 – The hernia defect is visualized, the contents and peritoneum are evacuated from the hernial sac.	☐ Yes	☐ No
B6 – A single retromuscular space is formed:		
B7 - Maximum dissection in lateral directions is performed	☐ Yes	☐ No
B8 - Neurovascular bundles are not damaged	☐ Yes	☐ No
B9 - Mobilization in the Ritzius space completed	☐ Yes	☐ No

B10 - CV MPO criteria are met in the presence of inguinal hernias.	☐ Yes	☐ No
C. Closure of the defect in the peritoneum, elimination of the hernia defect and diastasis of the rectus abdominis muscles.		
C1 – If present, the defect in the peritoneum is sutured without tension.	☐ Yes	☐ No
C2 – The hernia defect and diastasis were eliminated using a continuous suture with a non-absorbable thread with notches.	☐ Yes	☐ No
C3- The retromuscular space was measured to determine the size of the required mesh implant.	☐ Yes	☐ No
C4 – Introduction and distribution of the mesh implant over the entire surface without twists or bends.	☐ Yes	☐ No
D. Completing the operation		
D1 – Control of hemostasis and installation of drainage in the retromuscular space.	☐ Yes	☐ No
D2 - Desufflation under visual control.	☐ Yes	☐ No
D3 - Suturing trocar wounds	☐ Yes	☐ No
D4– External control of the anterior abdominal wall	☐ Yes	☐ No

This intraoperative checklist provides specific steps and criteria for each stage of the operation, divided into subgroups: A - access to the space, subgroup B - formation of a single retromuscular space, C - Closure of the defect in the peritoneum, elimination of the hernia defect and diastasis of the rectus abdominis muscles, and subgroup D – completion of the operation. After each step is completed, the operating team notes whether it was completed (“Yes”) or not completed (“No”). This provides systematic control over the surgical process and allows the operating team to easily monitor progress.

The introduction of an intraoperative checklist has a number of advantages. First, it helps improve patient safety by reducing the risk of errors and omissions during

operations. Second, the checklist standardizes procedures and promotes consistency across the surgical team. In addition, the checklist also enhances communication and collaboration among team members, and improves and accelerates the learning of clinical residents and junior surgeons.

As a result, the intraoperative checklist of endovideosurgical retromuscular hernioplasty using the eTEP approach is an important tool for surgeons to improve the safety and effectiveness of operations with eTEP access. It provides a structured sequence of surgical steps, contributes to the achievement of optimal results and is one of the steps to continuously improve medical practice and ensure a high level of quality surgical care for patients.

2.8 Clinical characteristics of the groups.

A prospective single-center study was conducted on the basis of the Federal State Budgetary Institution "L.G. Sokolov North-Western Regional Scientific and Clinical Center" of the Federal Medical and Biological Agency of Russia. The observation period was from 2018-2023. The study included 122 patients with ventral hernias, which included primary (n=61) and postoperative (n=61) hernias using block randomization. Further, in each of these cohorts, patients were divided depending on the type of surgery:

I. Primary ventral hernias (n=61).
   Group 1 - patients underwent open Rives-Stoppa hernioplasty (n=27).
   Group 2 - patients underwent eTEP-RS surgery (n=34).
II. Postoperative ventral hernias (n=61).
   Group 3 - patients underwent open Rives-Stoppa hernioplasty (n=29).
   Group 4 - patients underwent eTEP-RS surgery (n=32).

The study included patients with a primary or postoperative ventral hernia with a defect width of 3 to 6 cm. The exclusion criteria for this study were cases of strangulation, recurrent ventral hernias, hernias with skin infections and enterocutaneous fistulas, and patients with a body mass index (BMI) more than 35.

2.9 Methodology for assessing the results of surgical treatment of patients with ventral hernias in the early and postoperative period.

Early results of surgical treatment were assessed up to 6 months after surgery, and long-term results after observing the patient for at least 1 year. In the early postoperative period, the following parameters were assessed: duration of hospitalization, duration of surgery, intra-/postoperative complications, pain intensity and volume of required analgesic therapy.

Immediately after surgical treatment, the level of pain was studied in detail. Using a visual analogue scale (VAS) of pain, on days 1, 2, 3, 4, 5 after surgery, patients assessed the intensity of pain from 0 to 10 points [93,94]. Pain syndrome was assessed once a day, the absence of pain was equated to 0 points, its maximum intensity – to 10 points. Analgesic therapy was carried out according to the "3-step pain management ladder" proposed by the World Health Organization [95] (Figure 16).

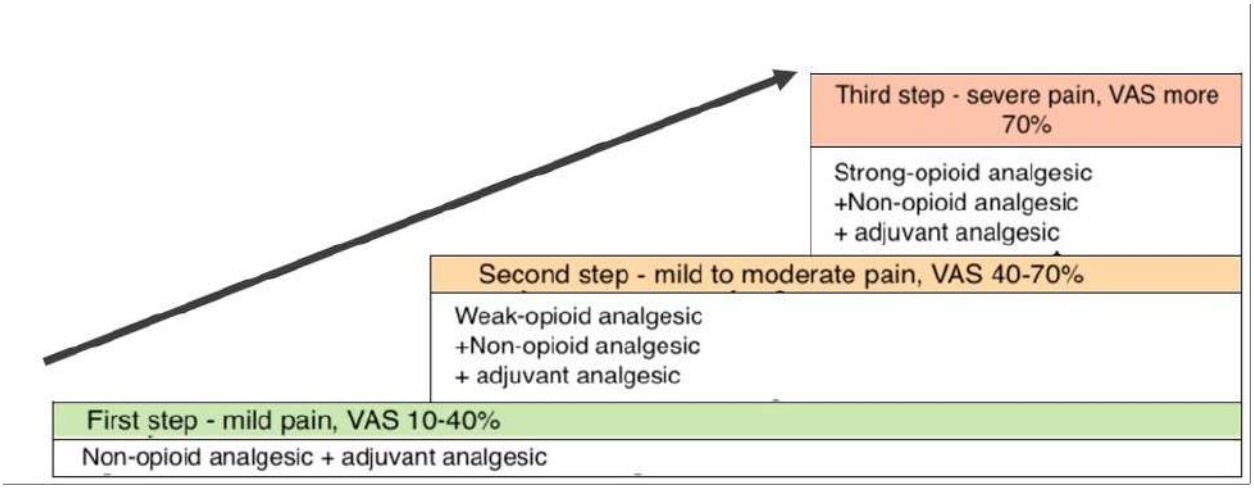


Figure 16 - "World Health Organization pain management ladder" [95]

First step therapy corresponds to the use of non-opioid painkillers. The drugs used in the study were from the group of non-steroidal anti-inflammatory drugs (NSAIDs). Analgesic therapy was assigned level 2 if it was necessary to prescribe "weak" opioids; only tramadol was used in the study. The third stage involved a combination of drugs, including "strong" opioids (promedol, fentanyl).

In the long-term postoperative period, telephone and face-to-face surveys of patients were conducted using the EuroHSQual scale [88] for subjective assessment of the intensity and duration of pain after discharge, the percentage of return of functional abilities, subjective assessment of surgical intervention, level of health after discharge and at the time of telephone questioning, the presence of recurrent hernia, as well as pain and discomfort at the time of telephone questioning. The observation period ranged from 1 year to 4 years. The presence and absence of relapses was monitored clinically, confirmed by a control CT scan of the AWO.

2.10 Method of tumescent anesthesia of intracorporeal suture for endovideosurgical retromuscular hernioplasty (eTEP-RS) of ventral hernias

As a prototype, we chose Klein's solution, widely used in plastic surgery and phlebology for peripheral regional anesthesia. When preparing the solution for tumescent anesthesia, we used the following components: physiological solution NaCl 0.9% in an amount of 50 ml, 4 ampoules of ropivacaine 100 mcg, 1 ampoule of adrenaline 100 mcg. The proposed composition of the solution for local anesthesia was put into practice on the basis of the Federal State Budgetary Institution "L.G. Sokolov North-Western Regional Scientific and Clinical Center" of the Federal Medical and Biological Agency of Russia.

The principle of the technique is to infiltrate the intracorporeal suture of the white line of the abdomen during retromuscular hernioplasty using the eTEP approach. The previously described tumescent solution, under the visual control of a laparoscope, is injected using a syringe into the soft tissue in the area of the sutured white line of the abdomen along its entire length (Figure 17).

To avoid obtaining distorted data on pain assessment, the anesthesiologist set the same target concentrations of anesthetics and muscle relaxants upon awakening in all cases. This monitoring was carried out using the TIVAManagerPro program.[96] The concentration of fentanyl in blood plasma was 2.0-2.2 ng/ml (perfusion index entropy level < 50%). Restoration of muscle tone in patients (TOF>97%) occurred when rocuronium plasma concentrations were below 0.5

μg/ml, and were maintained intraoperatively at 2-1.5 μg/ml (TOF=0). During general anesthesia, the intraoperative concentration of propofol in the blood plasma when using nitrous oxide with oxygen in a 1:1 ratio was in the range of 1.4-1.6 μg/ml, and awakening was carried out at a concentration below 1 μg/ml. When anesthesia was supported with inhalational anesthetics (Sevoflurane, Desflurane), the expiratory concentration was 2MACawake (0.7MAC). Thus, an attempt was made to exclude the influence of anesthesia on pain in patients in the early postoperative period.

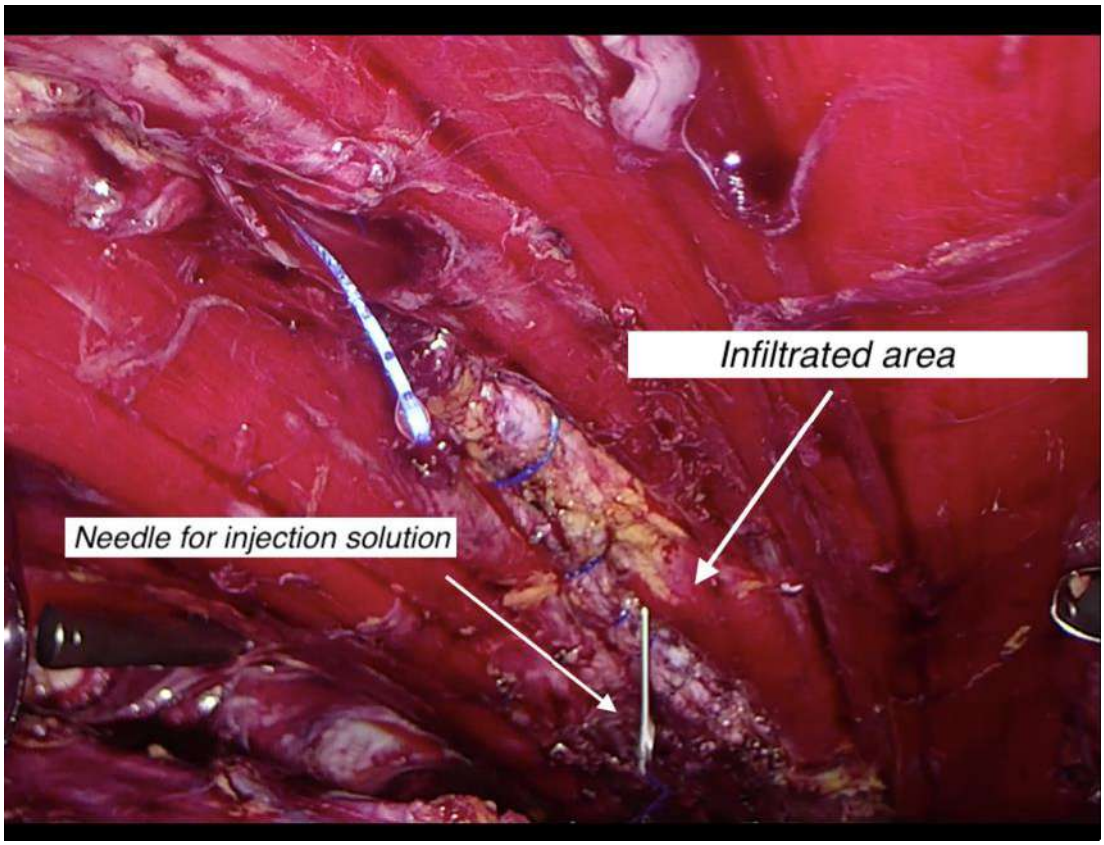


Figure 17 – Method of infiltration of the intracorporeal suture of the white line of the abdomen with a tumescent solution

To evaluate the effectiveness of the technique, a prospective single-center study was conducted at the Federal State Budgetary Institution "L.G. Sokolov North-Western Regional Scientific and Clinical Center" of the Federal Medical and Biological Agency of Russia. The observation period was from 2021-2023. The study included 35 patients with ventral hernias, which included primary and

incisional hernias using block randomization. A comparative study was performed on two groups of patients with retromuscular hernioplasty performed using the eTEP approach with (n=19 patients) and without the use of tumescent anesthesia (n=16 patients).

2.11 Statistical data processing

All indicators necessary for the study were entered into the Microsoft Office Excel program (Microsoft Inc., USA), which stored, edited, preliminary statistical analysis of data and prepared them for analysis. The work was carried out using a personal computer.

Statistical analysis was carried out using the StatTech v program. 3.1.2 (developer - Stattekh LLC, Russia).

Quantitative indicators were assessed for compliance with normal distribution using the Shapiro-Wilk test (for the number of subjects less than 50) or the Kolmogorov-Smirnov test (for the number of subjects more than 50).

Quantitative indicators with a normal distribution were described using arithmetic means (M) and standard deviations (SD), boundaries of the 95% confidence interval (95% CI).

In the absence of a normal distribution, quantitative data were described using the median (Me) and lower and upper quartiles (Q1–Q3).

Categorical data were described using absolute values and percentages.

Comparison of two groups according to a quantitative indicator with a normal distribution, with unequal variances, was performed using Welch's t-test.

Comparison of two groups for quantitative indicators whose distribution differed from normal was performed using the Mann-Whitney U test.

Comparison of percentages in the analysis of four-field contingency tables was performed using the Pearson chi-square test (for values of the expected phenomenon more than 10), Fisher's exact test (for values of the expected phenomenon less than 10)

Comparison of percentages in the analysis of multifield contingency tables was performed using the Pearson chi-square test.

CHAPTER III. Research results.

3.1 Comparison of the results of surgical interventions for hernioplasty of primary ventral hernias.

An analysis was performed of the characteristics of patients with primary ventral hernia depending on the “Surgery technique” indicator. (Table 3).

Table 3 - Characteristics of patients with primary ventral hernias

Indicators	Categories	Operation technique		p
		eTEP RS	Rives-Stoppa	
Gender, n (%)	Men	20 (58.8)	6 (22.2)	0.004*
	Women	14 (41.2)	21 (77.8)	
Type of hernia, n (%)				0.016*
	Epigastric hernia	19 (55.9)	22 (81.5)	
	Umbilical hernia	15 (44.1)	5 (18.5)	
Type of diastasis recti, n (%)	Type A	8 (47.1)	2 (33.3)	0.660
	Type B	9 (52.9)	4 (66.7)	
Cases of infringement in the anamnesis, n (%)	No	33 (97.1)	26 (96.3)	1,000
	Yes	1 (2.9)	1 (3.7)	
Concomitant pathology, n (%)	No	15 (44.1)	13 (48.1)	0.754
	Yes	19 (55.9)	14 (51.9)	
Obesity, n (%)	No	27 (79.4)	22 (81.5)	1,000
	Yes	7 (20.6)	5 (18.5)	
Diabetes mellitus type 2, n (%)	No	32 (94.1)	25 (92.6)	1,000
	Yes	2 (5.9)	2 (7.4)	
Hypertonic disease, n (%)	No	21 (61.8)	17 (63.0)	0.924
	Yes	13 (38.2)	10 (37.0)	
History of acute myocardial infarction, n (%)	No	31 (91.2)	27 (100.0)	0.248
	Yes	3 (8.8)	0 (0.0)	

* – differences in indicators are statistically significant ($p < 0.05$)

According to the data obtained when analyzing the indicator "Gender" (Figure 18), the indicator “Type of hernia” depending on the “Surgery technique” indicator, we identified statistically significant differences ($p = 0.004$, $p = 0.016$, respectively). When assessing the indicator "Type of diastasis of the rectus abdominis muscles", the indicator "Cases of strangulation in history", the indicator "Previous operations", the indicator "Concomitant pathology", Obesity, Type 2 diabetes mellitus,

Hypertension, Acute myocardial infarction in history depending on the “Surgery technique” indicator, it was not possible to establish statistically significant differences (p = 0.660, p = 1.000, p = 0.192, p = 0.754, p = 1.000, p = 1.000, p = 0.924, p = 0.248, respectively) (methods used: Fisher's exact test, Pearson Chi-square).

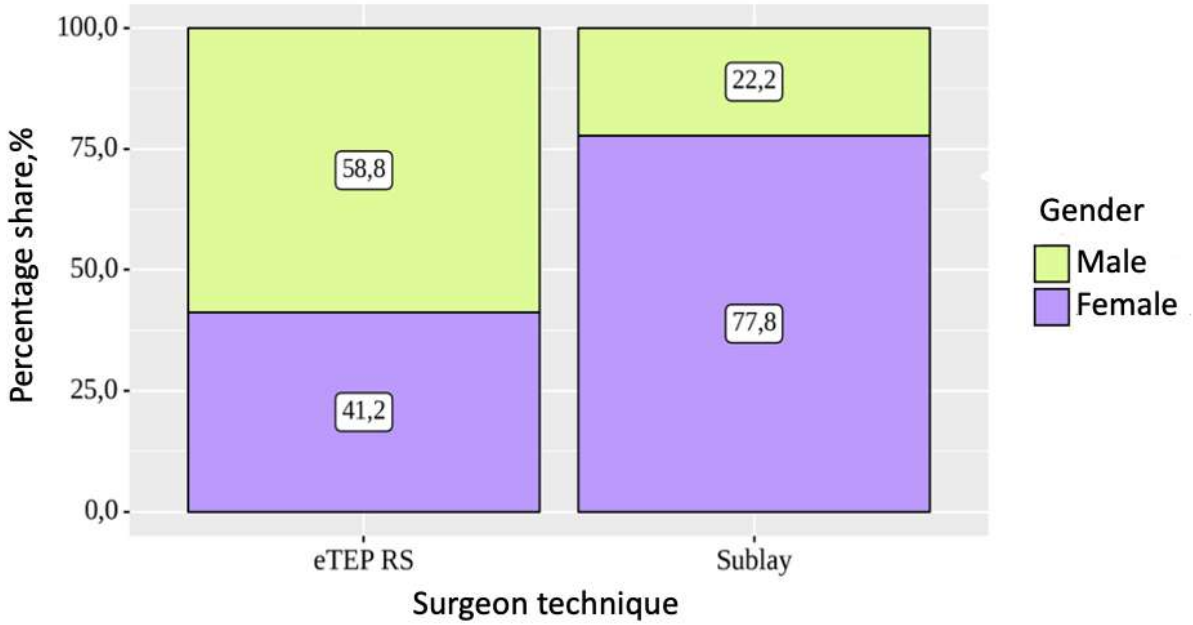


Figure 18 - Analysis of the "Gender" indicator depending on the indicator “Operation technique”

We also analyzed the patient's age and body mass index depending on the "Surgery technique" indicator. (Table 4).

Table 4 - Analysis of patients' age and body mass index depending on the indicator "Surgery technique"

Indicators	Categories	Operation technique			p
		Me	$Q_1 – Q_3$	n	
Age, (years)	eTEP RS	60	48 – 66	34	0.591
	Rives-Stoppa	59	44 – 64	27	
BMI, (kg/m2)	eTEP RS	31	27 – 32	27	0.233
	Rives-Stoppa	27	25 – 29	9	

When comparing the age of patients, the “BMI” indicator, depending on the “Surgery technique” indicator, it was not possible to identify statistically significant differences; patients in the two groups were comparable (p = 0.591, p = 0.233, respectively) (methods used: U– Mann–Whitney test).

3.1.1 Operation time and hospital stay

We analyzed the parameters of surgical intervention in patients with primary ventral hernia depending on the “Surgery technique” indicator (Table 5).

Table 5 - Analysis of parameters of surgical intervention depending on the indicator “Surgery technique”

Indicators	Categories	Operation technique			p
		Me	$Q_1 – Q_3$	n	
Duration of operation, (minutes)	eTEP RS	160	140 – 180	34	< 0.001*
	Rives-Stoppa	60	55 – 78	27	
Bed-day, (days)	eTEP RS	5	4 – 5	34	0.076
	Rives-Stoppa	5	4 – 6	27	
Implant width, (cm)	eTEP RS	15	15 – 18	34	< 0.001*
	Rives-Stoppa	10	8 – 10	27	
Implant length, (cm)	eTEP RS	30	30 – 30	34	< 0.001*
	Rives-Stoppa	15	15 – 15	27	

* – differences in indicators are statistically significant (p < 0.05)

According to the data obtained, when comparing the indicator “Duration of operation”, “Implant width”, the indicator “Implant length” depending on the indicator “Surgery technique”, statistically significant differences were revealed (p < 0.001, p < 0.001, p < 0.001 respectively) (methods used: Mann–Whitney U test). Thus, the operation time using eTEP access is significantly longer than with open Rives-Stoppa hernioplasty, due to the technical complexity of the minimally invasive technique. The endovideosurgical technique allows for significantly greater coverage of the hernia defect due to the larger size of the mesh implant. When comparing the “Bed days” indicator depending on the “Surgery technique”

indicator, it was not possible to identify statistically significant differences (p = 0.076) (method used: Mann-Whitney U test) (Figure 19).

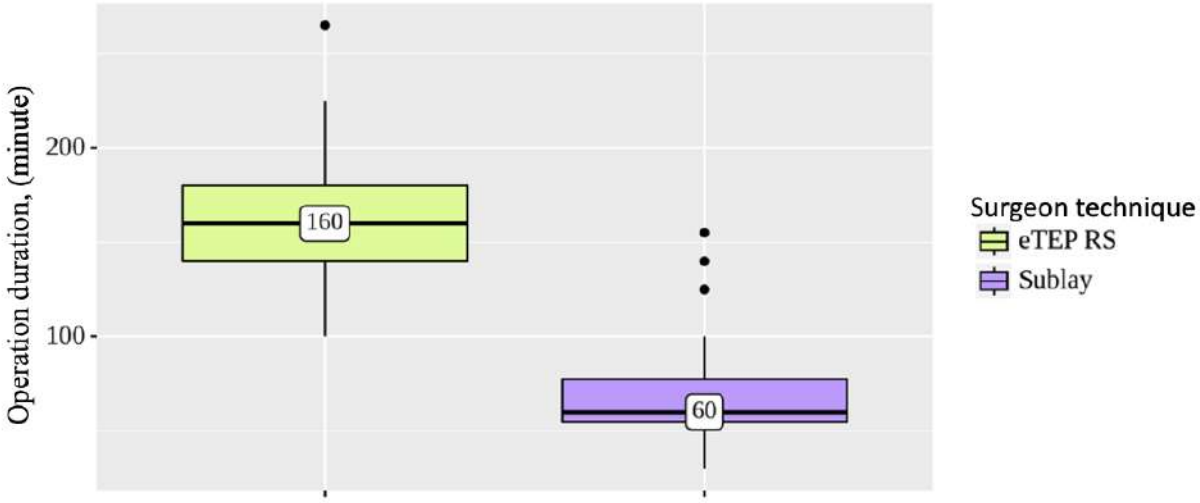


Figure 19 – Analysis of the indicator “Operation duration” depending on the indicator “Operation technique”

3.1.2 Intensity of pain in the early postoperative period

For each patient, on the first, second, third, fourth and fifth days after surgery, the intensity of pain in the area of postoperative intervention was measured using a visual analogue scale (VAS) (Table 6).

Table 6 - Analysis of the group “Severity of pain syndrome in the postoperative period” depending on the indicator “Operation technique”

Indicators	Categories	Operation technique			p
		Me	$Q_1 – Q_3$	n	
Pain scale for 1 day, (points)	eTEP RS	3	3 – 4	34	< 0.001*
	Rives-Stoppa	4	3 – 5	27	
Pain scale on day 2, (points)	eTEP RS	2	2 – 2	34	< 0.001*
	Rives-Stoppa	3	3 – 4	27	
Pain scale on day 3, (points)	eTEP RS	2	12	34	< 0.001*
	Rives-Stoppa	3	2 – 4	27	
Pain scale on day 4, (points)	eTEP RS	1	0 – 1	34	< 0.001*
	Rives-Stoppa	3	3 – 3	27	
Pain scale on day 5, (points)	eTEP RS	0	0 – 1	34	< 0.001*
	Rives-Stoppa	2	12	27	

* – differences in indicators are statistically significant (p < 0.05)

According to the results of statistical analysis, the indicators “Pain scale on day 1”, “Pain scale on day 2”, “Pain scale on day 3”, “Pain scale on day 4”, “Pain scale on day 5” depending on the indicator “Surgery technique”, statistically significant differences were established ($p < 0.001$, $p < 0.001$, $p < 0.001$, $p < 0.001$, $p < 0.001$, respectively) (methods used: Mann U test –Whitney). Thus, we can conclude that pain after surgery using the eTEP approach is less pronounced and goes away earlier than with the open Rives-Stoppa operation (Figure 20, Figure 21, Figure 22, Figure 23, Figure 24).

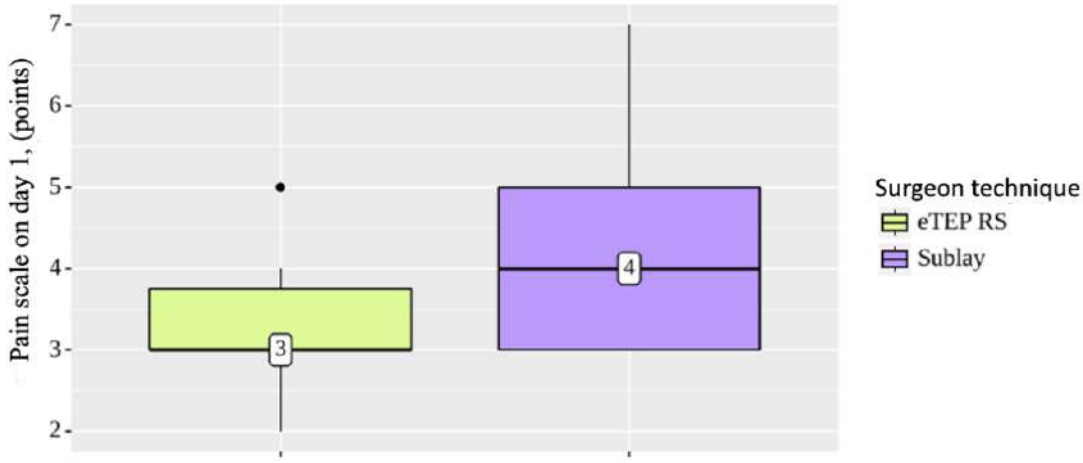


Figure 20 – Analysis of the indicator “Pain scale on day 1” depending on the indicator “Operation technique”

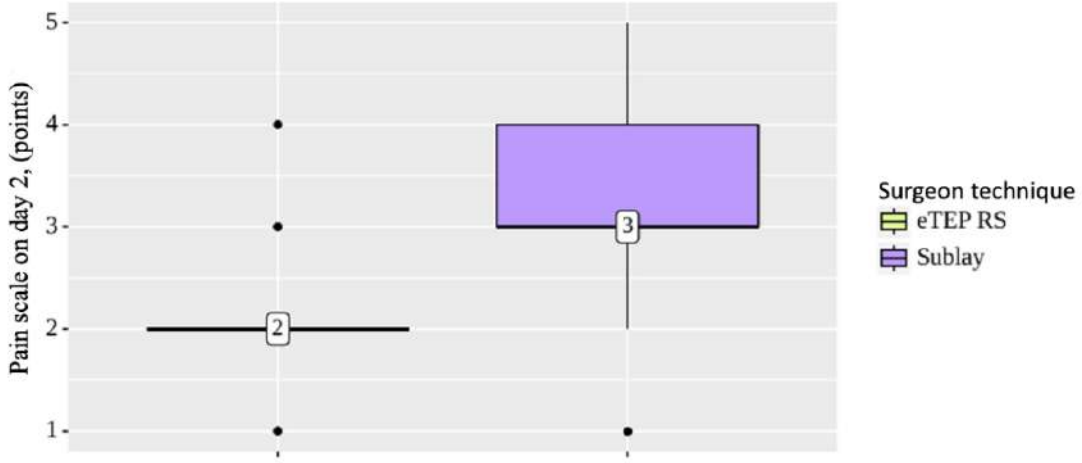


Figure 21 – Analysis of the indicator “Pain scale on day 2” depending on the indicator “Operation technique”

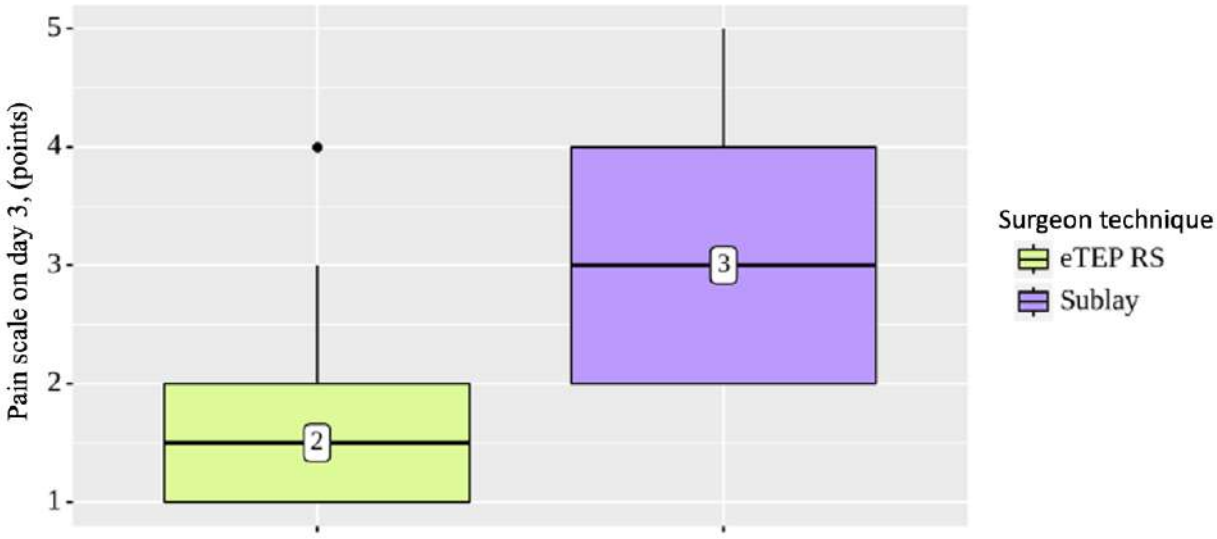


Figure 22 – Analysis of the indicator “Pain scale on day 3” depending on the indicator “Operation technique”

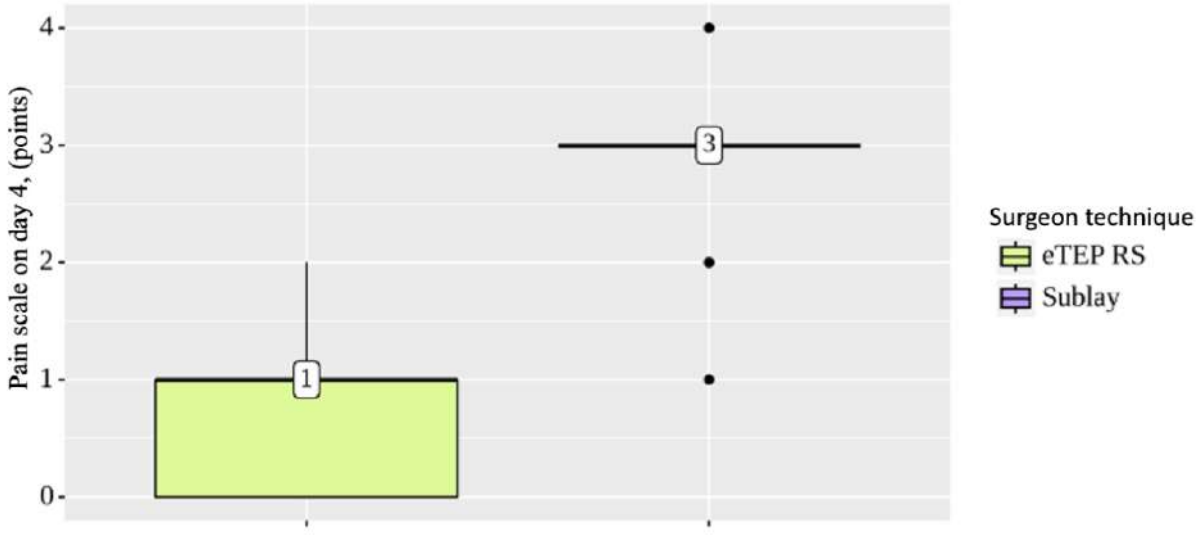


Figure 23 – Analysis of the indicator “Pain scale on day 4” depending on the indicator “Operation technique”

Figure 24 – Analysis of the indicator “Pain scale on day 5” depending on the indicator “Operation technique”

3.1.3 Complications in the early postoperative period

In accordance with the table presented, when assessing the "Seroma" indicator depending on the “Surgery technique” indicator, we identified statistically significant differences (p = 0.037, respectively) (methods used: Fisher’s exact test). The likelihood of developing this complication is much higher in the Rives-Stoppa group, due to the larger volume of the wound surface of the skin and underlying tissues compared to the eTEP approach (Table 7).

Table 7 - Analysis of the group “Characteristics of the postoperative period” depending on the indicator “Operation technique”

Indicators	Categories	Operation technique		p
		eTEP RS	Rives-Stoppa	
Seroma, n (%)	No	33 (97.1)	21 (77.8)	0.037*
	Yes	1 (2.9)	6 (22.2)	
Hematoma, n (%)	No	34 (100.0)	27 (100.0)	–
Paresthesia, n (%)	No	34 (100.0)	27 (100.0)	–

* – differences in indicators are statistically significant (p < 0.05)

3.1.4 Comparison of long-term results of surgical interventions

During the telephone survey, patients were asked to answer several questions. The intensity of the pain syndrome after discharge was assessed using a visual analogue scale, the duration of the pain syndrome after discharge, how quickly functional abilities returned to the previous level, how well the result of the operation met the patient's expectations, whether there were repeated operations, whether there was any pain or discomfort at the time of the survey (table 8).

When comparing the indicator "Pain syndrome after discharge", the indicator "Duration of pain syndrome", the indicator "Level of health after discharge" depending on the indicator "Surgery technique", we identified statistically significant differences ($p < 0.001$, $p = 0.040$, $p < 0.001$, $p = 0.004$ respectively) (methods used: Mann–Whitney U test).

Table 8 - Analysis of the group "Telephone questioning in the long-term postoperative period" depending on the indicator "Surgery technique"

Indicators	Categories	Operation technique			p
		M±SD/Me	95% CI / $Q_1 – Q_3$	n	
Pain syndrome after discharge, (points)	eTEP RS	0	0 – 3	34	0.040*
	Rives-Stoppa	2	2 – 3	27	
Duration of pain syndrome, (days)	eTEP RS	1	0 – 7	34	< 0.001*
	Rives-Stoppa	14	7 – 21	27	
Return function, (days)	eTEP RS	30	14 – 120	34	0.111
	Rives-Stoppa	90	30 – 135	27	
Assessment of treatment outcome, (points)	eTEP RS	5	4 – 5	34	0.136
	Rives-Stoppa	5	4 – 5	27	
Level of health after discharge, (points)	eTEP RS	80	80 – 90	34	0.004*
	Rives-Stoppa	70	70 – 80	27	
Health level at the time of the survey, (points)	eTEP RS	100	90 – 100	34	0.725
	Rives-Stoppa	90	90 – 100	27	

* – differences in indicators are statistically significant ($p < 0.05$)

When comparing the indicator "Return of function", the indicator "Evaluation of treatment outcome", the indicator "Pain syndrome at the time of the survey", the

indicator “Level of health at the time of the survey” depending on the indicator “Surgery technique”, we were unable to identify significant differences (p = 0.111, p = 0.136, p = 0.725, respectively) (methods used: Mann-Whitney U test) (Figure 25, Figure 26).

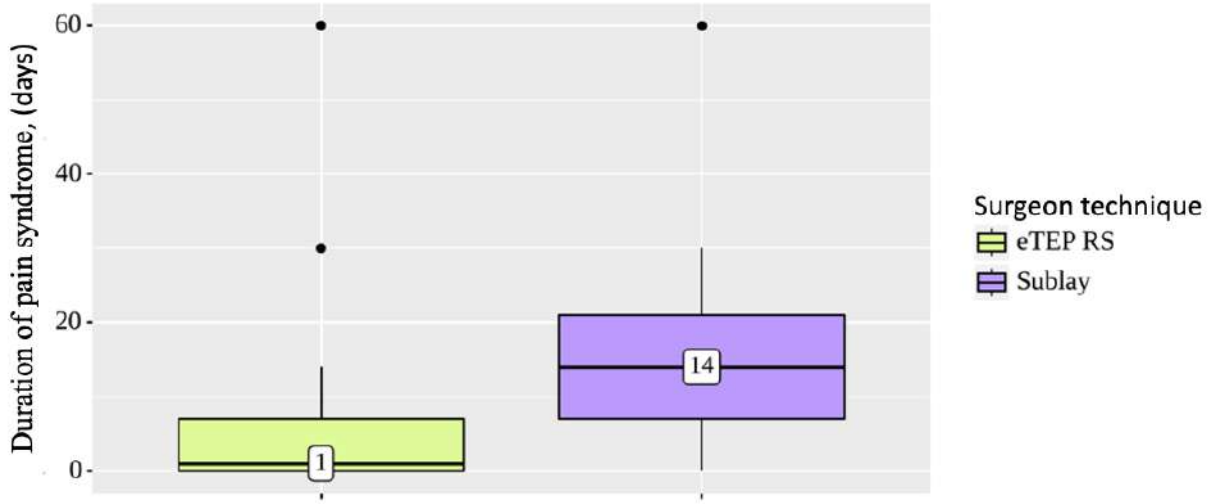


Figure 25 – Analysis of the indicator “Duration of pain syndrome” depending on the indicator “Operation technique”

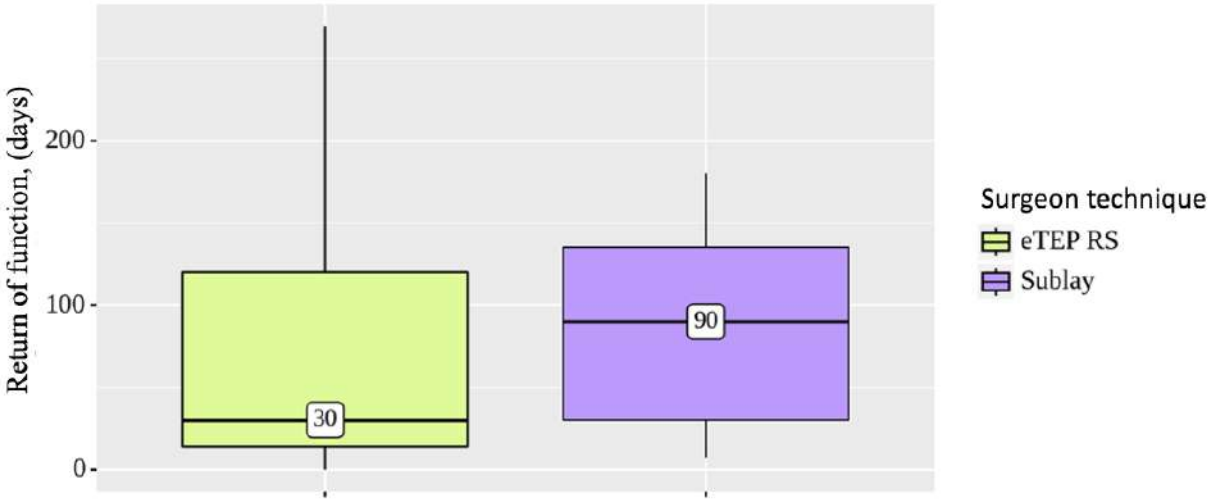


Figure 26 - Analysis of the "Return of function" indicator depending on the indicator “Operation technique”

3.2 Comparison of the results of surgical interventions for hernioplasty of postoperative ventral hernias.

According to the results of the analysis of the characteristics of patients with postoperative ventral hernias depending on the indicator “Surgery technique” were comparable in age, gender, BMI and comorbidities. It should be noted that according to the data obtained, when comparing the indicator “Prior operations” significant differences were found (p = 0.049) (methods used: Pearson Chi-square). In most cases (n=17), traditional Rives-Stoppa hernioplasty was used in patients with previous laparotomy; retromuscular hernioplasty using the eTEP approach was used in comparison with the open technique for recurrent ventral hernia (7 patients vs 1 patient) (p < 0.049) (table 9, table 10) (Fig. 27).

Table 9 - Analysis of characteristics of patients with postoperative ventral hernias

Indicators	Categories	Operation technique		p
		eTEP RS	Rives-Stoppa	
Gender, n (%)	Men	13 (40.6)	12 (41.4)	0.952
	Women	19 (59.4)	17 (58.6)	
Cases of infringement in the anamnesis, n (%)	No	31 (96.9)	29 (100.0)	1,000
	Yes	1 (3.1)	0 (0.0)	
Previous operations, n (%)	Laparotomy	11 (34.4)	17 (58.6)	0.049*
	Laparoscopy	14 (43.8)	11 (37.9)	
	Hernioplasty	7 (21.9)	1 (3.4)	
Concomitant pathology, n (%)	No	8 (25.0)	9 (31.0)	0.776
	Yes	24 (75.0)	20 (69.0)	
Obesity, n (%)	No	27 (84.4)	25 (86.2)	1,000
	Yes	5 (15.6)	4 (13.8)	
Oncopathology, n (%)	No	28 (87.5)	24 (82.8)	0.724
	Yes	4 (12.5)	5 (17.2)	
Diabetes mellitus type 2, n (%)	No	26 (81.2)	27 (93.1)	0.260
	Yes	6 (18.8)	2 (6.9)	
Hypertonic disease, n (%)	No	12 (37.5)	18 (62.1)	0.055
	Yes	20 (62.5)	11 (37.9)	
History of acute myocardial infarction, n (%)	No	31 (96.9)	29 (100.0)	1,000
	Yes	1 (3.1)	0 (0.0)	
History of stroke, n (%)	No	31 (96.9)	29 (100.0)	1,000
	Yes	1 (3.1)	0 (0.0)	
Bronchial asthma, n (%)	No	31 (96.9)	29 (100.0)	1,000
	Yes	1 (3.1)	0 (0.0)	

* – differences in indicators are statistically significant (p < 0.05)

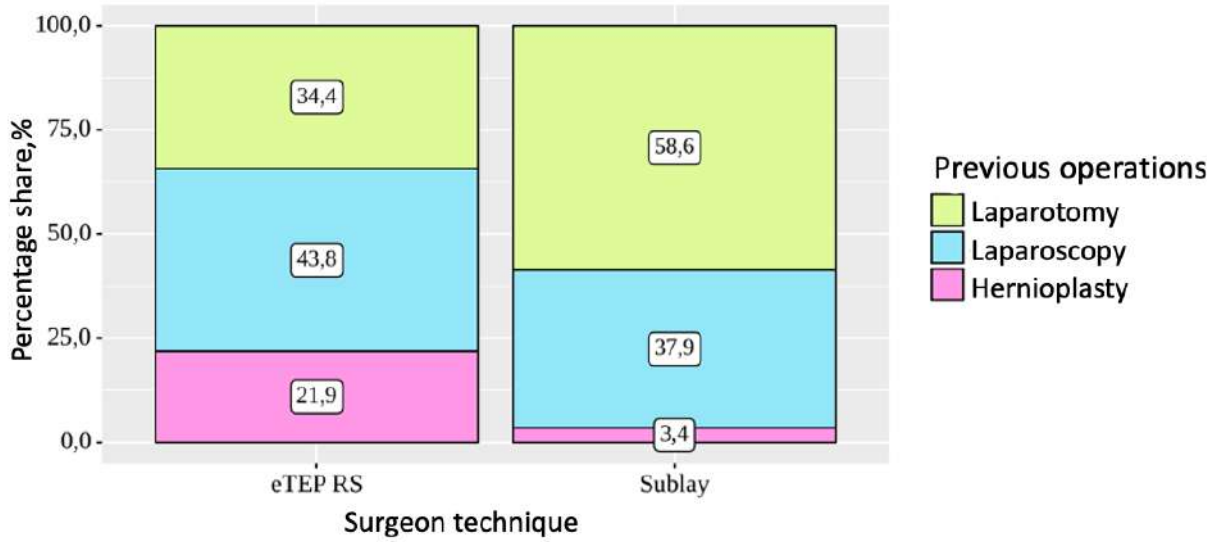


Figure 27 - Analysis of the indicator "Previous operations" depending on the indicator “Operation technique”

Table 10 - Analysis of the age of patients and body mass index with postoperative ventral hernias

Indicators	Categories	Operation technique			p
		M±SD/Me	95% CI / $Q_1 – Q_3$	n	
Age, (years)	eTEP RS	57 ± 14	52 – 62	32	0.669
	Rives-Stoppa	58 ± 13	54 – 63	29	
BMI, (kg/m^2)	eTEP RS	24	0 – 28	32	0.143
	Rives-Stoppa	26	0 – 25	29	

* – differences in indicators are statistically significant ($p < 0.05$)

3.2.1 Surgery time and hospital stay

Based on the data obtained, when comparing the indicator “Duration of operation”, the indicator “Bed days”, depending on the indicator “Surgery technique”, significant differences were identified ($p < 0.001$, $p < 0.001$, respectively) (methods used: Mann–Whitney U test). Thus, the time required to perform an operation using eTEP access is significantly longer, just like with hernioplasty for primary ventral hernias, than with open surgery. However, after hernioplasty of postoperative ventral hernias using the open Sublay method, patients

stayed in the hospital statistically significantly longer than after endoscopic hernioplasty (Table 11), (Figure 28).

Table 11 - Analysis of parameters of surgical intervention depending on the indicator “Surgery technique”

Indicators	Categories	Operation technique			p
		Me	$Q_1 – Q_3$	n	
Duration of operation, (minutes)	eTEP RS	160	140 – 211	32	<0.001*
	Rives-Stoppa	105	75 – 140	29	
Bed days, (days)	eTEP RS	4	3 – 5	32	<0.001*
	Rives-Stoppa	6	4 – 7	29	
Implant width, (cm)	eTEP RS	15	12 – 15	32	0.670
	Rives-Stoppa	15	10 – 20	29	
Implant length, (cm)	eTEP RS	30	30 – 30	32	<0.001*
	Rives-Stoppa	18	14 – 20	28	

* – differences in indicators are statistically significant ($p < 0.05$)

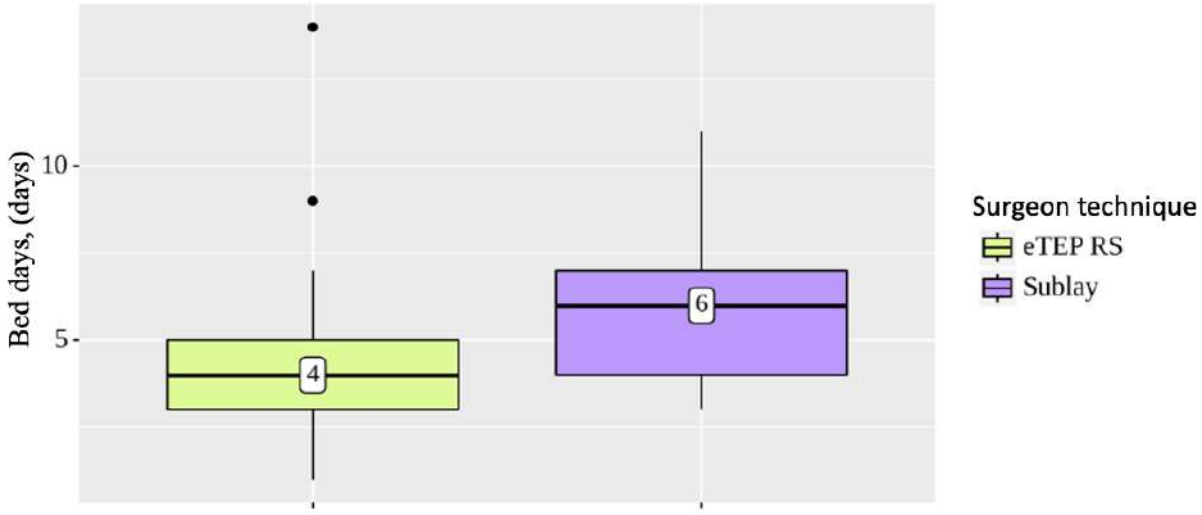


Figure 28 – Analysis of the indicator “Bed days” depending on the indicator “Operation technique”

3.2.2 Intensity of pain in the early postoperative period

We performed an analysis of the group “Severity of pain syndrome in the postoperative period” depending on the indicator “Operation technique”. Just like in the group of patients with primary ventral hernias, the intensity of pain in the area

of postoperative intervention was measured in each patient on the first, second, third, fourth and fifth days after surgery using a visual analogue scale (VAS) (Table 12).

Table 12 - Analysis of the group “Severity of pain syndrome in the postoperative period” depending on the indicator “Operation technique”

Indicators	Categories	Operation technique			p
		Me	$Q_1 – Q_3$	n	
Pain scale for 1 day, (points)	eTEP RS	3	3 – 4	32	< 0.001*
	Rives-Stoppa	4	3 – 5	29	
Pain scale on day 2, (points)	eTEP RS	2	12	32	< 0.001*
	Rives-Stoppa	3	3 – 4	29	
Pain scale on day 3, (points)	eTEP RS	1	eleven	32	< 0.001*
	Rives-Stoppa	3	3 – 4	29	
Pain scale on day 4, (Points)	eTEP RS	1	eleven	32	< 0.001*
	Rives-Stoppa	3	2 – 3	29	
Pain scale on day 5, (points)	eTEP RS	0	0 – 1	32	< 0.001*
	Rives-Stoppa	2	2 – 3	29	

* – differences in indicators are statistically significant ($p < 0.05$)

Based on the data obtained, when assessing the indicators of each postoperative day, it was found that the pain syndrome was less severe and was relieved more quickly after endovideosurgical hernioplasty using the eTEP approach ($p < 0.001$) (methods used: Mann-Whitney U test).

3.2.3 Complications in the early postoperative period

In accordance with the table presented, when assessing the "Seroma" indicator depending on the “Surgery technique” indicator, we identified statistically significant differences ($p = 0.046$, respectively) (methods used: Fisher’s exact test). The likelihood of developing this complication is much higher in the Rives-Stoppa group, due to the larger volume of the wound surface of the skin and underlying tissues compared to the eTEP approach (Table 13).

Also, in the early postoperative period, hematomas occurred in two cases in each group of patients; statistically significant differences could not be identified ($p = 1,000$) (methods used: Fisher’s exact test).

Table 13 - Analysis of the group “Characteristics of the postoperative period” depending on the indicator “Operation technique”

Indicators	Categories	Operation technique		p
		eTEP RS	Rives-Stoppa	
Seroma, n (%)	No	31 (96.9)	23 (79.3)	0.046*
	Yes	1 (3.1)	6 (20.7)	
Hematoma, n (%)	No	30 (93.8)	27 (93.1)	1,000
	Yes	2 (6.2)	2 (6.9)	
Paresthesia, n (%)	No	32 (100.0)	29 (100.0)	–
Suppuration of the surgical wound, n (%)	No	31 (96.9)	29 (100.0)	1,000
	Yes	1 (3.1)	0 (0.0)	

* – differences in indicators are statistically significant ($p < 0.05$)

3.2.4 Comparison of long-term results of surgical interventions

In the long-term postoperative period, as well as in the group of patients with primary ventral hernia, a telephone survey was conducted; the observation period ranged from one to four years. According to the survey results, when comparing indicators, more statistically significant differences are noted in comparison with the group of patients with primary ventral hernia. Thus, endovideosurgical hernioplasty using the ETER approach showed a faster and better recovery of patients in the long-term postoperative period, operated on for a postoperative ventral hernia ($p = 0.003$, $p = 0.005$, $p < 0.001$, $p = 0.004$, $p = 0.014$, $p = 0.017$, $p = 0.011$, respectively) (methods used: Mann–Whitney U test) (Table 14), (Figure 29, Figure 30).

Table 14 - Analysis of the group “Telephone questioning in the long-term postoperative period” depending on the indicator “Operation technique”

Indicators	Categories	Operation technique			p
		Me	$Q_1 – Q_3$	n	
Pain syndrome after discharge, (points)	eTEP RS	0	0 – 2	32	0.005*
	Rives-Stoppa	2	13	29	
Duration of pain syndrome, (days)	eTEP RS	0	0 – 7	32	< 0.001*
	Rives-Stoppa	14	7 – 21	29	
Return function, (days)	eTEP RS	thirty	14 – 49	32	0.004*
	Rives-Stoppa	90	30 – 120	29	

Assessment of treatment outcome, (points)	eTEP RS	5	5 – 5	32	0.014*
	Rives-Stoppa	4	4 – 5	29	
Level of health after discharge, (points)	eTEP RS	82	80 – 90	32	0.017*
	Rives-Stoppa	80	70 – 80	29	
Pain syndrome at the time of the survey, (points)	eTEP RS	0	0 – 0	32	0.294
	Rives-Stoppa	0	0 – 0	29	
Health level at the time of the survey, (points)	eTEP RS	100	95 – 100	32	0.011*
	Rives-Stoppa	90	80 – 100	29	

* – differences in indicators are statistically significant ($p < 0.05$)

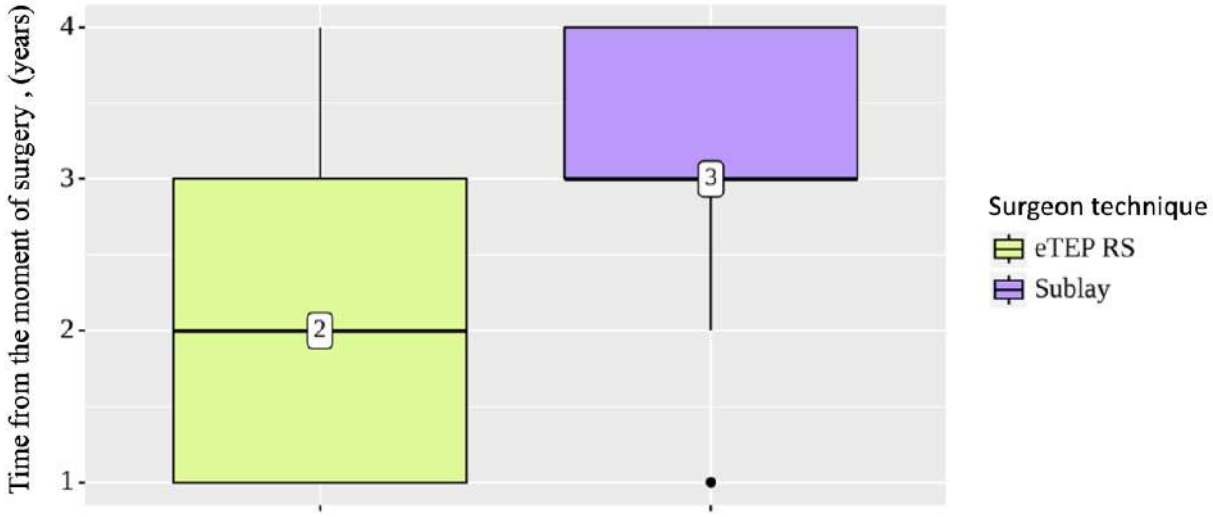


Figure 29 – Analysis of Time from the moment of surgery depending on the indicator “Surgery technique”

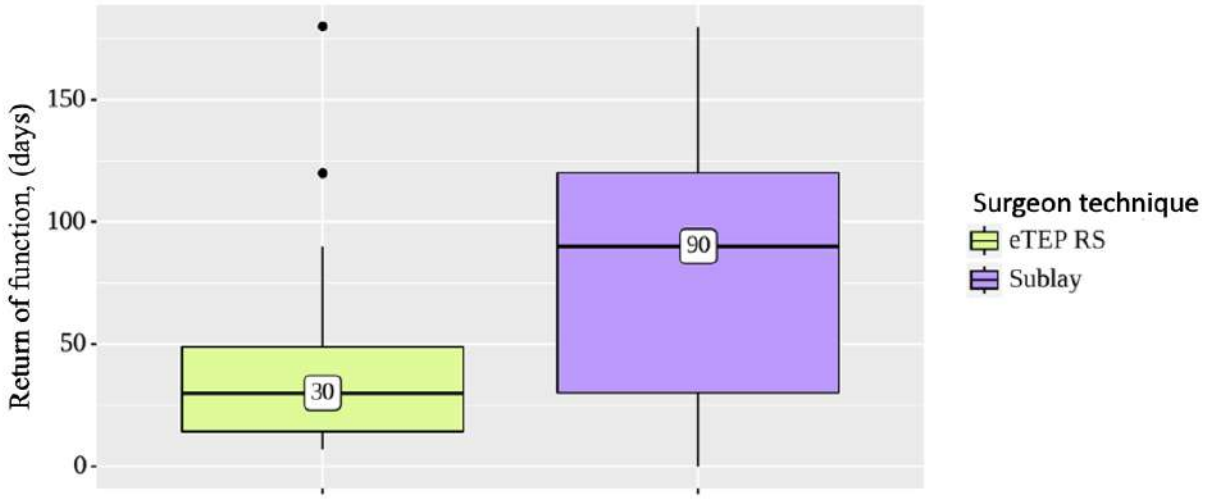


Figure 30 - Analysis of the "Return of function" indicator depending on the indicator “Operation technique”

3.3 The occurrence of relapse after retromuscular hernioplasty of ventral hernias in the long-term postoperative period.

During the entire observation period of both groups of patients, recurrences of ventral hernias were observed in four cases in patients with hernioplasty performed using the Rives-Stoppa method. In the long-term postoperative period, no relapses were registered in the group of patients with retromuscular hernioplasty using the eTEP approach.

In accordance with the table presented, when assessing the indicator "Relapse" Depending on the indicator "Surgery technique", significant differences were identified (p = 0.042) (method used: Fisher's exact test) (Table 15) (Figure 31).

Table 15 - Analysis of the indicator "Relapse" depending on the indicator “Operation technique”

Index	Categories	Operation technique		p
		eTEP RS	Rives-Stoppa	
Relapse, n (%)	No	66 (100.0)	52 (92.9)	0.042*
	Yes	0 (0.0)	4 (7.1)	

* – differences in indicators are statistically significant (p < 0.05)

Thus, the odds of relapse in the group of patients with open Rives-Stoppa hernioplasty were 11.400 times higher compared to the group of patients with endovideosurgical hernioplasty eTEP RS; the differences in odds were not statistically significant (95% CI: 0.600 – 216.519).

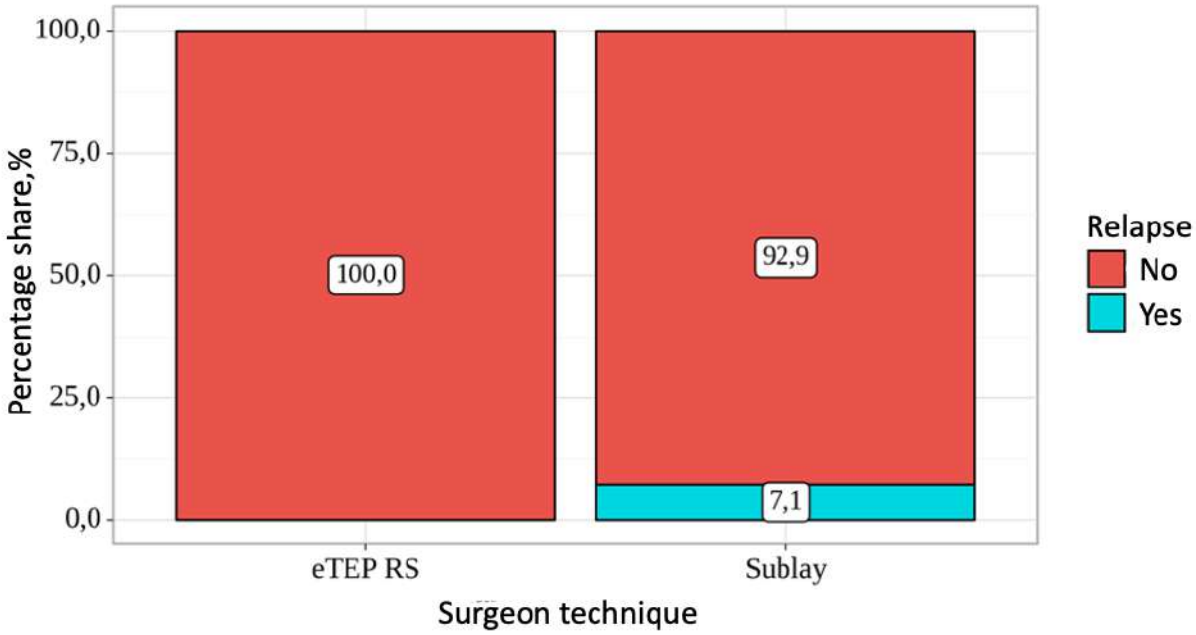


Figure 31 – Analysis of the “Relapse” indicator depending on the indicator “Operation technique”

3.4 Results of the use of tumescent anesthesia of the intracorporeal suture for endovideosurgical retromuscular hernioplasty (eTEP-RS) of ventral hernias

To evaluate the effectiveness of the technique, a comparative study of two groups of patients with retromuscular hernioplasty using the eTEP approach was performed with and without the use of tumescent anesthesia. The patients were comparable in terms of gender, age, size of the hernia defect and diastasis of the rectus abdominis muscles, and duration of surgical treatment. In the early postoperative period, during the first five days, patients were surveyed to assess the severity of pain in the suture area of the white line of the abdomen. To simplify the

assessment of pain, a questionnaire was compiled, including a visual analogue scale from 0 to 10 (Figure 32).

A statistical analysis of postoperative pain syndrome was carried out depending on the use of tumescent anesthesia. Quantitative indicators were assessed for compliance with normal distribution using the Shapiro-Wilk test (if the number of subjects was less than 50). In the absence of a normal distribution, quantitative data were described using the median (Me) and lower and upper quartiles (Q1–Q3). Comparison of two groups for quantitative indicators whose distribution differed from normal was performed using the Mann-Whitney U test. According to the data obtained, when analyzing the indicators, statistically significant differences were established (Table 16).

Table 16 - Analysis of pain syndrome depending on the use of tumescent anesthesia

Indicators Me (IQR 25-75)	**Application of anesthesia**		**p**
	Applied n =19	Not applied n = 16	
After waking up, (points)	1 (0-2)	2 (1-2)	< 0.001*
2 hours after surgery, (scores)	2 (1-3)	3 (2-4)	< 0.001*
6 hours after surgery, (scores)	3 (2-7)	4 (3-5)	0.001*
Pain scale for 1 day, (points)	2 (2-3)	4 (3-5)	< 0.001*
Pain scale on day 2, (points)	1 (1-2)	3 (3-4)	< 0.001*
Pain scale on day 3, (points)	1 (0-1)	2 (1-3)	< 0.001*
Pain scale on day 4, (points)	0 (0-0)	2 (1-3)	< 0.001*
Pain scale on day 5, (points)	0 (0-0)	1 (1-2)	< 0.001*

* – differences in indicators are statistically significant ($p < 0.05$)

Patient questionnaire

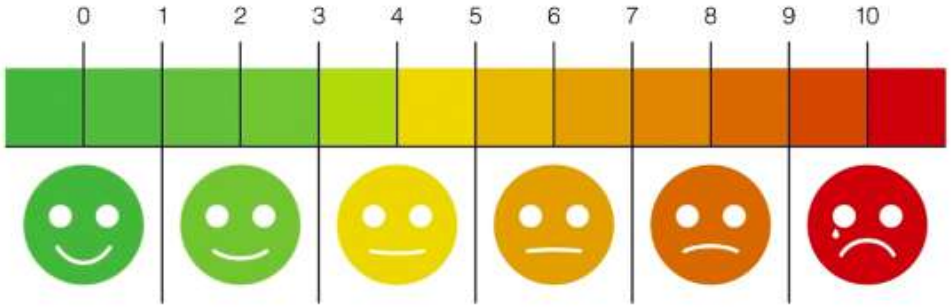
Patient's name _____

Sex **M** **F**

Weight ____**kg**

Height ____**cm**

Visual analog scale (VAS) of pain intensity



Times of day	Pain intensity
After waking up	
2 hours after surgery	
6 hours after surgery	
24 hours after surgery	
2nd postoperative day	
3nd postoperative day	
4nd postoperative day	
5nd postoperative day	

Figure 32 – Patient questionnaire for assessing pain in the early postoperative period

At all stages of the survey and assessment of pain syndrome when using tumescent anesthesia, a significantly lower severity of pain syndrome was noted in comparison with the control group of patients without the use of tumescent anesthesia.

It is worth noting that in the study group of patients, pain syndrome was practically not bothersome on the 4th and 5th days (Figure 33, Figure 34) ($p < 0.001$).

Figure 33 – Analysis of the indicator “Pain scale on day 4” depending on the use of anesthesia

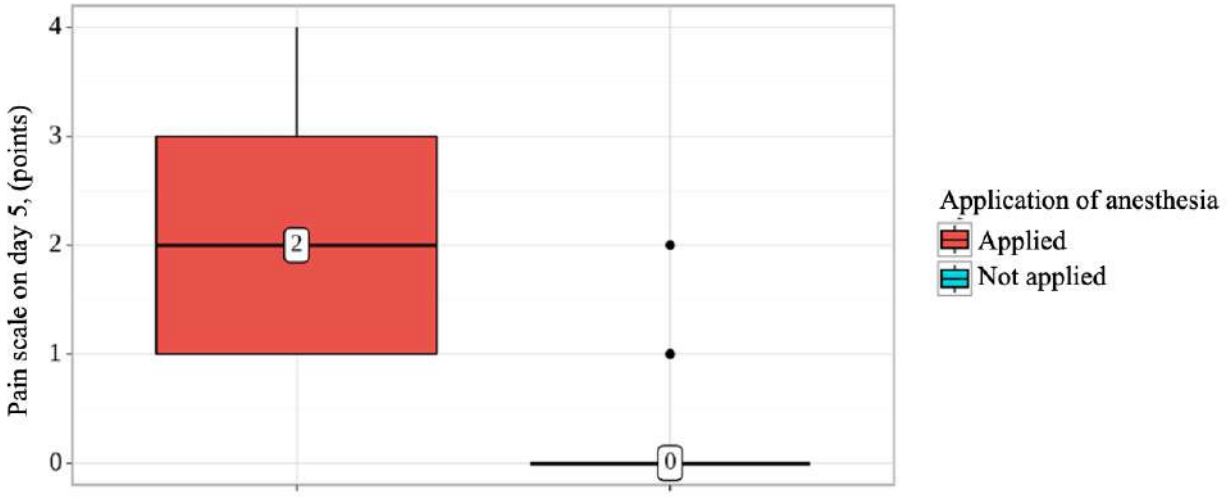


Figure 34 – Analysis of the indicator “Pain scale on day 5” depending on the use of anesthesia

Thus, an analysis of the dynamics of the pain syndrome allows us to state that the use of a tumescent solution during local anesthesia of the intracorporeal suture

of the white line of the abdomen after retromuscular endovideosurgical herniolopathy eTEP is associated with less severity of pain in the first 5 days, which contributes to faster activation of patients.

3.5 Learning curve in the context of mastering standardized retromuscular hernioplasty using the eTEP approach for primary ventral hernias.

At the start of the study, the clinic began actively introducing standardized endovideosurgical retromuscular hernioplasty. Taking into account the results of other independent studies, at the initial stage this technique was used in patients with a primary ventral hernia in combination with diastasis of the rectus abdominis muscles. Two operating teams participated in the study; each operator had experience in laparoscopic surgery at the time of starting to master the technique. Between 2018 and 2023, independent of the main study, each surgical team performed 30 retromuscular hernia repairs using the ETER approach. The first operating team performed a standardized endovideosurgical technique using a developed intraoperative checklist (study group), the second team of surgeons (control group) - without using standardization.

Based on the results of the study, the parameters of a standardized surgical intervention were assessed using an intraoperative checklist. The average duration of operations was165.4 ± 32.1 minutes. The average length of hospitalization after EVS was 5 ± 1 bed days. In the control group without the use of an intraoperative checklist, the average duration of surgery was 186.90 ± 33.55 minutes, and the average duration of hospitalization was 5 ± 1 bed days.

In the course of studying the learning curve, a correlation analysis was conducted of the relationship between the duration of the operation and the number of surgical procedures performed in both comparison groups. When assessing the relationship between the duration of the operation and the number of hernioplasties performed, the first operating team found a high degree of feedback (Table 17).

Table 17 - Results of correlation analysis of the relationship between the number of cases of surgical treatment and the duration of the operation using an intraoperative checklist

Index	Characteristics of correlation		
	r_{xy}	Connection tightness on the Chaddock scale	p
Number of cases - Duration of operation	-0.802	High	<0.001*

* – differences in indicators are statistically significant ($p < 0.05$)

The observed dependence of the duration of the operation on the number of surgical aids is described by the equation of paired linear regression:

$$Y_{\text{Duration of operation}} = -2.899 \times X_{\text{Number of cases}} + 209.598$$

If the number of EVS hernioplasties performed increases by 1, one should expect a decrease in the duration of the operation by 2.899 minutes. The resulting model explains 64.4% of the observed variance in operation duration (Figure 36).

Thus, after passing the learning curve, the experience gained in performing standardized EVS retromuscular hernia repair was sufficient to significantly reduce the average duration of the operation to (121.4 ± 14.2) minutes ($p < 0.01$) (methods used: Mann-Whitney U test). The results obtained are confirmed by other independent studies: the average duration of intervention in the group of patients with primary ventral hernias due to diastasis of the rectus abdominis muscles after passing the learning curve was 101.2 ± 17.1 minutes [97].

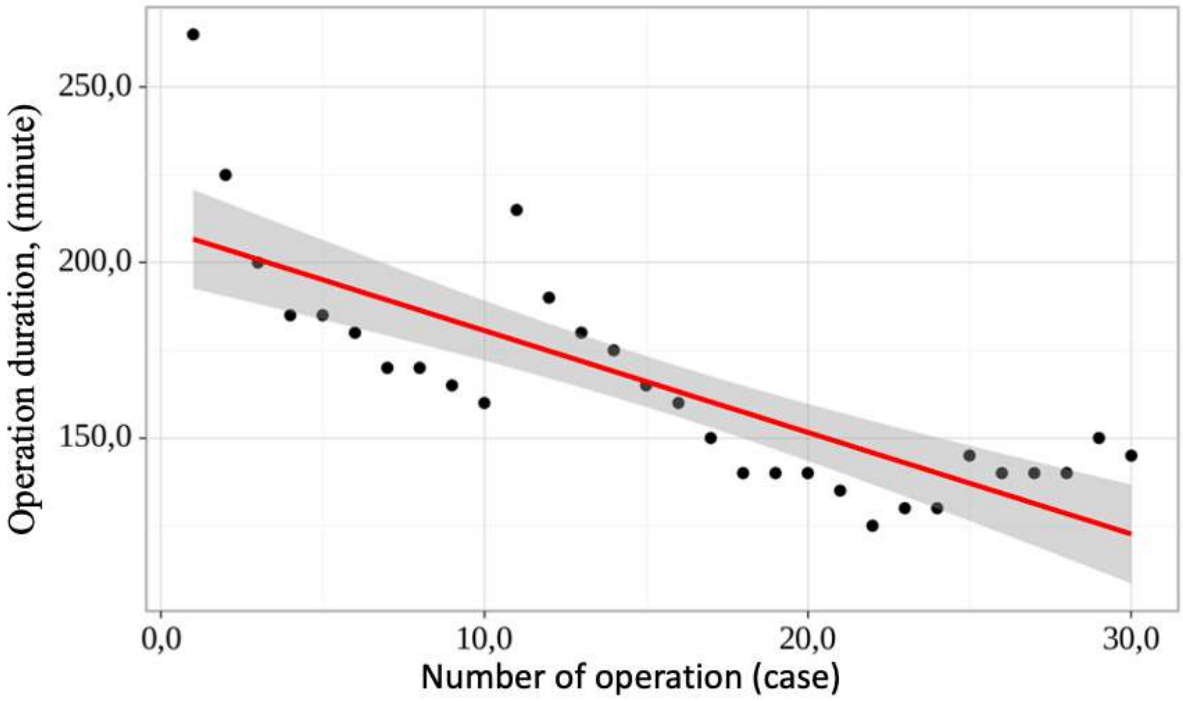


Figure 36 – Regression function graph characterizing the dependence of the duration of the operation on the number of cases of surgical treatment using an intraoperative checklist

When assessing the relationship between the duration of the operation and the number of hernioplasties performed in the control group without use, a noticeably close inverse relationship was established (Table 18).

Table 18 - Results of correlation analysis of the relationship between the number of cases of surgical treatment and the duration of the operation without the use of an intraoperative checklist

Indicators	Characteristics of correlation		
	r_{xy}	Connection tightness on the Chaddock scale	p
Number of operations – Duration of operation	-0.544	Noticeable	0.002*

* – differences in indicators are statistically significant ($p < 0.05$)

The observed dependence of the Duration of Operations on the Number of Operations is described by the paired linear regression equation:

$$Y_{\text{Duration of operation}} = -2.045 \times X_{\text{Number of operations}} + 218.281$$

With an increase in the number of endoscopic retromuscular hernioplasties performed using the eTEP approach without the use of an intraoperative checklist by 1 case, a decrease in the duration of operations by 2.045 minutes should be expected. The resulting model explains 29.5% of the observed variance in operation duration (Figure 37).

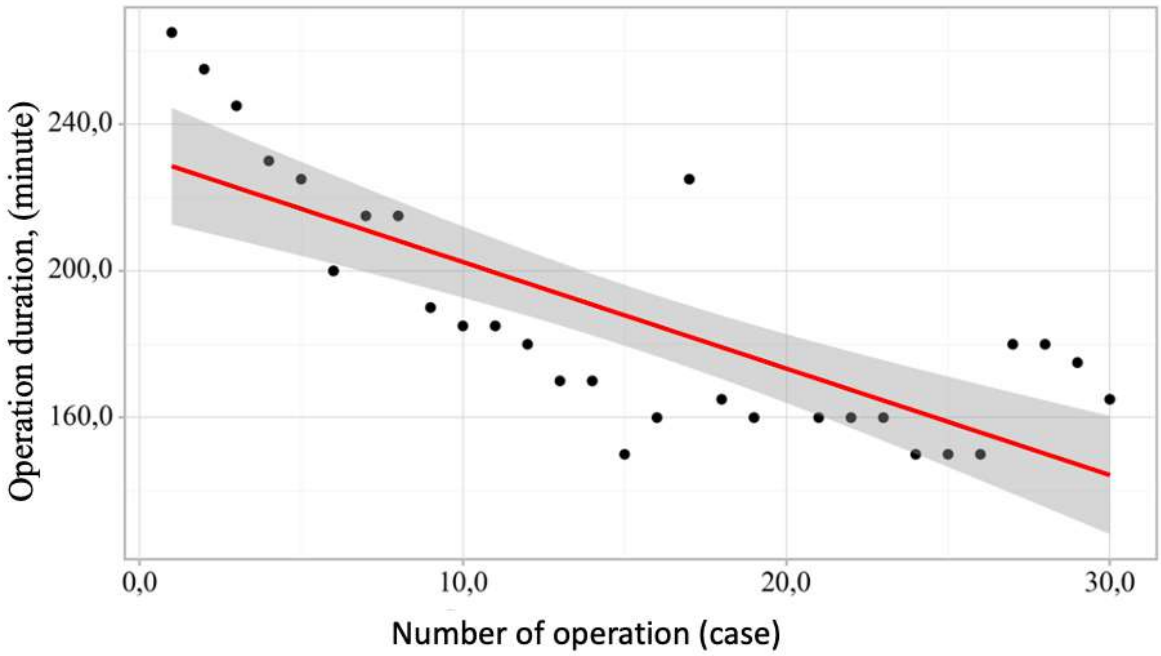


Figure 37 – Regression function graph characterizing the dependence of the duration of the operation on the number of cases of surgical treatment without the use of an intraoperative checklist

Applying the logarithmic formula for calculating the learning curve, we obtained the following results: the learning curve of the first team of surgeons was completed on the 8th case of standardized EVS hernioplasty using the eTEP approach using an intraoperative checklist (Figure 38), the learning curve of the second operating team without the use of an intraoperative checklist - the sheet was passed on case 14 (Figure 39) [97].

The results of the study show that the use of an intraoperative checklist as part of mastering a surgical technique does not affect the duration of hospitalization of patients, but statistically significantly reduces the duration of the learning curve of the operating team. Thus, the development and implementation of an intraoperative

checklist are statistically significant strategies for increasing the reproducibility of the technique, reducing the length of the learning curve and minimizing the complexity of a high-tech surgical technique.

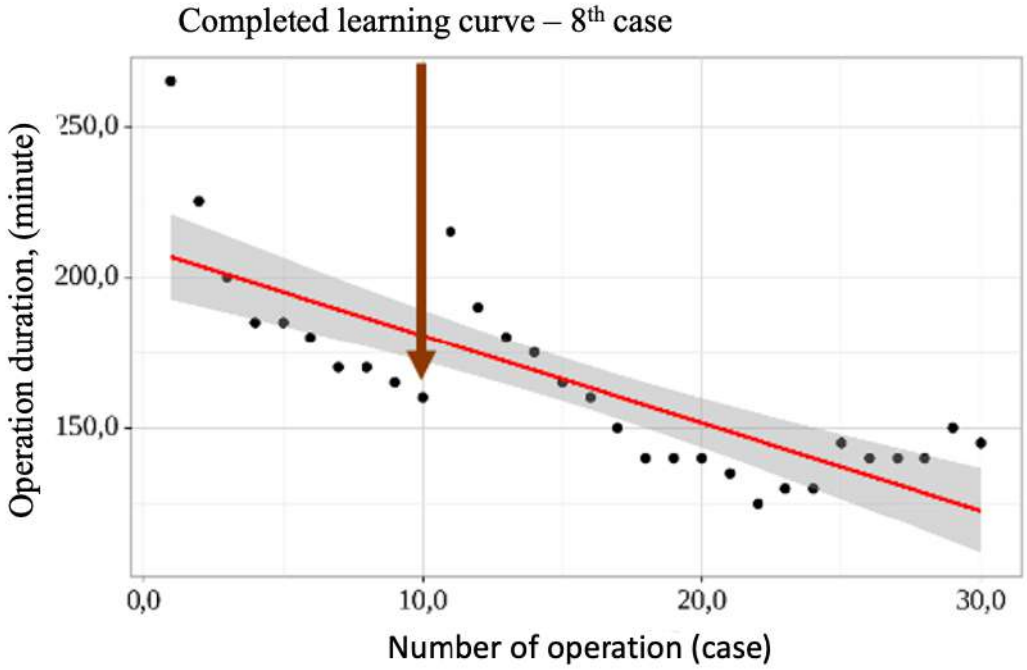


Figure 38 – Completed learning curve for EVS retromuscular hernioplasty using an intraoperative checklist

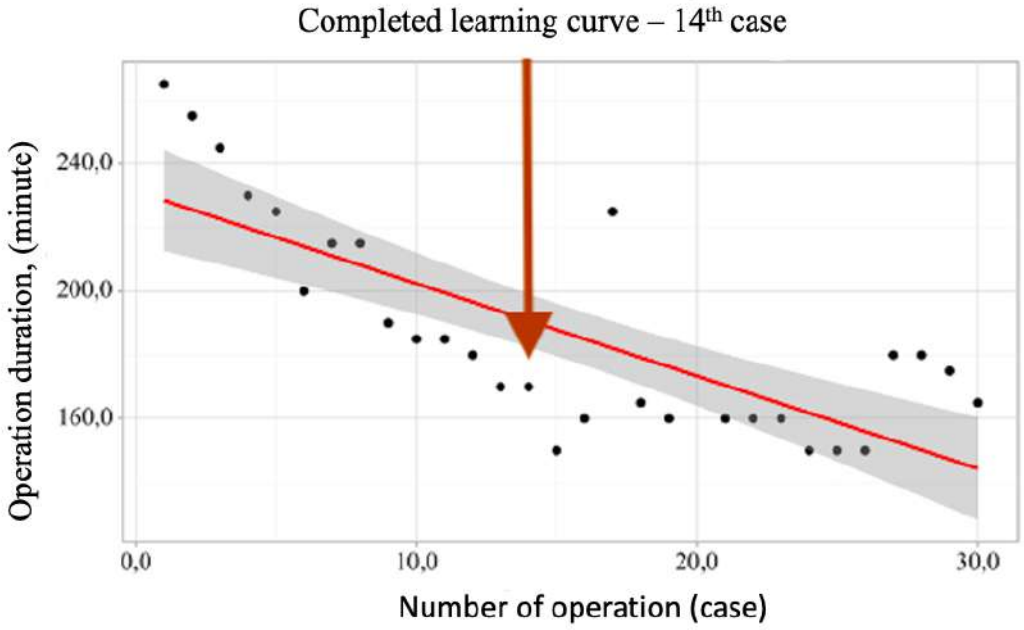


Figure 39 – Completed learning curve for endovideosurgical retromuscular hernioplasty without using an intraoperative checklist

Discussion

The problem of surgical treatment of ventral hernias is of significant relevance, since this pathology is widespread among the population, and the number of radical operations associated with this problem constitutes a significant proportion of the total number of surgical interventions. Ventral hernias most often occur in people of working age and the successful result of the operation is assessed as the absence of relapse and the absence of complications in the postoperative period, which can seriously affect the patient's quality of life. In case of relapse, the likelihood of a recurrence of the hernia increases significantly.

Today, there are many methods for repairing ventral hernias, but Rives-Stoppa open hernioplasty is the "gold standard". This method provides reliable fixation of the mesh endoprosthesis in the retromuscular space and has a low relapse rate. However, open Rives-Stoppa hernioplasty is accompanied by significant tissue trauma, which leads to pain in the postoperative period, increases the duration of hospitalization and requires long-term restoration of the patient's functions.

In connection with the above problems, in recent years new methods of surgical treatment of ventral hernias have been developed and introduced, aimed at reducing pain, improving the cosmetic effect and shortening the recovery period. One of these methods is endoscopic retromuscular hernioplasty using the eTEP approach, which is actively gaining popularity among herniologists and showing promising results. However, despite this, there has not yet been a sufficient number of studies confirming the advantages of the eTEP approach compared to traditional Rives-Stoppa hernia repair. Therefore, it is relevant to compare both early and long-term results of these two techniques.

In order to improve the results of treatment of patients with ventral hernias, a prospective single-center study was conducted on the basis of the 1st surgical department of the Federal State Budgetary Institution "L.G. Sokolov North-Western Regional Scientific and Clinical Center" of the Federal Medical and Biological Agency of Russia, including 122 patients with ventral hernias. This cohort of

patients was divided into 4 groups depending on the type of ventral hernia and the method of surgical treatment performed (Figure 40).

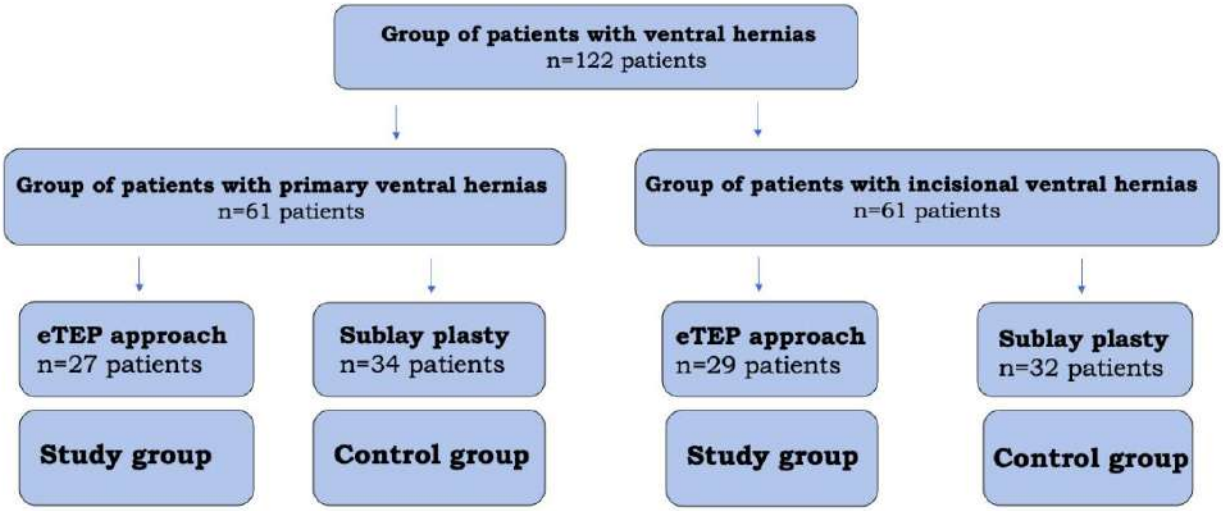


Figure 40 – Distribution of patients by groups

The study included patients with a primary or postoperative ventral hernia with a defect width of 3 to 6 cm. The exclusion criteria for this study were age under 18 years, systemic connective tissue diseases (systemic lupus erythematosus, scleroderma, etc.), cancer, emergency hospitalization, strangulated hernias, and patients with a body mass index (BMI) greater than 35.

It is mandatory to analyze the features of preoperative preparation, the anatomy of the anterior abdominal wall and the nuances of surgical intervention. It has been established that the mandatory procedure for preoperative preparation includes computed tomography of the anterior abdominal wall and pelvis to determine the surgical technique (lower and upper crossover) and apply preoperative markings for correct installation of trocars.

Based on the knowledge and experience gained, as part of the standardization of the surgical manual, an intraoperative checklist was developed that allows a detailed description of each step the surgeon must take during this surgical technique. This intraoperative checklist allowed not only to reduce the incidence of intraoperative complications, complications in the early and postoperative period, but also made it possible to simplify a high-tech, multi-stage operation into an easily

reproducible safe surgical aid. By implementing this checklist, the surgical team in this study was able to complete the learning curve for the 18th surgical case.

Analysis of the results of the early postoperative period showed that retromuscular hernioplasty using the eTEP approach has a number of advantages compared to open Rives-Stoppa hernioplasty, both in patients with primary and postoperative ventral hernias. The length of hospitalization ($p < 0.001$), duration and intensity of pain ($p < 0.001$) after hernioplasty using eTEP access is significantly lower than after open Sublay surgery, which allows patients who have undergone endovideosurgical surgery to become more active and restore functional abilities.

Open Rives-Stoppa repair is associated with a higher number of postoperative complications ($p = 0.037$, $p = 0.046$). In addition, patients operated on using this technique are much more likely to require antibiotic therapy ($p = 0.031$, $p = 0.004$ by Mann-Whitney U test).

Long-term results (more than 1 year) of endovideosurgical retromuscular hernia repair using the eTEP approach are also promising. Clinical assessment of the results using the EuraHSQol questionnaire demonstrates that the functional abilities of patients after IVH hernioplasty are restored much faster, and there is practically no pain after discharge. In addition, patients operated on with the traditional open method more often complain of discomfort in the area of postoperative intervention ($p < 0.001$, $p = 0.040$, $p < 0.001$, $p = 0.004$, $p = 0.039$, methods used: Mann-Whitney U test).

When assessing the timing of the return of patients' functional abilities, it was revealed that the period of return to their previous lifestyle in patients with hernioplasty using the eTEP approach was 3 times shorter compared to the group of patients with hernioplasty using the Sublay method ($p = 0.004$).

During the entire observation period of both groups, relapse after using both techniques was observed in four patients with Sublay hernioplasty. In the long-term postoperative period, no relapses were registered in the group of patients with retromuscular hernioplasty using the eTEP approach ($p = 0.042$) (method used: Fisher’s exact test).

To evaluate the effectiveness of tumescent anesthesia of the intracorporeal suture for endovideosurgical retromuscular hernioplasty (eTEP-RS) of ventral hernias was a prospective single-center study was conducted, including 35 patients with various types of ventral hernias. To ensure a random sample, patients were randomly divided into two groups: one group of patients received tumescent anesthesia, the other group did not use it.

To simplify the assessment of pain, a questionnaire was compiled, including a visual analogue scale from 0 to 10 (Figure 32). In the study, we found a significant reduction in the severity of pain when using tumescent anesthesia compared to patients who did not receive anesthesia. In particular, on the 4th and 5th days after surgery, patients from the study group experienced virtually no pain ($p<0.001$). The results obtained indicate the effectiveness of tumescent anesthesia in reducing pain after retromuscular hernioplasty using the eTEP approach.

As a part of the Critical View of Safety concept and standardization of endoscopic retromuscular hernioplasty using the eTEP approach, an intraoperative checklist was developed. To assess the effectiveness of the intraoperative checklist, a comparative study of the learning curve of two operating teams for endovideosurgical retromuscular hernioplasty using the eTEP approach for primary ventral hernias was conducted. The first surgical team (study group) used standardized EVS hernioplasty using an intraoperative checklist, the second surgical team (control group) did not use the developed intraoperative checklist. The average duration of operations in the study group was 165.4 ± 32.1 minutes. The average time of stay in the hospital after surgical treatment was 5 ± 1 bed days. In the control group without the use of an intraoperative checklist, the average operation time was 186.90 ± 33.55 minutes, and the average hospital stay was also 5 ± 1 bed days. In the learning curve analysis, a correlation analysis was performed to identify the relationship between operative time and the number of operations performed in both comparison groups. The results showed that there was a high inverse relationship between operative time and the number of operations performed using the intraoperative checklist ($p < 0.001$). The learning curve of the first operating team

was completed on the 8th case of using the technique, the second operating team successfully completed the learning curve after the 14th operation. The results obtained show that the introduction of an intraoperative checklist into practice helps to reduce the duration of the learning curve, which contributes to a faster implementation of the technique in the work of the surgical department.

Thus, in a comparative analysis of EVS retromuscular hernioplasty using the eTEP approach and open Rives-Stoppa hernioplasty, it was established that the introduction of endoscopic techniques into the surgeon’s arsenal can improve the results of treatment of patients with ventral hernias. The advantage of endovideosurgical hernioplasty is the easily tolerated early postoperative period, the rapid rate of restoration of the patient's functional abilities and the absence of relapses in the long-term postoperative period (up to 5 years). However, to scientifically substantiate the active implementation of the technique in everyday surgical practice, evaluation in large randomized trials is necessary.

Conclusions

1. The early postoperative period after endoscopic retromuscular hernioplasty is characterized by less severe pain after surgery ($p < 0.001$) and, accordingly, with fewer bed days spent compared to the open Rives-Stoppa operation ($p < 0.001$), which reduces the incidence of complications in early postoperative period. ($p < 0.05$).
2. In the long-term postoperative period, hernioplasty using the eTEP approach is associated with a faster recovery of patients' functional abilities ($p < 0.001$) and the absence of relapses over a four-year postoperative follow-up period ($p = 0.042$).
3. The development and implementation of an intraoperative checklist are effective strategies for increasing the reproducibility of operative techniques and reducing the length of the learning curve.
4. The use of a tumescent solution for local anesthesia of the intracorporeal suture of the white line of the abdomen during endoscopic retromuscular hernioplasty of ventral hernias is associated with less severity of pain in the first 5 days, which contributes to faster activation of patients ($p < 0.001$).

Practical recommendations

1. To successfully implement endoscopic retromuscular hernioplasty using the eTEP approach, the operating room must be equipped with the following equipment:
    - Multifunctional operating table with the ability to create a “jackknife” position.
    - Laparoscopic stand with image display on 2 monitors or with a monitor on a movable knee.
    - Availability of necessary laparoscopic instruments and consumables (optical trocars, needle holders with flat/round handles, non-absorbable suture material with notches)
2. During the training phase, the first and most important aspect is access to the retromuscular space. For safe access, it is recommended to use optical trocars.
3. If it is impossible to close the defect in the peritoneum, especially in postoperative ventral hernias, it is recommended to perform posterior separation repair (TAR). In this regard, at the stage of planning the operation, it is advisable to include in advance a surgeon who knows this technique in the operating team. Depending on the location and size of the defect in the peritoneum, it is possible to perform several options for separation plasty - unilateral, bilateral TAR, upper or lower bilateral TAR.
4. Suturing of a hernia defect with diastasis of the rectus abdominis muscles is recommended to be performed only with a monofilament non-absorbable thread with notches involving the medial edges of the anterior aponeurosis.
5. At the stage of closing defects in the peritoneum, it is not recommended to reduce the insufflation pressure below 11 mm Hg, due to the high risk of not visualizing small defects in the peritoneum. Missed small defects in the peritoneum are the gateway for migration of internal organs into the retromuscular space in the postoperative period.

6. Before installing a mesh implant, it is recommended to measure the formed retromuscular space with a sterile ruler for correct selection and installation of the mesh implant.
7. For the successful implementation and development of endovideosurgical retromuscular hernioplasty eTEP, it is recommended to introduce and use in practice an intraoperative checklist (Table 2).

Abbreviations

BMI – body mass index

CI – confidence interval

CT AWO – computed tomography of the abdominal wall organs

ECG - electrocardiography

ECHO-KG – echo – cardiography

EHS – European hernia society

eTEP - extended totally extraperitoneal plasty

EVS - endovideosurgical

FRP – function of external respiration

IPOM - intraperitoneal onlay mesh

LA - local anesthesia

MILOS - mini- or less-open sublay

PROMIS - patient-reported outcomes measurement information system

RCT - randomized clinical trial

SSI - surgical site infection

TA – tumescent anesthesia

TAR – transversus abdominal release

VAS – visual analogue scale

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