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Current Surgical Strategies and Risk-Based Classification in Ventral Hernia Repair

Karimov KHYA[1], Ibrokhimov MYO[2], Alimukhamedova NA[2], Shukurov BI[2]*

[1]*Republican Specialized Scientific and Practical Medical Center of Hematology, Tashkent, Uzbekistan*

[2]*Central Polyclinic of JSC "Uzbekistan Railways", Tashkent, Uzbekistan*

Abstract

Ventral hernias are among the most common conditions in abdominal surgery, associated with high rates of postoperative complications and recurrences. This review summarizes contemporary insights into the pathogenesis, classifications of ventral hernias (EHS, VHWG, HPW, CeDAR), approaches to assessing loss of domain, and patient risk stratification. Modern principles of surgical decision-making are discussed, including the use of various mesh implant positions and materials, as well as the importance of preoperative optimization of modifiable risk factors. Particular emphasis is placed on the advances in minimally invasive and robotic techniques, which represent the most promising directions for improving outcomes in ventral hernia repair.

Keywords: ventral hernias, incisional hernias, hernia pathogenesis, hernia classification, loss of domain, hernia repair, mesh implants, minimally invasive surgery, complication prevention, anterior abdominal wall surgery

Introduction

Ventral hernias are among the most frequently performed surgical procedures worldwide [1]. Inguinal hernias are the most common, affecting up to 43% of men and 6% of women, and account for over 20 million surgical repairs annually [1]. In the United States alone, more than 350,000 ventral hernia repairs are performed each year, yet the failure rate remains high, contributing to increased rates of postoperative complications, hernia recurrence, and the need for reoperations [2–4]. The technical complexity of hernia correction contributes to a wide range of postoperative complications (4% to 48%) and recurrence rates up to 50%, depending on the follow-up period [5]. Postoperative ventral hernias are recognized as one of the most common late complications of abdominal surgery. It is estimated that up to 3% of patients develop symptomatic hernias within two years after open abdominal procedures [6]. Preoperative surgeries further increase the risk of recurrence and complications [7]. These events also impose a considerable financial burden on healthcare systems [8], particularly in patients with modifiable risk factors such as smoking, obesity, and diabetes mellitus [9].

For example, in Japan, the average annual cost of treating postoperative ventral hernias is estimated at $1.7 billion [10]. Thus, even a 1% reduction in surgical interventions could save approximately $17 million annually for the Japanese healthcare system [10]. Similarly, the French Surgical Society estimates that reducing the incidence of postoperative hernias by at least 5% annually could save up to €4 million each year [11]. Despite numerous studies, the multifactorial nature of ventral hernia pathogenesis remains poorly understood. While clinical risk factors such as obesity, diabetes, aging, male sex, smoking, as well as surgical factors like suture type and closure technique, are well established [2,13], they only offer a partial understanding of the overall risk.

Definitions and Classification of Ventral Hernias

The primary aim of hernia classification systems is to establish a standardized and universally accepted terminology that facilitates data comparison across studies and supports surgical decision-making. Effective classification must consider various parameters, including hernia characteristics and patient condition. The European Hernia Society (EHS) classification is one of the most widely accepted systems for describing both primary and incisional anterior abdominal wall hernias [13]. A primary hernia is defined as a spontaneous protrusion of intra-abdominal contents through a defect in the abdominal wall, unrelated to previous surgery or trauma. The EHS system classifies hernias based on two parameters: location and defect size. Regarding location, two types of midline hernias (epigastric and umbilical) and two types of lateral hernias (Spigelian and lumbar) are recognized. Defect size is measured by the maximal transverse diameter. According to joint EHS and American Hernia Society (AHS) guidelines, the size classification is as follows: small (<1 cm), medium (1–4 cm), and large (>4 cm) for midline hernias [14]. For lateral hernias, the thresholds are slightly different: small (<2 cm), medium (2–4 cm), and large (>4 cm) [13].

An incisional hernia is defined as any defect in the anterior abdominal wall, with or without protrusion, located in the area of a previous surgical scar and detectable on clinical examination or imaging [15]. This category also includes primary hernias previously treated surgically. The EHS consensus emphasizes two key parameters for classifying incisional hernias: location and size [16]. Several systems have been developed to predict postoperative outcomes and risk of complications in ventral hernia repair:

1. Ventral Hernia Working Group (VHWG) Classification

First introduced in 2010 and revised in 2013, the VHWG classification stratifies the risk of surgical site complications and hernia recurrence [17,18]. It includes:

- Grade 1 (low risk): healthy patients without prior wound infections.
- Grade 2 (comorbid): patients with conditions such as diabetes, COPD, immunosuppression, obesity, or smoking.
- Grade 3 (contaminated field): presence of surgical field contamination.3A: clean-contaminated;
  1. 3B: contaminated;
  2. 3C: active infection.

While primarily designed for open surgery, its applicability in minimally invasive procedures is less evident, given the reduced infection rates in such cases [19].

2. The Hernia–Patient–Wound (HPW) classification, developed by Petro and Novitsky in 2016, is analogous to the TNM cancer staging system and offers a stratified prediction of postoperative complications and recurrence risk [20].

- H (hernia):
  1. H1: <10 cm
  2. H2: 10–20 cm
  3. H3: >20 cm
- P (patient comorbidity):

***Corresponding Author:** *Shukurov BI, Central Polyclinic of JSC "Uzbekistan Railways", Tashkent, Uzbekistan

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1. P0: none
2. P1: obesity (BMI >35), smoking, diabetes, immunosuppression
3. W (wound):
4. W0: clean
5. W1: contaminated

For instance, HPW stage 4 (H3 P1 W1) corresponds to a 39% risk of early complications and 31% risk of recurrence, whereas HPW stage 1 (H1 P0 W0) corresponds to only 6% and 5%, respectively [20,21] (Figure 1).

Figure 1: *Classification of Hernia–Patient–Wound (HPW) for predicting complications after hernia repair [20].*

Stage	Hernia	Patient	Wound	HPW stage	Surgical site events rate (%)	Recurrence rate (%)
1	1	0	0	H1 P0 W0	5.8	4.7
2	1 or 2	Any	0	H1 P1 W0 H2 Any W0	12.6	9.7
3	Any	Any	Any	H1 Any W1 H2 Any W1 H3 Any W0	20.2	13.2
4	3	Any	Any	H3 P1 W0 H3 Any W1	38.9	31.1

3. The Carolinas Equation for Determining Associated Risks (CeDAR) is a validated mathematical model implemented as a digital application that enables surgeons to estimate an individual patient's risk based on clinical and operative parameters. In addition to risk calculation, the model allows simulation of how modifying risk factors-such as smoking cessation or weight loss-can influence the predicted outcomes [22]. The complexity of ventral or incisional hernias depends on a variety of factors, including patient-related conditions, hernia characteristics, and previous abdominal wall interventions. Currently, no universally accepted definition or classification system exists for what constitutes a "complex hernia."

In 2014, an expert panel proposed a set of 22 variables that define hernia complexity [23]. These were grouped into four domains:

- Hernia size and location: defect width >10 cm, presence of loss of domain;
- Tissue status: skin ulcers, skin grafts, or previously open abdomen;
- Patient history and risk factors: obesity, diabetes, long-term corticosteroid use;
- Clinical context: emergency surgery, prior mesh repair.

Based on these variables, patients were stratified into low, moderate, or high complexity categories.

A subsequent international Delphi consensus supported by the European Hernia Society identified 18 key variables, the presence of at least one of which qualifies a hernia as complex [24]. These were categorized into four groups:

1. Hernia characteristics: width >10 cm, recurrent incisional hernia, loss of domain, coexistence of midline and parastomal hernia;
2. Local wound factors: skin defect, fistula, infected mesh, abdominal wall infection, stoma, previously open abdomen;
3. Abdominal wall condition: previous anterior or posterior component separation, TRAM flap reconstruction, abdominal wall resection;
4. General patient factors: BMI >40 kg/m², liver cirrhosis with ascites.

The term loss of domain (LOD) refers to the disproportionate distribution of abdominal contents, with a significant portion residing permanently in the hernia sac rather than within the peritoneal cavity. In such cases, attempting fascial closure after reduction may cause a substantial increase in intra-abdominal pressure, potentially leading to abdominal compartment syndrome or respiratory failure [25]. Several volumetric methods have been developed to quantify LOD using computed tomography (CT) or other imaging modalities. According to the Sabbagh method, LOD is considered significant when ≥20% of the total peritoneal volume is located within the hernia sac. The Tanaka method defines LOD when the ratio of hernia sac volume to abdominal cavity volume is ≥0.25 [26,27]. In 2020, an updated Delphi-based consensus defined LOD as "*a ventral hernia in which simple reduction of contents and primary fascial closure would carry a substantial risk of complications due to elevated intra-abdominal pressure*" [25].

Surgical Treatment Approaches

The rapid evolution of ventral hernia repair techniques has highlighted the need for standardized terminology, particularly regarding mesh placement planes. Terms such as sublay and underlay have historically been used inconsistently, referring to various anatomical positions. In 2020, an international panel of 20 experts conducted a Delphi consensus to propose standardized nomenclature for mesh positioning within the anterior abdominal wall [28].

The proposed anatomical planes include:

- Onlay – placed on top of the anterior fascia;
- Anterectus – between the anterior rectus sheath and the rectus muscle;
- Inlay – sutured to the edges of the defect without overlap;
- Interoblique – between the external and internal oblique muscles;
- Retro-oblique – below the internal oblique and above the transversus abdominis;
- Retrorectus – between the rectus muscle and its posterior sheath;
- Retromuscular (post-TAR) – retrorectus medially, between the transversus abdominis and its fascia laterally;
- Transversalis fascial – between the posterior sheath and transversus abdominis;
- Preperitoneal – between the transversalis fascia and peritoneum;
- Intraperitoneal – beneath the peritoneum and in contact with abdominal organs.

Among these, onlay, retrorectus, retromuscular, preperitoneal, and intraperitoneal placements are the most commonly used in clinical practice. A wide variety of mesh implants is available for hernia repair. A useful classification system groups them by material composition. In 2018, a standardized mesh labeling system was proposed that distinguishes between: permanent synthetic, biologic, bioabsorbable (synthetic absorbable), and hybrid meshes [29]. Meshes are also categorized by pore size (microporous <100 µm, small 101–600 µm, medium 601–1000 µm, large 1001–2000 µm, extra-large >2000 µm), weight (ultralight <35 g/m², light 35–50 g/m², medium 51–90 g/m², heavyweight >90 g/m²), and material type. Although no definitive correlation has been established between these properties and outcomes, current evidence suggests that lightweight, medium-porosity meshes provide better integration and reduced foreign body sensation [30,31].

In clean, non-contaminated cases, permanent synthetic meshes are preferred. In contaminated fields, the choice remains controversial. Some data support the use of synthetic mesh even in contaminated environments, although long-term outcomes remain uncertain [32,33]. Common synthetic materials include polypropylene, polyester, polyvinylidene fluoride (PVDF), and expanded polytetrafluoroethylene (ePTFE). Among these, polypropylene meshes remain the most widely studied and utilized [34]. Biologic meshes, derived from human or animal tissue, are used primarily in infected or high-risk wounds. However, randomized trials have not demonstrated clear superiority over synthetic options in complex scenarios [35]. Bioabsorbable meshes, composed of fully or partially degradable polymers, provide a more affordable alternative to biologics. Their degradation time ranges from a few months to 1–1.5 years [36]. Hybrid meshes, which combine properties of synthetic and biologic materials, represent the most recent innovation, though clinical data remain limited [37,38].

Preoperative Optimization and Risk Modification

For patients undergoing elective ventral hernia repair, preoperative optimization of both hernia- and patient-related modifiable risk factors is essential to improve surgical outcomes without causing undue delays in treatment [39]. As outlined in risk classification systems, certain specific factors significantly influence the likelihood of complications. Smoking cessation is strongly recommended at least four weeks prior to surgery, irrespective of hernia type. This intervention significantly reduces the risk of wound and pulmonary complications [40,41]. Obesity is one of the most impactful risk factors for both postoperative complications and recurrence. Patients with a body mass index (BMI) >30 kg/m² are at particularly high risk [7]. For those with BMI >35 kg/m², elective surgery should be approached cautiously, and preoperative weight reduction is encouraged [42]. Recent advances in minimally invasive techniques, however, have been associated with a decline in complication rates among obese patients [34,43]. In patients who are unresponsive to diet and physical activity alone, pharmacological options such as GLP-1 receptor agonists may promote significant weight loss within 3–6 months preoperatively. Bariatric surgery can also be considered either as a preparatory step or combined with hernia repair in patients with morbid obesity [44].

Diabetic patients with poor glycemic control are at increased risk for postoperative infectious complications and recurrence [40,45]. Although some studies show no clear association between HbA1c levels and adverse outcomes [46], most experts recommend maintaining HbA1c below 8% and ensuring tight perioperative glucose control. Ventral hernia patients often report reduced physical activity due to fear of worsening the hernia. However, prehabilitation-even in the form of light individualized exercise-has been shown to improve postoperative outcomes [47–50]. In patients with large hernias and loss of domain, botulinum toxin type A (BTA) injections into the lateral abdominal wall muscles promote muscle relaxation and elongation, facilitating fascial closure. Typically, Botox® is administered in a dose of 100–300 IU across three sites on each side, four weeks prior to surgery, under ultrasound guidance. Adverse effects are rare and usually limited to transient pain or hematomas at injection sites [51]. Nevertheless, the technique still requires further standardization [52,53]. Progressive preoperative pneumoperitoneum (PPP) may be used as an adjunct or alternative to BTA in cases of severe loss of domain. In this technique, 800–1000 mL of gas is insufflated daily via an intra-abdominal catheter to gradually stretch the abdominal wall. While PPP can facilitate hernia content reduction, complications such as pulmonary dysfunction, thromboembolism, bowel injury, and even rare fatal outcomes have been reported [54–56].

Surgical Management of Primary Midline and Incisional Hernias

Umbilical and epigastric hernias represent some of the most frequently encountered types of ventral hernias. Although their true prevalence is unknown, surgical repair is commonly performed [57]. Patients may remain asymptomatic or report bulging, intermittent pain, or discomfort. In asymptomatic cases, a watchful waiting strategy may be appropriate, but approximately 20% of such patients eventually require operative intervention [58]. In most cases of primary midline hernias, imaging studies are not necessary. However, for large hernias, potential loss of domain, obesity, rectus diastasis, uncertain defect size, or suspicion of multiple defects, ultrasound or computed tomography (CT) is recommended for optimal surgical planning [14]. Surgical repair may be performed using open or minimally invasive approaches. The choice depends on patient characteristics, defect size and location, institutional resources, and surgeon experience [59].

1. For small defects (<1 cm), open repair is typically preferred. The decision between suture repair and mesh placement should be made on an individual basis. Mesh use has been shown to reduce recurrence even in small hernias, although it may slightly increase the risk of wound-related complications [60–62]. When mesh is used, a flat preperitoneal polypropylene implant with at least 2 cm overlap is recommended [14,63,64].
2. For medium defects (1–4 cm), mesh reinforcement is strongly recommended. Open mesh repairs should provide a 3 cm overlap to minimize recurrence without significantly affecting wound complications or postoperative discomfort [14]. The decision between open and minimally invasive techniques should be individualized. Minimally invasive approaches are preferred in patients at high risk of wound complications or with multiple defects [14,59,65,66]. An additional benefit of laparoscopy is the ability to identify occult hernias and place a large mesh for linea alba weakness or diastasis recti [67].
3. Defects >4 cm are less commonly encountered in primary cases and are generally managed under the framework for incisional hernias [14].

Among all ventral hernias, incisional hernias represent the most heterogeneous category in terms of size, location, and associated anatomical challenges. Their development is influenced by numerous factors, including patient-specific characteristics, initial disease pathology, incision type, and closure technique [68]. CT imaging is frequently employed in the preoperative evaluation of incisional hernias to assess anatomy, defect size and location, presence of mesh, and to identify ongoing risk factors such as occult pathology or infection [40]. When the defect width exceeds 8 cm or loss of domain is present, component separation techniques may be necessary to facilitate fascial closure [40]. Proximity to bony structures can complicate mesh fixation and may require the use of bone anchors-titanium or polymeric devices drilled or driven into bone to securely affix the mesh. This method is particularly useful in large incisional hernias involving the pubis, costal margins, or iliac crests [69]. In patients with reducible, asymptomatic incisional hernias, the risk of emergent repair is low, and observation may be appropriate [70]. However, such hernias typically enlarge over time, leading to increased technical difficulty and poorer outcomes [71]. Patients with symptomatic hernias that impair quality of life should be offered surgery if medically fit [40]. Where benefit is uncertain, discussions regarding potential risks and preoperative risk factor optimization are essential.

Trends in Open, Laparoscopic, and Robotic Repair

Advancements in the anatomical understanding of the anterior abdominal wall have significantly modified traditional open reconstruction techniques. Among these, retromuscular (retrorectus) mesh placement remains the most durable open repair technique and is widely considered the standard for midline hernia reconstruction [40]. However, open repairs are associated with a higher risk of postoperative wound complications and prolonged hospital stay [72]. Minimally invasive hernia repair techniques, both laparoscopic and robotic, are increasingly being adopted for both midline and lateral incisional hernias. Over the past two decades, intraperitoneal onlay mesh (IPOM) repair with defect closure and mesh fixation has gained widespread use [73–75]. Nonetheless, concerns about adhesions and chronic pain from mesh fixation have prompted the development of newer techniques that place mesh in preperitoneal or retromuscular planes [76–79]. These advanced anatomical planes can be accessed via traditional laparoscopy or robotic platforms. Although these techniques are more technically demanding and time-consuming, they offer advantages such as reduced postoperative pain, shorter hospitalization, and lower infection risk, making them an attractive option for surgeons with expertise in minimally invasive techniques [80].

Conclusion

Ventral hernias remain a significant clinical challenge due to high recurrence rates, frequent postoperative complications, and substantial healthcare costs. Modern understanding of their pathogenesis, classification, and treatment strategies continues to evolve. The implementation of standardized classification systems (EHS, VHWG, HPW, CeDAR) facilitates consistent diagnostic criteria and outcome prediction. Patient stratification based on modifiable risk factors-including smoking, obesity, and diabetes-is critical. Preoperative optimization using physical conditioning, pharmacologic weight loss, botulinum toxin injection, or progressive pneumoperitoneum plays an increasingly important role. Surgical trends indicate a transition from traditional open techniques toward minimally invasive and robotic approaches, with growing emphasis on retromuscular and preperitoneal mesh positioning. The use of permanent synthetic, bioabsorbable, or hybrid meshes is expanding, although high-level evidence is still needed for newer materials. The future of ventral hernia management lies in personalized treatment planning, guided by validated risk prediction models and continuous innovation in surgical materials and technology for abdominal wall reconstruction.

References

1. Diaz R, Quiles MT, Guillem-Marti J, Lopez-Cano M, Huguet P, et al. (2011) Apoptosis-like cell death induction and aberrant fibroblast properties in human incisional hernia fascia. Am J Pathol. 178(6):2641–2653.
2. Si Z, Bhardwaj R, Rosch R, Mertens PR, Klosterhalfen B, et al. (2002) Impaired balance of type I and type III procollagen mRNA in cultured fibroblasts of patients with incisional hernia. Surgery 131(3):324–331.
3. Darmadi S, Warsinggih, Mappincara, Hendarto J, Labeda I, et al. (2021) Profile of collagen prolines level of anterior rectus sheath tissue in indirect inguinal hernia: A cross-sectional study. Ann Med Surg (Lond) 68: 102546.
4. Fajar A, Warsinggih, Syarifuddin E, Hendarto J, Labeda I, et al. (2022) The relationship between glycine levels in collagen in the anterior rectus sheath tissue and the onset of indirect inguinal hernia: A cross-sectional study. Ann Med Surg (Lond). 73:103166.
5. Helgstrand F (2016) National results after ventral hernia repair. Dan Med J 63(7):B5258.
6. Bosanquet DC, Ansell J, Abdelrahman T, Cornish J, Harries R, et al. (2015) Systematic review and meta-regression of factors affecting midline incisional hernia rates: Analysis of 14,618 patients. Plosone 10(9):e0138745.
7. Holihan JL, Alawadi Z, Martindale RG, Roth JS, Wray CJ, et al. (2015) Adverse events after ventral hernia repair: The vicious cycle of complications. J Am Coll Surg 221(2):478–485.
8. Reynolds D, Davenport DL, Korosec RL, Roth JS (2013) Financial implications of ventral hernia repair: A hospital cost analysis. J Gastrointest Surg 17(1):159–167.
9. Howard R, Thompson M, Fan Z, Englesbe M, Dimick JB, et al. (2019) Costs associated with modifiable risk factors in ventral and incisional hernia repair. JAMA Netw Open. 2(11):e1916330.
10. Hikino K, Koido M, Tomizuka K, Liu X, Momozawa Y, et al. (2021) Susceptibility loci and polygenic architecture highlight population specific and common genetic features in inguinal hernias. EbioMedicine 70:103532.
11. Gillion JF, Sanders D, Miserez M, Muysoms F (2016) The economic burden of incisional ventral hernia repair: a multicentric cost analysis. Hernia 20(6):819–830.
12. Li J, Zhang X, Sun Q, Li W, Yu A, et al. (2018) Circulating matrix metalloproteinases and procollagen propeptides in inguinal hernia. Hernia 22(4):541–547.
13. Muysoms F, Jacob B (2018) International hernia collaboration consensus on nomenclature of abdominal wall hernia repair. World J Surg 42(1):302–304.
14. Henriksen NA, Montgomery A, Kaufmann R, Berrevoet F, East B, et al. (2020) Guidelines for treatment of umbilical and epigastric hernias from the European Hernia Society and Americas Hernia Society. Br J Surg 107(3):171–190.
15. Korenkov M, Paul A, Sauerland S, Neugebauer E, Arndt M, et al. (2001) Classification and surgical treatment of incisional hernia: results of an experts' meeting. Langenbecks Arch Surg 386(1):65–73.
16. Muysoms FE, Miserez M, Berrevoet F, Campanelli G, Champault GG, et al.(2009) Classification of primary and incisional abdominal wall hernias. Hernia 13(4):407–414.
17. Breuing K, Butler CE, Ferzoco S, Franz M, Hultman CS, et al. (2010) Incisional ventral hernias: review of the literature and recommendations regarding the grading and technique of repair. Surgery. 148(3):544–558.
18. Kanters AE, Krpata DM, Blatnik JA, Novitsky YM, Rosen MJ (2012) Modified hernia grading scale to stratify surgical site occurrence after open ventral hernia repairs. J Am Coll Surg 215(6):787–793.
19. Hodgkinson JD, Maeda Y, Leo CA, Warusavitarne J, Vaizey CJ (2017) Complex abdominal wall reconstruction in the setting of active infection and contamination: a systematic review of hernia and fistula recurrence rates. Colorectal Dis 19(4):319–330.
20. Petro CC, Novitsky YW (2016) Classification of hernias. In: Novitsky YW (eds.), Hernia Surgery: Current Principles. Cham: Springer p.15–21.
21. Timmer AS, Claessen JJM, Boermeester MA (2022) Risk factor-driven prehabilitation prior to abdominal wall reconstruction to improve postoperative outcome: a narrative review. J Abdom Wall Surg 1:10722.
22. Augenstein VA, Colavita PD, Wormer BA, Walters AL, Bradley JF, et al. (2015) CeDAR: Carolinas equation for determining associated risks. J Am Coll Surg 221(1):S65–S66.
23. Slater NJ, Montgomery A, Berrevoet F, Carbonell AM, Chang A, et al. (2014) Criteria for definition of a complex abdominal wall hernia. Hernia 18(1):7–17.
24. Capoccia Giovannini S, Podda M, Ribas S, Montori G, Botteri E, et al. (2024) What defines an incisional hernia as 'complex': results from a Delphi consensus endorsed by the European Hernia Society (EHS). Br J Surg 111(1):znad346.
25. Parker SG, Halligan S, Liang MK, Muysoms FE, Adrales GL, et al. (2020) Definitions for loss of domain: an international Delphi consensus of expert surgeons. World J Surg 44(4): 1070–1078.
26. Tanaka EY, Yoo JH, Rodrigues AJ, Utiyama EM, Birolini D, et al. (2010) A computerized tomography scan method for calculating the hernia sac and abdominal cavity volume in complex large incisional hernia with loss of domain. Hernia 14(1):63–69.
27. Al Sadairi AR, Durtette-Guzylack J, Renard A, Durot C, Thierry A, et al. (2022) A simplified method to evaluate the loss of domain. Hernia 26(4):927–936.
28. Parker SG, Halligan S, Liang MK, Muysoms FE, Adrales GL, et al. (2020) International classification of abdominal wall planes (ICAP) to describe mesh insertion for ventral hernia repair. Br J Surg 107(3):209–217.
29. Kahan LG, Blatnik JA (2018) Critical under-reporting of hernia mesh properties and development of a novel package label. J Am Coll Surg 226(2):117–125.
30. Cobb WS, Kercher KW, Heniford BT (2005) The argument for lightweight polypropylene mesh in hernia repair. Surg Innov 12(1): 63–69.
31. Oliveira Trindade B, Marcolin P, Brandao GR, Bueno Motter S, Mazzola Poli de Figueiredo S, et al. (2024) Heavyweight versus non-heavyweight mesh in ventral hernia repair: a systematic review and meta-analysis. Hernia 28(2):291–300.
32. Rosen MJ, Krpata DM, Petro CC, Carbonell A, Warren J, et al. (2022) Biologic vs synthetic mesh for single-stage repair of contaminated ventral hernias: a randomized clinical trial. JAMA Surg 157(4): 293–301.
33. Harris HW, Primus F, Young C, Carter JT, Lin M, et al. (2021) Preventing recurrence in clean and contaminated hernias using biologic versus synthetic mesh in ventral hernia repair: the PRICE randomized clinical trial. Ann Surg 273(4): 648–655.
34. de Figueiredo SMP, Tastaldi L, Mao RMD, Lima DL, Huang LC, et al. (2023) Biologic versus synthetic mesh in open ventral hernia repair: A systematic review and meta-analysis of randomized controlled trials. Surgery 173(4):1001–1007.
35. Shi H, Wang R, Dong W, Yang D, Song H, Gu Y (2023) Synthetic versus biological mesh in ventral hernia repair and abdominal wall reconstruction: a systematic review and recommendations from evidence-based medicine. World J Surg 47(10):2416–2424.
36. Yu JF, Goldblatt HE, Alter-Troilo K, Hetzel E, Goldblatt MI (2022) Long-term outcome of absorbable synthetic mesh in clean ventral hernia repairs. Surg Endosc 36(7): 5144–5148.
37. Spurzem GJ, Broderick RC, Li JZ, Sandler BJ, Horgan S, et al. (2024) Maximizing mesh mileage: evaluating the long-term performance of a novel hybrid mesh for ventral hernia repair. Hernia. 28(4):1151–1159.
38. Timmer AS, Claessen JJ, Brouwer de Koning IM, Haenen SM, Belt EJ, et al. (2022) Clinical outcomes of open abdominal wall reconstruction with the use of a polypropylene reinforced tissue matrix: a multicenter retrospective study. Hernia

26(5):1241–1250.
39. Fafaj A, De Figueiredo SMP, Rosen MJ, Petro CC (2024) Preoperative optimization in hernia surgery: are we really helping or are we just stalling? Hernia 28(3):925–930.
40. Sanders DL, Pawlak MM, Simons MP, Aufenacker T, Balla A, (2023) Midline incisional hernia guidelines: the European Hernia Society. Br J Surg 110(12):1732–1768.
41. Henriksen NA, Bisgaard T, Helgstrand F, Danish Hernia Database (2020) Smoking and obesity are associated with increased readmission after elective repair of small primary ventral hernias: a nationwide database study. Surgery 168(3):527–531.
42. Abci I, Bilgi S, Altan A (2005) Role of TIMP-2 in fascia transversalis on development of inguinal hernias. J Investig Surg 18(3):123–128.
43. Addo A, Lu R, Broda A, George P, Huerta N, et al. (2021) Impact of Body Mass Index (BMI) on perioperative outcomes following minimally invasive retromuscular abdominal wall reconstruction: a comparative analysis. Surg Endosc 35:5796–5802.
44. Borbély Y, Zerkowski J, Altmeier J, Eschenburg A, Kröll D, et al. (2017) Complex hernias with loss of domain in morbidly obese patients: role of laparoscopic sleeve gastrectomy in a multi-step approach. Surg Obes Relat Dis 13(5):768–773.
45. Jensen KK, East B, Jisova B, Cano ML, Cavallaro G, et al. (2022) The European Hernia Society Prehabilitation Project: a systematic review of patient prehabilitation prior to ventral hernia surgery. Hernia 26(3):715–726.
46. Al-Mansour MR, Vargas M, Olson MA, Gupta A, Read TE, et al. (2023) Lack of association between glycated hemoglobin and adverse outcomes in diabetic patients undergoing ventral hernia repair: an ACHQC study. Surg Endosc 37(4):3180–3190.
47. Adams ST, Bedwani NH, Massey LH, Bhargava A, Byrne C, et al. (2022) Physical activity recommendations pre and post abdominal wall reconstruction: a scoping review of the evidence. Hernia 26(3):701–714.
48. Liang MK, Bernardi K, Holihan JL, Cherla DV, Escamilla R, et al. (2018) Modifying risks in ventral hernia patients with prehabilitation: a randomized controlled trial. Ann Surg 268(4):674–680.
49. Renshaw SM, Poulose BK, Gupta A, Di Stasi S, et al. (2021) Preoperative exercise and outcomes after ventral hernia repair: making the case for prehabilitation in ventral hernia patients. Surgery 170(2): 516–524.
50. de Jong DLC, Wegdam JA, Berkvens EBM, Nienhuijs SW, de Vries Reilingh TS (2023) The influence of a multidisciplinary team meeting and prehabilitation on complex abdominal wall hernia repair outcomes. Hernia 27(3): 609–616.
51. Timmer AS, Claessen JJM, Atema JJ, Rutten MVH, Hompes R, et al. (2021) A systematic review and meta-analysis of technical aspects and clinical outcomes of botulinum toxin prior to abdominal wall reconstruction. Hernia 25(6):1413–1425.
52. Wegdam JA, de Vries Reilingh TS, Bouvy ND, Nienhuijs SW (2021) Prehabilitation of complex ventral hernia patients with botulinum: a systematic review of the quantifiable effects of botulinum. Hernia 25(6):1427–1442.
53. Deerenberg EB, Shao JM, Elhage SA, Lopez R, Ayuso SA, et al. (2021) Preoperative botulinum toxin A injection in complex abdominal wall reconstruction: a propensity-scored matched study. Am J Surg 222(3):638–642.
54. Elstner KE, Moollan Y, Chen E, Jacombs ASW, Rodriguez-Acevedo O, et al. (2021) Preoperative progressive pneumoperitoneum revisited. Front Surg 8: 754543.
55. Giuffrida M, Biolchini F, Capelli P, Banchini F, Perrone G (2024) Botulinum toxin and progressive pneumoperitoneum in loss of domain ventral hernias: a systematic review. J Abdom Wall Surg 3:12650.
56. Ramaswamy A (2023) Preoperative optimization for abdominal wall reconstruction. Surg Clin North Am 103(5):917–933.
57. Burcharth J, Pedersen MS, Pommergaard HC, Bisgaard T, Pedersen CB, et al. (2015) The prevalence of umbilical and epigastric hernia repair: a nationwide epidemiologic study. Hernia 19(5): 815–819.
58. Kokotovic D, Sjolander H, Gogenur I, Helgstrand F (2016) Watchful waiting as a treatment strategy for patients with a ventral hernia appears to be safe. Hernia 20(2): 281–287.
59. Christoffersen MW, Henriksen NA (2023) Treatment of primary ventral and incisional hernias. Br J Surg 110(10):1419–1421.
60. Kaufmann R, Halm JA, Eker HH, Klitsie PJ, Nieuwenhuizen J, et al. (2018) Mesh versus suture repair of umbilical hernia in adults: a randomised, double-blind, controlled, multicentre trial. Lancet 391(10123):860–869.
61. Henriksen NA, Jensen KK, Bisgaard T, Helgstrand F (2022) Danish Hernia Database. Suture or mesh repair of the smallest umbilical hernias: a nationwide database study. World J Surg 46(7):1898–1905.
62. Wehrle CJ, Prabhu AS, Thompson R, Petro CC, Miller BT, et al. (2024) Mesh versus suture repair of incisional hernias 2 cm or less: is mesh necessary? A propensity score-matched analysis of the abdominal core health quality collaborative. Surgery 175(5):799–805.
63. Ponten JEH, Leclercq WKG, Lettinga T, Heemskerk J, Konsten JLM, et al. (2019) Mesh OR Patch for Hernia on Epigastric and Umbilical Sites (MORPHEUS-trial): the complete two-year follow-up. Ann Surg 270(1):33–37.
64. Berger RL, Li LT, Hicks SC, Liang MK (2014) Suture versus preperitoneal polypropylene mesh for elective umbilical hernia repairs. J Surg Res 192(2): 426–431.
65. Novitsky YW, Cobb WS, Kercher KW, Matthews BD, Sing RF, et al. (2006) Laparoscopic ventral hernia repair in obese patients: a new standard of care. Arch Surg 141(1): 57–61.
66. Maspero M, Bertoglio CL, Morini L, Alampi B, Mazzola M, et al. (2022) Laparoscopic ventral hernia repair in patients with obesity: should we be scared of body mass index? Surg Endosc. 36(3):2032–2041.
67. Dhanani NH, Olavarria OA, Holihan JL, Shah SK, Wilson TD, et al. (2023) Robotic versus laparoscopic ventral hernia repair: one-year results from a prospective, multicenter, blinded randomized controlled trial. Surg Endosc 37(4):2911–2921.
68. Deerenberg EB, Henriksen NA, Antoniou GA, Bramer WM, et al. (2022) Updated guideline for closure of abdominal wall incisions from the European and American Hernia Societies. Br J Surg 109(11):1239–1250.
69. Vagholkar K (2022) Novel technique for mesh fixation to the bone in recurrent post-traumatic lumbar hernia. Med Arch 76(3):229–232.
70. Verhelst J, Timmermans L, van de Velde M, Jairam A, Vakalopoulos KA, et al. (2015) Watchful waiting in incisional hernia: is it safe? Surgery 157(2):297–303.
71. Jensen KK, Arnesen RB, Christensen JK, Bisgaard T, Jorgensen LN (2019) Large incisional hernias increase in size. J Surg Res 244:160–165.
72. Sauerland S, Walgenbach M, Habermalz B, Seiler CM, Miserez M (2011) Laparoscopic versus open surgical techniques for ventral or incisional hernia repair. Cochrane Database Syst Rev 3):CD007781.
73. Chelala E, Barake H, Estievenart J, Dessily M, Charara F, et al. (2016) Long-term outcomes of 1326 laparoscopic incisional and ventral hernia repair with the routine suturing concept: a single institution experience. Hernia 20(1):101–110.
74. Köckerling F, Simon T, Adolf D, Köckerling D, Mayer F, et al. (2019) Laparoscopic IPOM versus open sublay technique for elective incisional hernia repair: a registry-based, propensity score-matched comparison of 9907 patients. Surg Endosc 33(10):3361–3369.
75. Heniford BT, Park A, Ramshaw BJ, Voeller G (2003) Laparoscopic repair of ventral hernias: nine years' experience with 850 consecutive hernias. Ann Surg 238(3):391–399.
76. Henriksen NA, Jensen KK (2024) Trends in use of laparoscopic intraperitoneal onlay mesh for ventral hernia repair. JAMA Surg 159(2):109–111.
77. Soare AM, Cartu D, Nechita SL, Andronic O, Surlin V (2021) Complications of intraperitoneal mesh techniques for incisional

hernia-a systematic review. Chirurgia (Bucur). 116(Suppl): S36–S42.
78. Belyansky I, Daes J, Radu VG, Balasubramanian R, Reza Zahiri H, et al. (2018) A novel approach using the enhanced-view totally extraperitoneal (eTEP) technique for laparoscopic retromuscular hernia repair. Surg Endosc 32(4):1525–1532.
79. Muysoms F, Van Cleven S, Pletinckx P, Ballecer C, Ramaswamy A (2018) Robotic transabdominal retromuscular umbilical prosthetic hernia repair (TARUP): observational study on the operative time during the learning curve. Hernia 22(6):1101–1111.
80. Claus C, Cavazolla LT, Furtado M, Malcher F, Felix E (2021) Challenges to the 10 golden rules for a safe minimally invasive surgery (MIS) inguinal hernia repair: can we improve? ABCD Arq Bras Cir Dig 34: e1597.