REVIEW ARTICLE

Complex Ventral Hernias: A Review of Past to Present

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ABSTRACT

With the incidence of ventral hernias increasing, surgeons are faced with greater complexity in dealing with these conditions. Proper knowledge of the history and the advancements made in managing complex ventral hernias will enhance surgical results. This review article highlights the literature regarding complex ventral hernias, including a shift from a focus that stressed surgical technique toward a multimodal approach, which involves optimization and identification of suboptimal characteristics.

INTRODUCTION

Complex abdominal wall defects represent one of the more challenging dilemmas faced by general surgeons. The natural history of abdominal hernias has demonstrated that with time a patient's quality of life will worsen.[1] More importantly, complex abdominal wall defects propagate additional morbidity and can result in substantial complications if left untreated.[2] As a ventral hernia progresses, studies have demonstrated that this condition impinges on psychological well-being, with patients reporting lower satisfaction with body image and mental health.[1] This same study demonstrated that patients with ventral hernias were less sexually active, had greater rates of body pain, and had diminished social and physical functioning.[1]

As the most common complication after laparotomy, incisional hernias are typically the inciting factor in the development of these complex defects.[3,4] With an estimated 4 million laparotomies performed annually in the US alone, the incidence of these defects is on the rise.[3,4] Hernias can derive from a variety of sources, including a history of trauma, previous surgery, congenital defects, infection, and even cancer.[1,3] A survey in 2016 showed 65% of experts surveyed agreeing that loss of domain and hernia volumes greater than 30% of abdominal contents are mandatory characteristics for defining large, complex abdominal wall defects.[5] However, the true complexity of such defects cannot be measured solely by a standard definition. The difficulty seen in repairing these defects ultimately depends on a multitude of factors.[2] These include the location, size, depth, and condition of the surrounding tissue associated with the defect.[2]

The surgical management of ventral hernias has evolved. Primary closure of fascial defects was originally the mainstay of therapy in hernia repair. Unfortunately, recurrence rates were unacceptable, with some studies reporting rates greater than 50%.[6,7] This led to the advent of a tension-free repair with use of prosthetic mesh. First introduced in the 1950s,[8] the use of mesh repair has expanded over time, and with improved recurrence rates, the tension-free mesh repair eventually became the gold standard for repair.[7,9] However, despite the improved recurrence rates seen with mesh use, it can subject patients to unwanted mesh-related complications, and as such, the surgical field has yet to obtain an ideal repair for complex hernias.[6,7,9,10]

At the inception of laparoscopic techniques for herniorrhaphy in 1993, certain advantages were deemed to be inherent to this approach. In general, laparoscopic techniques are associated with reduced hospital stay, faster recovery, and a 3% recurrence rate at roughly 2 years postoperatively.[11] However, certain hernia characteristics, such as loss of domain, previously placed mesh, and extensive abdominal surgical history may preclude the use of laparoscopy.[12] For such defects, expansion on the open primary repair was pursued by Ramirez et al,[13] with a technique founded on the principle of myofascial advancement and manipulation. The component separation, as it was eventually coined, has since had modifications made to its approach, with each variation possessing unique pros and cons.

However, despite operative innovation, recurrence rates remain far from acceptable. For this reason, surgeons are now shifting their focus away from operative technique and heightened emphasis on optimizing patient-related factors. This has become one of the newest developments in the history of this condition's management. In relation, the adaptation of multimodal recovery pathways, originally developed by colorectal surgeons, has shown promising effects on postoperative outcomes.[14] This same philosophy is now being employed in managing patients who are undergoing abdominal wall reconstruction. With a focus on perioperative optimization, it is hoped that these trends translate to improved success. This article aims to review, expand, and highlight the progression of technique, as well as the management strategies used in treating complex abdominal wall defects.

PREOPERATIVE CONSULTATION

Preoperative assessment of large ventral hernia defects is the cornerstone of success. It allows for identification of

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factors that may preclude certain operative interventions and promotes presurgical steps to optimize a patient's status before undergoing such a repair. Rosen[15] corroborates this and holds the preoperative consultation critical to managing patients undergoing ventral herniorrhaphy. Because extensive morbidity and mortality are associated with repair of complex abdominal defects, it is critical to understand associated morbidity and to educate patients during the presurgical evaluation.[16] Preoperative assessment therefore should define, as well as align, the patient's and surgeon's goals and expectations.[12] If presurgical evaluation detects any substantial comorbidity or disease process, surgeons should consider consultation with an internal medicine physician to facilitate optimization.[16]

Preoperative evaluation should begin with a thorough history and physical examination. Special attention should be given to the size and location of the hernia as well as prior incisions or stomas.[6] Overlying skin changes such as ulceration, thinning, and cellulitis should also be noted, as should the presence of draining sinuses or exposed mesh.[6] Because patients with these characteristics have a ten-fold increase in soft-tissue infection rates, identification is of the utmost importance, and proper treatment is necessary before repair.[15] During physical examination, patients should be evaluated in the standing and supine positions.[16] Valsalva maneuver should also be used during examination because it can enhance the sensitivity of the physical examination findings.[16] Inability to reduce herniated contents, especially of large size, below the level of the fascia should raise suspicion for a loss of domain.[15]

Surgical history, as well as previous operative reports, should be reviewed. It has been demonstrated that patients with a history of prior abdominal hernia repair have an increased risk of infection, 42% vs 12%, with a repeated operation.[15] The operative history should pinpoint previous repairs, types of mesh used (if any at all), and into which plane the mesh was placed because these factors will influence surgical therapy greatly.[6] Active reconnaissance should be used if deemed necessary and can include discussions with previous surgeons in addition to requesting operative reports. Additionally, the number of previous ventral hernia repairs is an independent risk factor for recurrence, complication rates, and reoperation rates, further highlighting the importance of the preoperative assessment.[17] Investigating the cause of previous surgical failures should encompass identification of suboptimal conditions and subsequent optimization.

The context of a patient's hernia is paramount to the preoperative assessment because presentation will often dictate urgency and method of repair. In general, indications to repair ventral hernias are subjective, but most commonly include symptom relief, cosmesis, and prevention of future morbidities such as pain, incarceration, enlargement, and skin changes associated with the defect.[18] The urgent or emergent nature of presentation can affect morbidity and mortality, with mortality rates reported to be 0.3% for elective repairs compared with 1.1% for complicated cases.[19] However, whenever feasible, surgeons should continue to exercise careful and meticulous presurgical assessment, unless precluded by an emergent presentation.

In general, the operative approach chosen should be based on the anticipated complexity as well as the experience and comfort a surgeon possesses with the operation.[12] However, as a guide, the presence of extensive adhesions or history of previous major operations potentiate the risk of intestinal injuries during laparoscopic adhesiolysis.[12] Additional factors to consider are presence of active infection, coagulable states, loss of domain, poor skin quality over the defect, and patient expectations, specifically scar revision or panniculectomy desires.[15] The use of an open procedure in the presence of these characteristics should be strongly considered because the likelihood of conversion from laparoscopic to open repair is exceptionally high and may add undue morbidity.[12]

PREOPERATIVE OPTIMIZATION

Comorbidities should be assessed and medically optimized before any surgical repair because the presence of these are associated with higher recurrence and complication rates.[6] The presence of coronary artery disease, chronic obstructive pulmonary disease, corticosteroid use, and low preoperative albumin levels were found to be significant independent predictors of wound infection and hospital length of stay.[20] Effective patient optimization generally includes smoking cessation at least 4 weeks before surgery, tight glycemic control (glucose level below 110 mg/dL; hemoglobin A_{1C} concentration less than 7.0%), nutritional optimization, and aggressive medical therapy with bronchodilators to improve oxygenation in those patients with chronic obstructive pulmonary disease or chronic hypoxia.[4,20-22] Nutritional optimization, effective glycemic control, weight loss in obese patients, and smoking cessation are cost-effective methods that should be routinely used to optimize patients preoperatively.[4] An overview of these measures appears in Table 1.[4,6,15,20-25]

Table 1. Preoperative optimization[4,6,15,20-25]

Condition	Recommendation
Diabetes mellitus	HbA_{1C} < 7%; perioperative glucose level ranges from 140 mg/dL to 160 mg/dL ideally
Smoking	Cessation at least 4 weeks before surgery
Obesity	BMI > 50 kg/m^2: Not recommended for elective repair BMI > 45 kg/m^2: Consider bariatric surgery referral BMI > 30 kg/m^2: Weight loss and diet counseling
Malnourishment	Albumin > 3 g/dL, nutritional drink (eg, IMPACT Advanced Recovery, Nestlé Health Science)
COPD/emphysema	Bronchodilator therapy; pulmonary consultation
MRSA	Preoperative screening
Cardiac history	Cardiology consultation; obstructive sleep apnea screening

BMI = body mass index; COPD = chronic obstructive pulmonary disease; HbA_{1c} = hemoglobin A_{1c};
MRSA = methicillin-resistant *Streptococcus aureus.*

Smoking cessation is imperative because smokers have higher risks of wound morbidity and hernia recurrence.[15] Smoking diminishes oxygen tension in tissues, ultimately decreasing collagen deposition during wound healing.[4] Lindström et al[22] assessed the benefits of perioperative smoking cessation, finding a 49% risk reduction in all postoperative complications in those abstaining from smoking at least 4 weeks preoperatively. Nutritional optimization is another essential aspect of preoperative evaluation because the presence of malnutrition or brittle diabetes mellitus can be detrimental to surgical success. Poor glycemic control in the perioperative and postoperative period, up to 60 days after surgery, has repeatedly been shown to increase the risk of wound infections.[4] A range of 140 mg/dL to 160 mg/dL in blood glucose levels during the perioperative period is advocated as the optimal target by Martindale and Deveney.[4]

Malnourished patients and those with obesity must be optimized to prevent operative failure. Numerous studies have demonstrated preoperative albumin levels to be one of the strongest predictors of overall 30-day postsurgical mortality and morbidity.[4,20,23,24] A Veterans Affairs study demonstrated preoperative albumin levels less than 3.0 g/dL to be the most important predictor of postsurgical complications.[24] Additionally, albumin levels have been found to correlate with the length of hospital stay as well as wound infection rates.[20] Presence of obesity can have extensive implications on surgical outcomes. Patients with a body mass index greater than 45 kg/m^2 should consider bariatric evaluation before undergoing elective hernia repair.[6] Martindale and Deveney[4] have essentially excluded elective hernia repair as an option for those with a body mass index greater than 50 kg/m^2 because the recurrence risk is prohibitively high. For those with a body mass index greater than 30 kg/m^2, an increased risk of skin and soft-tissue infections, as well as higher wound dehiscence rates, have been reported.[21,25]

PREOPERATIVE IMAGING

Computed tomography (CT) of the abdominal wall is an excellent tool in assessing ventral hernia characteristics. According to Earle et al,[12] CT imaging can define musculature integrity and assess defect relationship to intraabdominal structures, enhancing a surgeon's ability to determine the safest and most ideal approach for mesh placement. For the most part, no intravenous or oral contrast agent is necessary; however, the surgeon should use discretion on the basis of the presentation or when certain anatomical aspects of the hernia are unclear.[6] The use of CT is especially helpful in morbidly obese patients, those with history of recurrent hernias, if loss of domain is suspected, or with defects near bony structures.[15] Rosen[15] advocates for CT assessment to further evaluate possible loss of domain, which typically has extensive volume of abdominal contents localized to the hernia sac. A survey among specialists found that CT scanning, functional respiratory evaluation, and cardiology consultation are indispensable parts of the preoperative evaluation, with CT the most commonly employed.[5] The use of preoperative imaging is especially beneficial in patients with recurrences, for evaluating vasculature and tissue planes, to better delineate nonmidline hernias or for identifying defects unnoticed on physical examination.[4,12]

Although not useful in determining the extent of intraabdominal adhesions, preoperative CT imaging can detect signs of occult inflammation or infected fluid cavities that may alter mesh utilization and surgical approach.[6,12] One study showed an occult hernia detection rate of 48% in those who underwent laparoscopic hernia repairs, which originally went undetected on physical examination.[26] An additional study found significantly better results in the detection of hernia recurrence after mesh repair using CT scanning when compared with physical examination alone, with 98% and 88% detection rates, respectively.[27] The possibility of infection or additional hernias encountered unexpectedly in the operating room make CT imaging a lucrative tool during preoperative consultation.

OPTIONS FOR OPERATIVE REPAIR

Rives-Stoppa Repair

The Rives-Stoppa repair was first described in the 1980s and uses a retrorectus dissection plane. This operation has demonstrated extensive durability with avoidance of subcutaneous flap creation.[6] The operation releases the posterior rectus sheath off the rectus muscles and allows for further mobilization.[6] This is typically accomplished by incising the posterior rectus sheath within 0.5 cm from its medial border and dissecting bluntly toward the semilunar line.[6] As one dissects laterally, it is important to identify the neurovascular bundles running between the internal oblique and transversus abdominis muscles because they can lead to unnecessary morbidity if damaged.[6,15] Mesh is then often placed in a retromuscular fashion, anterior to the posterior fascial plane.[6]

Recurrence rates after Rives-Stoppa repair at midterm and long-term follow-up have been reported to be 3% and 6%, respectively.[15] This operation also maintains the functional and anatomic integrity of the abdominal wall musculature, which is considered crucial to successful abdominal wall reconstruction.[28] However, despite its excellent record, the limited lateral dissection used in this technique limits its applicability.[6] With this said, certain situations are inherently not suited for the Rives-Stoppa repair and include nonmidline ventral hernias lateral to the linea semilunaris, limited amount of retrorectus space needed for mesh placement, and insufficient medial advancement of the posterior rectus sheath and musculature.[6] Because of these limitations, additional operative techniques have been developed.

Posterior Component Separation with Transversus Abdominis Release

The transversus abdominis release has demonstrated utility in repairing complex and nonmidline defects that the Rives-Stoppa repair fails to address. This approach uses a retrorectus dissection plane, similar to the Rives-Stoppa repair with added lateral mobilization and mesh overlap.[6] Near the margin of the semilunar line, usually 0.5 cm medial, the posterior rectus sheath is incised, exposing the underlying transversus abdominis muscle.[6,15] The underlying fascia is then dissected off the muscle plane as far laterally as the psoas muscle if needed.[6,15]

The use of transversus abdominis release provides extensive benefits during repair. First, it maximizes preservation of abdominal wall blood flow and limits the creation of large skin flaps.[29] It alleviates the tension created by the laterally connecting thoracolumbar fascia, which allows for further medial advancement of the posterior rectus sheath.[15] It also allows for further expansion of the abdominal cavity, improving tension off-loading.[15] These effects are possible because the transversus abdominis muscle extends more medially than the remaining oblique muscles and is essentially the main contributor to intraabdominal pressure, ultimately allowing enhanced tension-free repair.[15] The posterior component separation with transversus abdominis release has consistently shown a recurrence rate less than 10% in numerous studies.[29-31]

Anterior Component Separation

The anterior component separation uses a dissection anterior to the rectus muscles. During the operation, a subcutaneous plane is formed by incising the external oblique fascia, just lateral to the lateral aspect of the rectus muscles.[6,15] Additional dissection to the margin of the anterior axillary line can be performed if tension-free approximation is not attained at first.[6,15] This technique provides for extensive medial mobilization of the abdominal wall musculature while allowing effective midline reconstruction.[6]

Despite exceptional medial coverage, the limiting factor in the use of this approach is the sequelae that follow the creation of skin flaps. Krpata et al[29] found an increased rate of wound morbidity and complication rates when an anterior component separation was performed. Compared with the use of a posterior component separation, the anterior component separation had a significantly higher total complication rate (48.2% vs 25.4%, $p = 0.01$).[29] The authors attributed this finding to the extensive dead space created by the subcutaneous dissection.[29] Furthermore, after mobilization, the subcutaneous tissue is left relatively ischemic, predisposing it to infection and seroma formation.[6,15] This study also observed a trend toward higher rates of recurrence when compared with posterior component separation; however, the difference failed to meet statistical significance (14.3% vs 3.6%, $p = 0.09$).[29]

POSTOPERATIVE CARE

Historically, important aspects of recovery have involved proper airway management, pain control, and nutritional support. However, practices in immediate postoperative care in all surgical fields have vastly changed in the last decade. The use of routine narcotic pain administration and subjective diet advancement is being replaced by standardized regimens tailored to improve and speed recovery.

With present-day quality constraints, cost inflation, and subpar medical accessibility, the use of standardized recovery can have an extensive impact on more than just hernia results. In relation, a study published in 2016 demonstrated significant benefit in the use of a standardized recovery pathway.[32] Between traditional and enhanced recovery protocols, respectively, authors reported significantly shorter times to diet advancement (liquids: 2.7 vs 1.1 days; regular diet: 4.8 vs 3.0 days, $p < 0.001$), return of bowel function (5.2 vs 3.6 days, $p < 0.001$), length of stay (4.0 vs 6.1 days, $p < 0.001$), and reduced 90-day readmission rate (16% vs 4%, $p < 0.001$).[32] This protocol aimed at mitigating the metabolic consequences associated with postsurgical recovery.[32] The authors state that the pathway is based on the key principles of pain management and acceleration of intestinal recovery.[32] Summary recommendations from this study are listed in Table 2.[32]

With the impressive findings seen in recovery, the use of standardization, although promising, may not always be ideal. One of the most critical aspects to manage in nonideal circumstances in the early postoperative course is proper airway management and identifying patients at risk of respiratory failure. Long operative times increase open abdomen exposure, enhancing insensible losses and fluid shifts.[15] Patients undergoing lengthy procedures with extensive surgery or those with a history of severe pulmonary disease are generally admitted to the intensive care unit.[15] One study found respiratory complications to occur in 20% of patients after open component separation surgery.[33] Intubation is therefore advocated when plateau airway pressures increase more than 6 cm H_2O intraoperatively or postoperatively because increased airway pressures represent a 9-fold increased risk in pulmonary complications.[33] The persistent elevation of airway or abdominal pressures may indicate the need for paralysis up to 48 hours.[6,33] If, however, the patient is not critically ill, adequate pain control, chest physiotherapy, and aggressive use of incentive spirometry should be routinely employed.[6,15,33]

Postoperatively, diet and nutritional support should be optimized to ensure adequate healing. Conservative diet advancement is typically employed in patients undergoing complex hernia repair. Overly aggressive diet progression can induce retching and vomiting, which can jeopardize repair and propagate aspiration.[6] As a caveat, nasogastric tube decompression is generally reserved for patients who have intestinal resections, major intestinal manipulation, or prolonged adhesiolysis.[15] At times, a subtle presentation mimicking that of ileus can confound the diagnosis of early postoperative bowel obstruction. It should be noted that more than 90% of early postoperative bowel obstructions are partial and tend to resolve spontaneously.[16] However, any signs or concerns for early bowel obstruction should prompt CT imaging to further evaluate the abdomen.[6] Early reexploration is warranted if findings suggest a completely obstructed or strangulated bowel on workup because of the likelihood of irreversible mechanical obstruction.[6,16]

Additional aspects of postoperative recovery include mobility and drain care. In general, intraoperatively placed subcutaneous drains are removed on the basis of consistency and when output is less than 50 mL/d for 2 consecutive days.[6] Ambulation is encouraged as soon as possible but should be considered on a case-by-case basis.[15] On discharge, patients are given instructions on activity restrictions and should not lift more than 4.5 kg (10 lb) for up to 6 weeks postoperatively.[15] This is advocated to minimize increases in intraabdominal pressure, one of the major factors attributed to hernia recurrences.[15]

Abdominal binders have historically been used in the postoperative period for comfort.[6] Certain advocates for its use believe abdominal binders may actually lessen the risk of seroma formation, improve postoperative pain control, and enhance postural stability.[34] A study performed in 2014 investigated the effects of abdominal binder use on postoperative recovery after major abdominal surgery.[34] This study showed no significant evidence linking binder use to pulmonary function, seroma formation, or improved postoperative pain control.[34] However, the study did demonstrate significant benefits in psychological distress levels as well as physical functioning and mobilization after postoperative day 5 when binders were used.[34]

Table 2. Summary of enhanced recovery after surgery pathway for ventral hernia repair	
Phase of care	**Pathway component**
Preoperative	Weight loss counseling Diabetic control (HbA_{1C} < 8%) Smoking cessation > 4 weeks Obstructive sleep apnea screening Preoperative nutritional shake MRSA screening
Perioperative	Subcutaneous heparin, 5000 U once, with sequential compression devices to lower extremities Oral alvimopan,12 mg once Oral gabapentin, 100-300 mg once First-generation cephalosporin or vancomycin for screen positive for MRSA
Intraoperative	Pain control: • Limit use of narcotics and paralytics • Intraoperative TAP block, 20 mL of liposomal bupivacaine diluted to 200 mL (100 mL per side)
Postoperative	Pain control: • IV hydromorphone PCA: 0.2 mg every 6-10 min, no breakthrough dose; no basal rate; stopped on POD 2 once a clear liquid diet is begun • Oral oxycodone, 5-10 mg every 4 h as needed, started once off IV PCA • Oral acetaminophen, 650 mg, every 6 h, started immediately postoperatively • Oral gabapentin, 100-300 mg 3x daily, started on POD 1 • IV/oral diazepam, 5 mg every 6 h as needed: 2.5-mg dose for patients > age 65 y; hold for patients with obstructive sleep apnea, sedation, or any respiratory compromise • Oral NSAIDs, 600-800 mg orally every 6-8 h as needed, can use IV ketorolac, 15-30 mg every 6 h for up to 72 h; hold for patients with renal dysfunction Intestinal recovery: • No routine nasogastric tube placement • NPO except medications on operative day only • Scheduled diet advancement: POD 1, limited clear liquids (< 250 mL/shift); POD 2, clear liquids ad libitum; POD 3, regular diet • Oral alvimopan, 12 mg twice daily, until discharge or POD 7 Fluids: Fluid conservative strategy: lactated Ringer's at 100 mL/h on operative day; 5% dextrose in half normal saline at 75 mL/h on POD 1; saline lock IVF on POD 2

[a] Source: Majumder et al.[32]
HbA_{1c} = hemoglobin A_{1c}; IV = intravenous; IVF = intravenous fluid; MRSA = methicillin-resistant *Staphylococcus aureus;* NPO = nothing by mouth; NSAID = nonsteroidal anti-inflammatory drug; PCA = patient-controlled analgesia; POD = postoperative day; TAP = transversus abdominis plane.

CONCLUSION

With the large number of abdominal operations performed each year, the incidence of ventral hernias is on the rise. Open ventral hernia repair remains the primary option for surgeons when faced with complex abdominal wall reconstruction. The advancements in tension-free repair as well as component separation have improved success rates. However, despite improvement, certain aspects of surgical repair have yet to translate to acceptable results.

To improve successful correction rates of complex abdominal defects, emphasis has shifted from surgical technique and toward a multimodal approach involving optimization and identification of suboptimal characteristics. Although the technical experience and procedural method used by the surgeon is of importance, assessing patient-related factors and comorbidities may provide the missing aspect necessary for an ideal operative approach. With enhanced recovery pathways being incorporated into the management of complex abdominal wall defects, it is hoped that these advancements can assist surgeons in greatly improving repair success and patient quality of life. ❖

Disclosure Statement

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Multiplicity of Hot Irons

If practitioners, since the time of Albucasis, had been contented with his doctrine, and never had ventured to think for themselves, surgery had not been what it now is, and its great merit would still have consisted in the multiplicity of its hot irons.

— Percivall Pott, 1714-1788, English surgeon, one of the founders of orthopedics