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ADVANCES IN SURGERY

Laparoscopic Hernia Repair

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Keywords

• Ventral hernia repair • Laparoscopic hernia repair • Robotic hernia repair • Abdominal wall reconstruction • Laparoscopy • Incisional hernia • Laparoscopic ventral hernia repair

Key points

- Surgeons must assess several patient factors as well as their level of comfort with LVHR and ultimately opt for an approach that provides the best outcome combined with a low potential for risk.
- The mesh to defect ratio strongly affects recurrence rates. In general, the broader the mesh, the lower the chance for recurrence.
- Compared with open, LVHR has decreased risk of surgical site infection and may be an appropriate approach for patients with risk factors for wound-related complications that cannot be modified.
- Consideration may be given to primary fascial defect closure during LVHR, which may reduce rates of postoperative seromas and recurrence.
- Advancements in technology and traditional LVHR technique, such as extraperitoneal mesh placement and robotic approach, have allowed for more advanced repairs and may improve the shortcomings of a bridged LVHR.

INTRODUCTION

Ventral incisional hernias are a ubiquitous problem for general surgeons; approximately 22% of patients develop an abdominal musculo-fascial defect within 3 years of laparotomy [1]. Furthermore, 229,000 Americans a year report hernias as the primary cause of their disability, affecting their ability

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to perform activities of daily living and instrumental activities of life [2]. Thus, ventral hernia repair (VHR) remains one of the most common operations performed by surgeons and is a procedure of significant importance for its ability to restore quality of life (QOL) [3]. Although the use of mesh has improved the outcomes compared with a tissue-based repair and has long been accepted as the preferred method to minimize recurrence, less agreement surrounds the ideal approach to repair [4–6].

As with the other areas of surgical practice, the advent of minimally invasive surgery (MIS) added a new technique to the surgical approach of VHR. Although the generalized benefits of MIS include improved QOL, shortened recovery, decreased pain, and improved cosmesis, MIS approaches to VHR have had mixed outcomes in these areas but continue to garner attention, popularity, and academic study [7–10]. Since laparoscopic ventral hernia repair (LVHR) was first described in 1993 by Leblanc and Booth in a feasibility study of 5 patients who underwent a bridged intraperitoneal onlay mesh (IPOM) repair [11], LVHR is now used in 22% to 31% of VHRs in the United States [12–14].

Traditional LVHR takes advantage of the key principles of hernia repair surgery, such as wide mesh overlap and underlay mesh positioning and tries to take advantage of the Law of LaPlace by distributing intraabdominal pressure across a large area of overlapping mesh. Proponents of LVHR note the advantages of shortened hospitalization, reduced rates of wound complications, and minimal soft-tissue dissection. Continued challenges of laparoscopic approach include lack of anatomic and physiologic reconstruction with bridged repair and increased and prolonged discomfort compared with open surgery [15]. However, modifications in technique are continuously presented in the literature and debated in an effort to improve on these weaknesses. For example, robotic surgery has been looked at as a possible tool to help surgeons facilitate a more functional hernia repair.

As described in our editorial of SAGES guidelines, the greatest problem that must be faced when discussing LVHR or, really, any VHR, is that many of the basic engineering fundamentals to perform a dependable, repeatable hernia repair have not been answered [16]. If the strength of the abdominal wall, the force generated in various levels of physical activity, the roles that body mass index or abdominal girth play in pressure generation within the abdomen, the impact of the size of an abdominal wall defect, the real and long-lasting strength of tissue in-growth of mesh, in general, and the various meshes in particular, against an intact peritoneum, the long-term impact of mesh-visceral adhesions are not known reliably, and how any and all of these blend together to have an impact on recurrence, QOL, and complications, then can a ventral hernia be treated effectively? How much is currently known about VHR pales in comparison with how much there is yet to understand. Truly, with the evidence that is available, how do we know how strong a mesh needs to be? How many sutures or tacks should be applied? Should fixation be with permanent or absorbable materials? Where should fixation be placed? What mesh should be chosen? How much overlap is appropriate and what role do the defect size and patient characteristics play in this decision? What physical activities should be limited after surgery and for how long? This article provides a summary of LVHR with a focus on technical considerations, special populations, outcomes, and innovations in methods as expressed in the literature.

INDICATION FOR LAPAROSCOPIC VENTRAL HERNIA REPAIR

As many as one-third of patients with incisional hernia are asymptomatic from their hernia [17]. Thus, the question of watchful waiting for such patients may be considered. Longitudinal studies have noted low rates of incarceration or need for emergent surgery with at least 2 to 5 years of observation [18,19]. However, a noticeable deterioration in physical function with worsening of pain and pain severity may be observed [19]. A multicenter randomized controlled German study (AWARE study) is currently recruiting to assess the effects of watchful waiting versus surgical repair on pain during normal activities for patients with asymptomatic and oligosymptomatic incisional hernias [20,21].

The consideration of surgical approach, namely open versus minimally invasive, should be addressed during consultations for appropriate ventral or incisional hernias (Table 1). Current recommendations for repair include symptomatic hernias, including those with pain or discomfort as well as patients with disability or reduced QOL as a result of their hernia. Further indications for surgical correction include prevention or treatment of complications, such as enlargement, skin problems, obstruction, incarcerations, and strangulation [22,23].

Historically, open VHR had been the standard approach for incarcerated hernias. However, the laparoscopic approach is being increasingly used for emergent VHRs with decreased infectious and wound-related morbidity [24]. The incidence of complications and recurrences in emergency cases are similar to elective cases. However, selection criteria for such emergent cases is important and the following should be considered [25]:

Table 1
Indications and contraindications of LVHR

Indications	Possible contraindications
Symptomatic relief	Medical contraindication for general anesthesia (eg, hemodynamic instability or coagulopathy)
Avoid/prevent future complications	Hostile/frozen abdomen
Treatment of acute complications	Gangrenous or perforated viscus
	Open abdominal wounds with active infection or enterocutaneous fistula
	Loss of domain
	Abdominal skin grafts
	Patients in need of skin or soft-tissue reconstruction

- Absence of marked bowel distention that would impede the working space
- Lack of peritonitis or other high-risk septic situations (eg, enterocutaneous fistula, bowel necrosis, or perforation)
- Hemodynamic stability
- A patient without any acutely moribund or severe medical comorbidities precluding pneumoperitoneum

Ultimately, a surgeon's level of comfort and expertise and training significantly dictate the options for laparoscopic hernia repair. SAGES guidelines for LVHR encourage surgeons to base their decision to perform LVHR on the anticipated complexity, resource availability, and surgeon experience with LVHR [22]. Several preoperative and intraoperative factors associated with increased complexity include incarceration, suprapubic location, recurrent hernias, and larger defects [26]. Further factors to consider include the potential for adhesion formation associated with intraperitoneal mesh. The LVHR approach with placement of an intraabdominal mesh may be ill suited for patients highly likely to require subsequent intraabdominal surgeries, such as young patients, or those with inflammatory bowel disease or certain malignancies with potential for future debulking procedures. Conversely, a minimally invasive approach is well suited for patients with comorbidities that make them high risk for wound complications, such as patients with diabetes, smokers, or obese patients [27–29].

SPECIAL CONSIDERATIONS

Obesity

Obesity is a major risk factor for postoperative complications in several surgical fields. In part due to the increased risk of postoperative complications and significantly increased intraabdominal pressure, obese patients are also predisposed to incisional hernia formation and hernia recurrence. VHR is not immune to this problem; several studies have demonstrated that obesity is a major risk factor for postoperative complications, recurrence, and reoperation after hernia repair [30–32]. Laparoscopic surgery has been found to be superior to an open approach in obese patients undergoing VHR in terms of mitigating wound complications [33]. One national study demonstrated that, compared with LVHR, open surgery increased the odds of a surgical site infection (SSI) for all obesity classifications by greater than 2-fold [34]. Such findings have been so compelling that current guidelines from the International Endohernia Society (IEHS) state that for obese patients with ventral or incisional hernias, a laparoscopic approach is preferred; however, this is an opinion from that group and many factors must be taken into account [23].

Recurrence rates continue to be a concern for obese patients regardless of the approach and range from 5% to 19% [35–38]; a 4-fold increase in recurrence in morbidly obese patients (BMI >40 kg/m^2) has been described [32]. Patients with BMI greater than 30 kg/m^2 and defects larger than 8 to 10 cm are at risk of higher recurrence [39]. As a result, some investigators propose additional steps, such as larger mesh size, additional fixation points, or defect closure to mitigate this increased risk, but none of these recommendations have been proven.

GENERAL STEPS OF THE LAPAROSCOPIC VENTRAL HERNIA REPAIR TECHNIQUE

Bowel Preparation

Preoperative mechanical bowel preparation may be useful in select cases. Proponents note that it may allow for bowel decompression and potentially a resultant increase in working space [40], but this has not been proven. Furthermore, decompressed bowel offers theoretic advantages of safer bowel handling during manipulation as well as decreased risk of enteric contamination in the event of an enterotomy. However, opponents of mechanical bowel preparations note the inconvenience to patients and a lack of evidence to demonstrate a difference in postoperative wound events [41].

Abdominal Access and Trocar Placement

The point of initial abdominal access should take into consideration hernia location as well as any previous abdominal procedures and associated scars that would suggest potential intraabdominal adhesions. Several techniques are available, including Veress needle insufflation, direct optical trocar insertion, open Hasson technique, or combination of these. Optimal port placement may vary by case, however, typical placement is away from the defect to allow mesh placement that does not interfere with or cover trocars, but in some cases initial trocars are placed in the hernia itself. Care should be taken not to place the trocars excessively lateral because that may only act to impede access to the anterior abdominal wall due to obstructions from the patient's thigh or the operative table.

Frequent port configurations included 2 or 3 trocars staggered and separated by approximately 8 cm (or a handbreadths) along one side of the abdomen with an additional trocar on the opposite side. Alternatively, a pair of trocars can be placed along each anterior axillary line. This configuration lends itself to convenient mesh fixation with the laparoscope and tacking device having easy access and visibility of a contralateral quadrant of the mesh. Although descriptions of LVHR with minimal port placement and ports only along 1 side are described, a concern is that only placing that camera on 1 side of the mesh may affect proper mesh positioning, potentially increasing the risk of recurrence [42].

Adhesiolysis

The most difficult and time-consuming portion of the procedure is often adhesiolysis. Frequently a window of access and plane free from adhesions can be found between the costal margin and iliac crest on 1 side of the peritoneum. External manual compression of the anterior abdominal wall alters the angle of attack and may facilitate dissection when needed. The boundaries of the hernia sac should be delineated and dissected to the margins for approximately

5 cm to allow for the overlapping mesh to lay flat. If there is no concern of bowel obstruction, then any additional adhesiolysis beyond the boundaries of where the mesh will lay may only add risk without benefit from a technical perspective.

Measuring the Defect

Accurate measurements are important to determine appropriate mesh size and overlap. Several techniques have been described, with most advocating intraperitoneal dimensions for improved accuracy. Such internal appraisals of defect size negate the effect of abdominal wall thickness and curvature in overestimating defect size. Indeed, extracorporeal measurements of hernia defects on average can overestimate defect size by 1.7 to 3.1 cm compared with intracorporeal measures [43,44]. Commonly described measuring techniques include

- Insertion of a thin plastic ruler that can be directly opposed to the abdominal wall [45].
- Spinal needles inserted transabdominally at the edge of the defect facilitate longitudinal and transverse dimensions [46].
- A silk suture on a Keith needle can be introduced transabdominally at one extent of the hernia defect and exited at the opposite end. Using the suture, the internal dimensions can be marked and subsequently measured.

Primary Fascial Defect Closure

A question that has arisen with the maturation of LVHR techniques is whether to close the hernia defect as opposed to bridging the fascia with the traditional IPOM approach. Many investigators have noted that, except in the most extreme cases, bridging of mesh is used infrequently during open VHR. Therefore, the bridging technique of LVHR has naturally been called into question. Common reasons cited for primary facial defect closure included reduced rates of seroma and recurrence and possible improved functionality and contour of the abdominal wall. A metanalysis of almost entirely retrospective studies comparing fascial and nonfascial defect closure outcomes reviewed 16 articles and concluded that seroma formation and recurrence were higher in the nonclosure group [47]. A more recent single-institution comparative study of 783 patients demonstrated similar findings, with patients who underwent defect closure had a statistically significant decrease in surgical site occurrences, seromas, and objective recurrences [48]. Despite this, these advantages remain controversial with some conflicting data showing no difference in seroma, SSIs, or surgical site recurrences requiring procedural interventions between bridged repairs and repairs with defect closure [49]. Thus, whereas the International Endohernia Society Guidelines (IEHS) for the treatment of LVHR recommend primary fascial closure of hernia defects of limited size, the SAGES guidelines as yet do not recommend the practice and suggest it should be based on the surgeon's discretion, citing a lack of high quality data to suggest rigorous validation [22,23].

Mesh Selection

The characteristics of an ideal mesh have been previously described and included a noncarcinogenic, chemically inert material capable of sterilization that is sufficiently mechanically strong. The material should be nontoxic to native tissue with minimal risk of allergic or inflammatory foreign body reaction. Further properties important for mesh positioned within the intraperitoneal cavity include resistance to infection, barrier to adhesions along the visceral surface, and adequate incorporation [50,51]. Early reports of LVHR frequently used uncoated permanent synthetic mesh, commonly polypropylene or expanded polytetrafluoroethylene. However, issues with uncoated polypropylene mesh within the peritoneal cavity became readily apparent, and included erosion, fistula, bowel obstruction, and infection [52–55]. Thus, barrier-coated mesh should be used for IPOM positioned LVHR to minimize the risk of visceral adhesions to the mesh and associated complications. A variety of absorbable barrier options are available to provide protection against adhesiogenesis, including oxygenized regenerated cellulose, omega-3-fatty acid, carboxymethylcellulose, and hyaluronic acid.

Mesh Size and Overlap

Adequate mesh overlap is accepted as a key component to successful LVHR. Although the optimal degree of overlap is not proven, some guidelines suggest a minimum size limit of 3 to 4 cm, and others simply recommend that the mesh be sized with "appropriate overlap" based on defect size, hernia location, and important clinical factors such as obesity [22,23]. In general, it seems that investigators have increased the degree of overlap as they have gained experience and the technical savvy to do so [32]. One recent meta-analysis of 8864 patients noted the risk of hernia recurrence decreased with increasing mesh overlap from 8.6% with less than 3 cm to 4.6% with 3 to 5 cm, and to a remarkable 1.4% with greater than 5 cm of overlap during laparoscopic repairs [42].

It is being increasingly understood that a blanket cutoff of mesh overlap for all defect sizes and hernia types fails to fully address the forces at play and technical nuances of IPOM LVHR. Understanding of the mesh to defect ratio is being increasingly appreciated as an important consideration when attempting to positively have an impact on recurrence after LVHR. During IPOM repairs, the intraabdominal pressure exerts an episodic, unopposed force at the central bridge portion of the mesh. This force is proportional to the area over which it is delivered (using the equation force = pressure × area) and therefore increases with increasing size of the defect. Similarly, this force is offset by the degree of mesh overlapped and incorporated into the surrounding abdominal wall [56]. This concept demonstrates the importance of maintaining an adequate mesh overlap, which may be somewhat proportional to the defect. As the defect size enlarges, the oversimplification of 3 to 5 cm of mesh overall may increasingly fail [57]. Recent data suggest that an adequate defect to mesh ratio of at least 13 is required to maintain acceptably low recurrence rates. Hauters and colleagues [58] demonstrated that with long-term 5 year follow-up a defect area to mesh area ratio of less than 13 was independently predictive of recurrence and ratios of less than 8, 9 to 12, 13 to 16, and greater than 16 provided recurrence rate of 70%, 35%, 9%, and 0%, respectively. However, for a 100 cm^2 defect, a 1300 cm^2 mesh would be impossible to insert laparoscopically in most patients.

Mesh Fixation

Adequate mesh fixation of any intraperitoneal mesh is also a fundamental and controversial component of LVHR. Transfascial fixation with permanent sutures is a common method used in IPOM LVHR [59]. Other methods of fixation include sutures, tacks, glue, staples, or a combination of these. However, the optimal method of fixation is debated in the literature, and no clear consensus has been reached. Many investigators have reported excellent outcomes with low recurrence using a combination of tacks and sutures [60,61]. Reports of equally adequate outcomes have also been demonstrated with fixation by way of tacks alone [62,63]. A recent systematic review and network meta-analysis comparing sutures, tacks, and combination methods of fixation during LVHR failed to demonstrate a statistically significant difference between the methods analyzed, but it did note that crude recurrence rates and surface under the cumulative ranking curve (SUCRA) analysis favored suture fixation and suggested that sutures had a 93% probability of being superior [64]. Alternatively, proponents of tacks have demonstrated good outcomes with a "double crown" approach with decreased rates of acute postoperative pain lasting up to 3 months with no difference in recurrence compared with transfascial suture fixation [65]. A comparison of suture and tacks is provided in Table 2.

The most common method for transfascial fixation incorporates 4 cardinal sutures. Sutures are preplaced at the periphery of the mesh and the tails left long to be brought through the abdominal wall with a suture passer. Once the mesh has been prepared, it may be rolled up and introduced by way of an 11 or 12 mm trocar. Similarly, tacks, whether in conjunction with sutures or in isolation, should be placed along the periphery of the mesh at approximately less than 1 cm intervals and within 5 mm of the edge to prevent bowel from incarcerating between the mesh and the anterior abdominal wall. External

Table 2
Comparison of suture versus tack fixation

Sutures		Tacks	
Pros	Cons	Pros	Cons
Lower cost compared with tacks	Possible increased pain	Shorter operating room time	Possible decreased pain
More robust fixation to anterior fascia		Fewer incisions/ improve cosmesis	Need for increased mesh overlap (≥5 cm)

manual pressure and "cupping" of the abdominal wall around the tacking device ensures a perpendicular angle between the abdominal wall and the tacker. Such an orientation may avoid skiving of the tack and facilitate secure fixation.

INNOVATIONS IN THE LAPAROSCOPIC VENTRAL HERNIA REPAIR TECHNIQUE

Transabdominal Preperitoneal Repair

Transabdominal preperitoneal hernia (TAPP) repair has long been used for laparoscopic inguinal hernia repair. The benefits of extraperitoneal mesh placement have been realized, and the same approach is now being used for VHR with both laparoscopic and robotic techniques described [66,67]. Traditional LVHR includes the placement of intraperitoneal mesh. Such mesh position can exhibit visceral adhesion formation, and rarely, fistula formation, bowel obstruction, and chronic pain. However, with preperitoneal mesh placement, the parietal peritoneum acts as a barrier between the mesh and visceral cavity and avoids the intense inflammatory reaction caused by direct contact of the mesh with the intraabdominal viscera. Other proposed benefits of preperitoneal mesh placement include homogeneous distribution of forces across the entire surface of the mesh. An experimental swine model comparison of IPOM versus TAPP polypropylene mesh placement demonstrated significantly fewer adhesions and less intraabdominal inflammatory response with a TAPP approach. Furthermore, significantly better mesh incorporation occurred with a TAPP repair as marked by more robust fibroblast proliferation and foreign body reaction [68].

Several investigators have demonstrated the feasibility and safety of TAPP approach. Prasad and colleagues [69] reported on a series of 68 patients with moderate-sized hernias (mean defect size = 31 cm^2) without major complications. The most common postoperative complications included 6% seroma, 4.4% postoperative urinary retention, 4.4% SSI, and 2.9% bowel injury. At a mean follow-up of 22.7 months, a 3% recurrence rate was noted. The same investigators also performed a prospective comparative study of IPOM versus TAPP and noted reduced cost of the TAPP approach due to no need for a barrier-coated mesh as well as decreased seroma rates and similar recurrence rate at midterm follow-up of 23 months. The investigators concluded that the TAPP approach reduces the risk of complications related to intraperitoneal mesh but acknowledge that further comparative multicentric prospective trial are warranted [70]. Further benefits of the TAPP approach noted by proponents include a supposed ability to forego mesh fixation because the preperitoneal pocket provides added fixation especially with the use of self-fixating mesh, leading to improved postoperative pain and QOL [71].

Laparoscopic Retrorectus Repair/Enhanced-View Totally Extraperitoneal Repair

Retrorectus hernia repair as popularized Rives and Stoppa more than 3 decades ago has been a popular approach for open VHR. Like the TAPP approach, it excludes the mesh from the visceral cavity with the added benefit of a myofascial release of the posterior rectus sheath, thus releasing tension from the midline closure. Adapted for laparoscopy in the early 2000s by Miserez and Penninckx as a complete extraperitoneal method with sublay polypropylene reinforcement, they demonstrated its feasibility in 15 patients without any major complications and a single early postoperative recurrence at 5.5 months [72]. Other investigators have since described adapted versions of the repair with a combined intraperitoneal and extraperitoneal approach and use of a laparoscopic stapling device to plicate the posterior rectus sheath [73]. The only comparative study of open and laparoscopic retrorectus repairs demonstrated comparable outcomes with no differences in postoperative complications or QOL between the 2 approaches [74].

Most recently, Belyansky and colleagues [75] have again popularized the method, with their totally extraperitoneal retrorectus repair using either a laparoscopic or robotic approach, termed enhanced-view totally extraperitoneal repair (eTEP). The approach focuses on access at the lateral edge of the retrorectus space with retromuscular dissection and crossing over to the contralateral space to connect the 2 areas. Dissection is initially started with a balloon dissector and then continued with a combination of blunt and sharp dissection. The hernia sac may be addressed by sharp dissection of the distal attachments and dorsal mobilization or by sharply incising the sac and performing laparoscopic adhesiolysis as needed. The investigators included the addition of a laparoscopic transversus abdominal release as needed, noting the following indications for a posterior component separation:

- Defects wider than 10 cm
- Retrorectus space narrower than 5 cm
- Poorly compliant abdominal wall
- Undo tension on the posterior rectus sheath closure

Defects were sutured closed with barber sutures. The investigators note that fixation was optional in their study with some foregoing any mesh fixation with a retrorectus mesh. A robotic method has also been described, both with excellent postoperative outcomes [75,76].

Robotic Ventral Hernia Repair

Compared with laparoscopic, robotic ventral hernia repair (RVHR) is relatively new, with the earliest reports appearing in 2003 [77]. Since that time, its adoption was initially slow, but it has gained popularity in recent years. As a result, many questions concerning outcomes, costs, and technique are now a major topic of research with early articles showing conflicting results. Armijo and colleagues [78] demonstrated worse outcomes with RVHR in regard to infectious outcomes and other minor complications compared with LVHR. Conversely, in a comparative review of more than 21,000 patients, RVHR showed superior outcomes in length of stay and SSI after adjusting for comorbidities [79]. What does hold constant throughout the literature is the increased hospital cost, charges to the patient, and operative time for RVHR [78–80]. Many proponents hypothesize that with increased market competition from anticipated competing surgical systems, the cost gap will decrease. Currently, potential benefits of robotic repair include

- Facilitate ease of hernia defect closure
- Ease of extraperitoneal placement of mesh
- Reduced mesh fixation or fixation by an internal running suture, potentially leading to decreased postoperative pain
- Improved length of stay

A theme that has been constant among surgeons adopting robotic techniques is their comfort in approaching cases in a minimally invasive fashion that they would have previously been uncomfortable performing laparoscopically.

OUTCOMES OF LAPAROSCOPIC VENTRAL HERNIA REPAIR

Recurrence

Recurrence rates after LVHR have been demonstrated to be acceptably low and comparable with open repair, ranging between 0% to 17% with mid- to long-term follow-up (Table 3). Recurrence, which is often considered the traditional mark of excellence of hernia repair, depends on a myriad of factors as previously discussed, including mesh overlap and methods of fixation, postoperative infection or other wound complications, and the possible additive effect of fascial closure [56–58,81]. Optimizing patients preoperatively has also been a focus of many studies. Smoking cessation, weight loss, reduction of steroid dosage, and optimization of chronic illnesses have been shown to improve outcomes.

Seroma

Seroma formation represents one of the most common postoperative complications after LVHR. One small prospective study demonstrated that at 7 days

Table 3
Recurrence following LVHR

Study	N	Recurrence	FDC	Mesh overlap (cm)	Follow-up (months)
Agarwal et al [105], 2009	29	0%	Yes	>4	34
Franklin et al [106], 2004	384	2.9%	No	3–5	47.1
Chelala et al [107],2016	1326	3.2%	Yes	>5	78
Muysoms et al [65], 2013	63	7.9%	—	—	24
Orenstein et al [108], 2011	47	0%	Yes	5–7	16.2
Berger et al [109], 2002	147	2.7%	No	3–5	15
Clapp et al [97], 2013	176	8.3	Yes	3–6	24
Rosen et al [110], 2003	96	17.7	No	≥3–4	30
Heniford et al [32], 2003	850	4.3	No	≥4	20

Abbreviation: FDC, fascial defect closure.

postoperatively, seromas can be identified in 100% of patients with ultrasonography. With that, only a small percentage of these were clinically relevant, and, fortunately, most resolved without intervention [82]. Thus, although well published, treatment and prevention of seromas remain circumstantial. From a prevention standpoint, the use of pressure dressings has been controversial. Other techniques, such as hernia sac excision, cauterizing the hernia sac, or decreasing the dead space, have been tried but failed to show any prudence in trials [70]. When required, aspiration is an acceptable first-line treatment, but when used repeatedly, it has been shown to increase the infection risk [83]. Persistent seromas may be treated using percutaneous drainage with or without injection with doxycycline. Further aggressive surgical options include operative drainage of the seroma cavity and argon beam ablation of the mesothelial layer.

Surgical Site Infections

Perhaps the greatest argument for LVHR is the significant decrease in SSI. Franklin and colleagues [84] documented rates for laparoscopic repair to be 1.1%, whereas open repairs had an infection rate of 10%. The theoretic explanation stems from the small incisions, less exposure to skin flora, a reduction in dissection and devitalization of tissues, and less exposed subcutaneous tissues. Several studies have looked at risk factors associated with SSI after LVHR to identify areas that can be improved to decrease future infections. In elderly patients, chronic obstructive pulmonary disease and low preoperative albumin level were seen as independent factors [85]. Smoking cessation has been a focal point of preventable risk factors, with smokers demonstrating an up to 5-fold increased risk for SSI [86]. Other notable patient-centered risk factors include hypoxia, obesity, peripheral vascular disease, and history of infection [87–89]. Surgery-related risk factors include operative time greater than 3 to 4 hours, hypothermia, lack of glycemic control, and, in trauma patients, blood transfusions [87,90,91]. Mesh implantation did not influence infection rates but obviously carries greater consequences with infection.

Enterotomies

VHRs are associated with the risk of enterotomy. In addition to the potential for resultant infectious complications, enterotomies have a significant effect on the course of the repair, namely the use of mesh (synthetic versus nonsynthetic) or even tissue repair alone. Rates of enterotomy during adhesiolysis for LVHR range from 0.5% to 6% [26,36,92] This complication can lead to a significantly increased mortality rate [23].

When injuries do occur, they can be managed in a number of ways [32]:

- Conversion to open laparotomy and completion of the hernia repair without mesh placement or with the use of nonpermanent synthetic or biologic mesh
- Laparoscopic repair of the enterotomy and completion of adhesiolysis with a planned return in 3 to 7 days for LVHR
- In select cases, when little contamination has occurred, completion of LVHR with mesh can be performed with acceptable results [93,94].

Although the use of synthetic mesh in contaminated fields has been reported in the literature with favorable outcomes, the investigators do not advocate the insertion of a permanent synthetic implant in the face of contamination. Decisions regarding optimal management of an intraoperative enterotomy should be addressed on a case by case basis [95].

Pseudorecurrence

Apart from true hernia recurrence, 1 long-term shortcoming of standard bridged IPOM repairs is the slow eventration of mesh through the hernia defect leading to pseudorecurrence. The incidence of clinical pseudorecurrence, defined as the subjective sense of a bulge without any objective evidence of recurrence or seroma formation, may occur in up to 20% of LVHRs [96–98]. With regard to the patient's interpretation of their hernia repair, this may be associated with poor cosmesis [99]. In cases with significant symptoms from pseudorecurrence after LVHR, surgeons should consider repeat repair [23].

Quality of Life

Mesh fixation during LVHR seems to be an important source of postoperative pain and therefore a significant driver of QOL for up to 6 months postoperatively [100]. One large international prospective QOL study comparing laparoscopic and open ventral hernia found increased rates of symptomatic pain and activity limitation in the acute postoperative period, noting that the laparoscopic approach was independently associated with impaired QOL within the first month of surgery [15]. Many believe that the transfascial sutures may be a significant contributor to the development of acute postoperative pain experienced by many after LVHR, leading some to advocate local injection of sutures site as an effective treatment option for acute postoperative pain [101]. Efforts to compare fixation methods and identify a method associated with improved QOL have failed to definitively identify any approach that provides decreased pain or improved QOL when comparing absorbable or permanent tacks, transfascial sutures, fibrin glue, or a combination of these [63,102]. Once past the acute recovery phase, QOL after LVHR compared with open repair is comparable [103,104].

SUMMARY

Laparoscopic, and more generally minimally invasive, VHR has been established as a viable, safe, and effective method of hernia repair. To this point, clear benefits have been established with regard to fewer infectious wound complications, which make it an appropriate option for those with risk factors for wound complications that cannot be modified preoperatively. However, risk associated with intraperitoneal mesh placement and adhesiolysis require meticulous technique and patient selection to maintain acceptable outcomes. Important efforts by surgical innovators to improve on these shortcomings optimistically hope to effect meaningful change in areas such as postoperative pain, recurrence, and mesh-related complications. Inevitably these efforts will continue to refine the process of LVHR.

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