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GUIDELINES

SAGES guidelines for laparoscopic ventral hernia repair

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Preamble

The goals of ventral hernia repair are relief of patient symptoms and/or cure of the hernia with minimization of recurrence rates. While laparoscopic ventral hernia repair (LVHR) has gained popularity in recent years, there is still significant controversy about the optimal approach to ventral hernia repair. This document has been written to assist surgeons utilizing a laparoscopic approach to ventral hernia repair in terms of patient selection, operative technique, and postoperative care. It is not intended to debate the merits of prosthetic use and specific types of prosthetics.

Disclaimer

Guidelines for clinical practice are intended to indicate preferable approaches to medical problems as established by experts in the field. These recommendations have been made based on existing data or a consensus of expert opinion when little or no data are available. Guidelines are applicable to all physicians, without regard to specialty training or interests, who address these clinical problem(s) and are intended to indicate the preferable, but not necessarily the only, acceptable approaches. Guidelines are intended to be flexible. Given the wide range of specifics in any healthcare problem, the surgeon must always choose the course best suited to the individual patient and the variables in existence at the moment of decision.

Guidelines are developed under the auspices of the Society of American Gastrointestinal Endoscopic Surgeons (SAGES) and its various committees and approved by the Board of Governors. Each clinical practice guideline has been systematically researched, reviewed, and revised by the guidelines committee and reviewed by an appropriate multidisciplinary team. This guideline was available for public comment for a period of 1 month prior to its finalization. The recommendations are therefore considered valid at the time of their production, based on the data available. Each guideline is scheduled for periodic review to allow incorporation of pertinent new developments in medical research, knowledge, and practice.

Methodology

A systematic literature search was performed on MEDLINE in March 2009 and was updated in October 2012. The search strategy included the following terms: Hernia, Ventral/su [Surgery] + Laparoscopy + English + Human.

The abstracts were reviewed by the assigned working group members of the SAGES guidelines committee. Duplicates, letters to the editor, and articles not involving ventral, incisional, or Spigelian hernias were not generally included unless there was a direct correlation with the specific subject. Studies that compared different types of mesh were beyond the scope of this guideline and were not included.

The reviewers graded the level of evidence using the GRADE guidelines (Table 1) and searched the bibliography of each article for additional articles that may have been missed during the original search. Additional relevant

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Table 1 GRADE system for rating the quality of evidence for SAGES guidelines. Adapted from Guyatt et al. [178]

Quality of evidence	Definition	Symbol used
High quality	Further research is very unlikely to alter confidence in the estimate of impact	⊕⊕⊕⊕
Moderate quality	Further research is likely to alter confidence in the estimate of impact and may change the estimate	⊕⊕⊕
Low quality	Further research is very likely to alter confidence in the estimate of impact and is likely to change the estimate	⊕⊕
Very low quality	Any estimate of impact is uncertain	⊕
GRADE recommendations based on the quality of evidence for SAGES guidelines		
Strong	It is very certain that benefit exceeds risk for the option considered	
Weak	Risk and benefit well balanced, patients and providers faced with differing clinical situations likely would make different choices, or benefits available but not certain regarding the option considered	

articles were obtained and included in the review for grading. To facilitate the review by multiple reviewers, the guideline was divided into the following topics:

1. Laparoscopic versus open repair
2. Preoperative considerations
3. Operative technique
4. Postoperative management: avoiding and treating problems

Additional articles pertaining to specific subsections of the above topics were reviewed and graded, providing the evidence used to formulate the recommendations included in these guidelines.

Laparoscopic versus open repair

Guideline 1 Laparoscopic ventral hernia repair has a lower rate of wound infections compared with open repair. Recurrence rates and postoperative pain are similar between the two techniques during mid-term follow-up. The advantages offered by LVHR over open hernia repair in terms of decreased wound complication rates should be taken into consideration by surgeons and disclosed to patients when they counsel them about surgical options (High-quality evidence, Strong recommendation).

Four meta-analyses, including a Cochrane systematic review, have assessed the comparative effectiveness of the laparoscopic and open ventral hernia repair. These studies have examined data from available comparative randomized controlled trials and concluded that there was no difference in recurrence rates or postoperative pain between the techniques, but significantly fewer wound infections occurred after laparoscopic hernia repair. Since the publication of this level I evidence, three more randomized controlled trials have been published. The findings of these new RCTs are congruent with the results of the meta-analyses: fewer surgical-site infections after laparoscopic repair and similar recurrence rates. In regard to postoperative complications, one found lower rates after laparoscopic repair, one after open repair, and one no difference. Postoperative pain was less a year after laparoscopic repair in one of the studies but similar in another (which noted better physical functioning after laparoscopic repair). One RCT also demonstrated a 5-day quicker return to work after laparoscopic repair. The largest prospective but not randomized study to date ($n = 710$) that compared quality of life after laparoscopic and open ventral hernia repair demonstrated a decrease in quality of life at 1 month after laparoscopic repair but no difference beyond 6 months.

Meta-analyses of available studies may be difficult to interpret because techniques, mesh types, mesh position, and fixation methods vary widely in the published literature, which make valid comparisons challenging. Further, while no level I evidence study to date has demonstrated any differences in recurrence rates between the two techniques, the longest average follow-up duration reported has been 35 months, and therefore further long-term studies are needed.

References for laparoscopic versus open: [1–8].

Preoperative considerations

Indications and patient selection

Guideline 2 Surgeons should base their decision to perform LVHR on the anticipated complexity of the operation, the resources available at their institutions, and their experience and training with this operation. Prior hernia repairs, large defect sizes, and incarcerated hernias increase the difficulty and duration of the procedure and should be taken into consideration by surgeons (Moderate-quality evidence, Strong recommendation).

The indication to repair a ventral hernia is for symptom relief and/or prevention of future problems related to the hernia such as pain, acute incarceration, enlargement, and

skin problems. For all hernia repairs, it is important to define the goals of the operation preoperatively and align those goals between the patient and the surgeon.

It is important to consider the size of the hernia defect when contemplating a laparoscopic approach, as larger defects generally increase the difficulty of the procedure. A recently published guideline by an Italian Consensus Conference recommended caution for defects greater than 10 cm but did not consider such defects as absolute contraindication. On the other hand, the same group recommended that hernias with a defect size <3 cm should not be approached laparoscopically. This recommendation was based on expert opinion and a survey showing that less than 10 % of surgeons used prosthetics in defects less than 3 cm; it was therefore deemed as "an indirect indication of a minimum size limit for laparoscopy." The present MEDLINE search of the literature did not reveal any evidence in support of this recommendation. In addition, the best available evidence today suggests that prosthetics should be used even for small (umbilical) hernia defects, as the recurrence rates are minimized compared with primary repair. Further, the recent guidelines published by the International Endohernia Society recommend the use of mesh for all abdominal wall hernias independent of the defect size. Expert opinion suggests that the laparoscopic approach to ventral hernia repair may be beneficial in the morbidly obese patient and in recurrent cases compared with the open approach. Therefore, additional evidence is needed before a minimum size for laparoscopic repair can be defined. Reported conversion rates in the literature range between 0 and 14 % in series with over 50 patients. Possible reasons for a higher conversion rate may include poor patient selection, severe adhesions, incarcerated hernia content impossible to reduce, and/or inadequate training and expertise.

Given the variation of technical ability and institutional capability, along with the gradual acquisition of experience, surgeons must use their judgment when determining whether to perform a laparoscopic or open ventral hernia repair. When considering a laparoscopic approach to a ventral hernia, the surgeon should consider his or her own experience when selecting patients. There is limited evidence on how expertise with laparoscopic ventral hernia repair is developed; however, it appears prudent to recommend that less experienced surgeons should start with less complex cases. A study analyzing 180 cases of a prospectively collected database found a number of clinical factors that significantly increased operative time (which was used as a surrogate of laparoscopic repair complexity). The most significant factors influencing operative time were adhesiolysis and prior ventral hernia repair(s), both of which clearly increased the complexity of the laparoscopic repair. Other factors reported in the literature that increase the complexity of laparoscopic ventral hernia repair include large defects (>10 cm diameter), hernias in unusual locations (subxiphoid, suprapubic, flank, etc.), incarcerated hernia, hernias with small defect size but large hernia sac, obesity, bowel distention, pregnancy, and presence of ascites.

The aforementioned factors, which are known to increase the technical difficulty of the operation, should help guide the surgeon in selecting the appropriate patients for LVHR. The decision of whether or not to perform a LVHR encompasses the surgeon's training and experience, as well as the institution's capability to provide the proper equipment and supplies. As training and experience is gained, gradually more complex laparoscopic ventral hernia repairs may be appropriately undertaken.

References for indications and patient selection: [9–30].

Special considerations

Guideline 3 Special situations such as loss of domain, presence of abdominal skin grafts or of an active enterocutaneous fistula, the need to remove previously placed prosthetic mesh, or large abdominal wall defects may represent contraindications to laparoscopic repair (Moderate-quality evidence, Strong recommendation).

In the following situations, the laparoscopic approach to ventral hernia repair may be problematic and associated with higher conversion rates and potentially suboptimal outcomes.

1. Loss of domain

Loss of domain is a term describing a situation of a massive hernia (hernia sac) where reduction in the hernia content would cause major abdominal hypertension leading to the potential complication of abdominal compartment syndrome. The term is used in patients with a massive hernia sac containing greater than 30 % of the abdominal contents and possibly some of the solid organs.

2. Abdominal skin grafts

An abdominal skin graft overlying the hernia defect makes a proper adhesiolysis between the viscera and the posterior aspect of the graft difficult, with the consequence of graft ischemia and necrosis, thus exposing the prosthetic, which would risk infection and the need for removal. Further, adhesiolysis can lead to visceral injuries that are missed, increasing the risk of fistula formation. An open approach is therefore preferable.

3. Need to remove large prosthetic mesh

If removal of a previously placed prosthetic is deemed necessary and this will result in a large enough wound to

perform the hernia repair in an open fashion, an open approach should be undertaken.

4. Small defect but large hernia sac

This situation represents a scenario that may be difficult to address laparoscopically, especially if there are adhesions between the viscera and the hernia sac. The adhesions may be difficult to visualize or reach with laparoscopic instruments due to the narrow defect size or angulation required to visualize the hernia sac contents through the hernia defect. Pulling on the viscera with great force can also result in inadvertent visceral injury. On the other hand, external pressure on the abdominal wall in the area of the hernia may help reduce the sac contents intraabdominally or make them easier visible for safe dissection and should be employed when this situation is encountered. A laparoscopic approach may be associated with a higher probability of conversion to an open approach under these circumstances.

5. Incarcerated hernia

This scenario is often present with the small defect and large sac scenario as described above. Trying to reduce acutely or chronically incarcerated viscera can result in inadvertent visceral injury. Experts might be able to reduce an incarcerated hernia laparoscopically by incising the neck of the hernia with a laparoscopic scissor without diathermy (expert opinion). Further, external pressure may prove very valuable. A laparoscopic approach may be attempted but will have a higher probability of being converted to an open or laparoscopic-assisted approach. Good surgical judgment is required to minimize the risk of visceral injury.

6. Active enterocutaneous fistula

Active enterocutaneous fistulas are generally considered a contraindication for laparoscopic hernia repair, as the current laparoscopic techniques include prosthetic mesh placement and are therefore reserved for clean and clean-contaminated cases.

7. Abdominal wall defect

Hernias from previous gunshot wounds to the abdomen with a missing abdominal muscle or fascia or areas on the abdominal wall with previously elevated flaps (TRAM) might have defects too large to bridge and impossible to approximate with laparoscopic techniques and should therefore be considered for an open component separation technique.

References for special considerations: [9–11, 16, 18, 20, 27, 31–40].

Diagnosis

Guideline 4 While most ventral hernias are easily diagnosed based on clinical examination, a preoperative abdominal CT scan or ultrasound may be considered for selected patients with suspected ventral hernias to confirm the diagnosis or to aid the surgeon with preoperative planning (Moderate quality, Strong recommendation).

Diagnosis of a ventral hernia is typically made during the history and physical examination. Imaging studies including ultrasound, provocative ultrasound, computed tomography (CT) with and/or without Valsalva, and magnetic resonance imaging (MRI) can also be used for diagnosis. Imaging studies may be helpful to assess the anatomic details of a ventral hernia, augmenting the physical examination, especially when a hernia cannot be reduced, and therefore the defect cannot be palpated and the size not estimated. These situations commonly arise with small defects, obese patients, or incarceration (acute or chronic). CT has been found to be useful in diagnosing occult hernias, multiple defects, abscess, and hematoma, as well as in differentiating incarcerated hernias from abdominal wall neoplasms. In a retrospective review of 146 consecutive LVHRs, 48 % of patients had occult defects not detected on preoperative physical examination.

In one study, diagnosis of hernia recurrence after mesh repair was correct 88 % of the time on physical exam, while CT was correct in 98 % of cases. Another study that evaluated the comparative effectiveness of dynamic abdominal sonography versus CT for the diagnosis of ventral hernias demonstrated a sensitivity of 98 % and specificity of 88 %, with PPV 91 % and NPV 97 % for the dynamic sonography, which identified hernias in a few more patients than CT imaging.

Preoperative CT is also helpful in defining the abdominal wall anatomy in non-midline hernias such as those on the flanks, suprapubic or subxiphoid regions, and identifying posterior abdominal wall defects. CT scans accurately assess the relationship of the hernia to structures such as the bladder, pubic symphysis, anterior superior iliac spine, and the ribs, in addition to defining the integrity and nature of the muscles of the abdominal wall and the size of the defect. This information is useful for the surgeon when deciding on the safest point of access and where or how to anchor the mesh. Imaging data may also allow the surgeon to determine that an open or laparoscopic-assisted approach may be more appropriate. CT scanning is not useful in determining the presence and character of intraabdominal adhesions, a known factor that increases complexity of LVHR. Finally, CT cannot determine compliance of the abdominal wall or the feasibility of closing

the defect and replacing all the viscera within the peritoneal cavity.

References for diagnosis: [41–45].

Bowel preparation

Guideline 5 Mechanical bowel preparation prior to LVHR may be useful in select cases, but additional evidence on its risks/benefits is needed before a recommendation can be provided (Low-quality evidence).

Prior to LVHR some surgeons prefer bowel preparation either routinely or selectively. Reported advantages of bowel preparation include dealing with a clean bowel in case there is an enterotomy, decompressing the GI tract to avoid bowel distension (especially if colon was contained in the hernia sac), improving the safety of intraoperative bowel handling and adhesiolysis, and avoiding a full colon in the event of a postoperative ileus (which has been reported to range between 0.8 and 20 %). Most authors report using mechanical preoperative bowel preparation without antibiotics. While the available evidence on the benefits and risks of bowel prep before LVHR is lacking, a recent study on pigs by Vlot et al. demonstrated increased working space after bowel preparation.

References for bowel preparation: [9, 11, 16, 20, 26, 29, 31, 32, 46–52].

Patient position

Guideline 6 Patient positioning should use all appropriate precautions to prevent patient injury while enabling access to the needed abdominal wall to allow for adequate size mesh placement and fixation. Supine position with the arms tucked will offer the most versatile position when performing LVHR. Hernias requiring lateral or posterior access should be performed with the patient in a full or partial lateral position (Low quality, Strong recommendation).

The patient should be placed during LVHR in a safe and stable position to assure access to the hernia through operative exposure and an ergonomic working position for the surgeon and operating team. A supine position with the arms tucked at the patient's sides is the standard position for patients with midline hernias, while hernias of the flanks or posterior abdominal wall require a lateral decubitus or modified lateral decubitus position. Careful patient positioning ensures adequate working space to perform adhesiolysis and handling and fixation of the mesh.

Frequent tilting of the OR bed, Trendelenburg, and/or reverse Trendelenburg position may be needed to optimize operative exposure by passively retracting the viscera out of the way, especially for large hernias or hernias located off the midline or in the subxiphoid/suprapubic location. The need for frequent position changes during LVHR makes the secure attachment of the patient to the OR bed with appropriate padding of pressure points imperative.

References for patient position: [9, 11, 16, 20, 26, 29, 31, 32, 46–51].

Urinary bladder catheter

Guideline 7 Placement of a urinary bladder catheter during LVHR should be determined based on the anticipated duration of the procedure and the location of the hernia. For LVHR near the symphysis that requires dissection and prosthetic fixation to the pubic bone, the placement of a three-way catheter should be considered to allow drainage and easy instillation of sterile saline solution to distend the bladder, which may help in recognizing and avoiding bladder injuries (Low quality, Weak recommendation).

Placement of a urinary bladder catheter during LVHR should be determined based on the anticipated duration of the procedure and the location of the hernia. Incisional hernias from previous lower midline incisions, particularly if the defect is near the symphysis, generally require fixation to the inferior pubic ramus. In order to properly fix the prosthetic to these structures, extraperitoneal dissection and mobilization of the bladder (similar to exposure in laparoscopic inguinal hernia repair) is necessary. Placement of a urinary bladder catheter before prepping and draping the patient allows for continuous drainage and monitoring of urine output. An empty bladder also gives additional space in the abdominal cavity, which might be essential in reducing larger hernias. If a three-way catheter is used, the bladder can be filled with sterile saline solution while clamping the outflow temporarily, which may facilitate easier identification of the urinary bladder during dissection and may help prevent injury to the bladder. In the event of a urinary bladder injury, a distended bladder may further aid in the detection and repair of the injury.

References for urinary bladder catheter: [11, 53, 54].

Prophylactic antibiotics

Guideline 8 A single-dose first-generation cephalosporin (cefazolin) should be given preoperatively for LVHR. Vancomycin should be added in patients colonized with MRSA. Vancomycin or clindamycin should be given to patients allergic to cephalosporins (Moderate quality, Strong recommendation).

The guidelines recently published jointly by the American Society of Health-System Pharmacists (ASHP), the Infectious Diseases Society of America (IDSA), the Surgical Infection Society (SIS), and the Society for

Healthcare Epidemiology of America (SHEA) recommend that a single dose of a first-generation cephalosporin (cefazolin) be administered within 60 min prior to incisional hernia repair with a prosthetic. For patients known to be colonized with MRSA, a single preoperative dose of vancomycin should be added and administered within 120 min prior to surgery. For b-lactam allergic patients, clindamycin or vancomycin should be given. Even though these guidelines were developed from the evidence included in the inguinal hernia literature, they also apply to incisional hernias, where the risk of infection seems to be higher than in inguinal hernias.

The most common microorganisms isolated from surgical-site infections after hernia repair are aerobic gram-positive organisms and include aerobic streptococci, Staphylococcus species, and Enterococcus species. MRSA is commonly found in prosthetic mesh infections.

References for prophylactic antibiotics: [1, 9–11, 15, 16, 20, 22, 27, 28, 31, 34, 36–39, 44, 46–49, 54–86].

Plastic adhesive drape

Guideline 9 Antimicrobial-impregnated plastic adhesive drapes are often used during LVHR, but the current literature does not support their use, as no evidence exists that they decrease surgical-site infections (Low quality, Weak recommendation).

Plastic adhesive drapes are used commonly during LVHR. The only study looking at this practice related to ventral hernia repair was a retrospective review of 506 laparoscopic and open ventral hernia repairs at a single institution that reported plastic adhesive drapes were used in 59.1 % of the cases, mostly by the highest volume laparoscopic surgeons. Proposed benefits of utilizing these types of drapes are (1) reducing contact between the prosthetic and skin and (2) securing the drapes to the patient to avoid breaks in the sterile field. Because the drapes are placed so laterally, unless they are adherent to the skin, they are at risk for lifting off the skin and exposing unprepped portions of the abdominal wall or the operating table itself. While this study noted a perceived benefit among surgeons in terms of improving surgical draping, it failed to demonstrate a benefit in terms of infection reduction.

The use of an iodophor-impregnated plastic incise drape in abdominal surgery has been shown to lower the incidence of wound contamination but not surgical-site infection (SSI) rates, and a meta-analysis in 2007 of a variety of studies and case types revealed there was no evidence that plastic adhesive drapes reduced SSI rates and some evidence that they may actually increase SSI rates if the drapes were non-iodinated.

During LVHR, some surgeons place the prosthetic on the abdominal wall to assess prosthetic and suture anchor location. The prosthetic therefore will potentially be exposed to skin flora, the most common bacteria associated with prosthetic infection, and this practice has largely driven the concept of utilizing a plastic, adhesive drape for LVHR. Although prosthetic infection is typically due to Staphylococcus species, review of the literature reveals that prosthetic contamination and/or infection in the early postoperative period (within 30 days) after LVHR is almost always due to missed or delayed enterotomy. Prosthetic infection not related to enterotomy is likely due to factors such as the infectious disease-related medical history of the patient (particularly history of wound or prosthetic infection), existing infectious disease-related issues (e.g., occult infection), wound classification (based on concomitant GI procedures, skin infection, etc.), use of prophylactic antibiotics, abdominal wall preparation, prosthetic choice, and prosthetic handling. Further complicating the issue is the fact that most reports do not include microbiological data related to prosthetic infection, and many prosthetic infections occur after 30 days, often up to 1 year postoperatively.

In summary, while plastic adhesive drapes impregnated with iodine reduce wound bacterial inoculum, they have not been proven to reduce clinical infection rates. Plastic adhesive drapes may reduce breaks in sterile technique due to the wide draping requirements of LVHR. Besides the small additional cost, potential side effects of the adhesive drape include mild skin irritation and adverse wound healing which are rare.

References for plastic adhesive drape: [13, 39, 41, 47, 58, 67, 73, 84, 87–92].

Operative technique

Abdominal access and trocar placement

Guideline 10 The location of initial abdominal access (primary port placement) for LVHR should be as far from the hernia defect and prior laparotomy incisions as possible. The ideal location for this port may be the left or right upper quadrant, but location should be modified according to the patient's surgical history and anatomy (Moderate quality, Strong recommendation).

Guideline 11 A Veress needle, open Hasson technique, or optical trocar entry may all safely be used for primary port placement during LVHR. The specific technique used should be primarily based on the surgeon's experience and outcomes with the technique and take into consideration the patient's surgical history and anatomy (Moderate quality, Strong recommendation).

Guideline 12 Secondary port placement should be performed under direct vision and placed as lateral from the hernia defect as possible to allow the surgeon to work in an ergonomically favorable position for adhesiolysis and placement/fixation of the prosthetic (Moderate quality, Strong recommendation).

The principles of safe abdominal access for laparoscopic surgery apply to LVHR, and technical details about establishment of pneumoperitoneum can be found in the SAGES Fundamentals of Laparoscopic Surgery (FLS) program. There have been no comparative data regarding techniques for establishing pneumoperitoneum specifically for LVHR, although a variety of techniques have been described in the published literature, all with low rates of complications and successful establishment of pneumoperitoneum. Current options for initial peritoneal access for LVHR include direct trocar insertion with an optical trocar (with or without a pneumoperitoneum with the use of the Veress needle), or an open Hasson technique. Multiple meta-analyses and randomized controlled trials with a variety of general surgical and gynecological laparoscopic procedures reveal no difference in major complication rates with direct trocar insertion without pneumoperitoneum compared with establishment of pneumoperitoneum with Veress needle prior to initial trocar insertion. Regardless of the technique, the surgeon should have adequate training and/or experience with it in similar clinical situations. Additionally, since many LVHRs are performed for midline hernias, it is recommended to access the abdomen off the midline, to avoid areas with potential adhesions of bowel. The techniques reported in the literature for LVHR are listed in Table 2.

Table 2 Methods for establishing pneumoperitoneum and port placement

First author	Year	*n*	Access Technique	Location of initial entry site	Total number and location of ports
Bageacu [58]	2002	159	Veress needle	"…as far as possible from the hernia (typically on the left anterior axillary line in the case of a midline hernia."	3–4; location not mentioned
Ben-Haim [10]	2002	100	Open technique	"…as laterally from the hernia site as possible."	No number mentioned. Location "according to hernia site"
Berger [60]	2002	150	Open technique	"as far from the hernia as possible and mainly in the subcostal area."	5–7; location "laterally on both sides"
Chowbey [46]	2000	200	Veress, open technique	"…unless contraindicated, the Veress needle is inserted in the left subcostal region…" If Veress insertion unsuccessful, open technique used.	3; left abdominal wall laterally
Franklin [32]	2004	384	Veress, "very rarely" open technique	"…usually from a non-midline location…"	3–4; "lateral to rectus muscles"
Frantzides [69]	2004	208	Optical viewing trocar	"…as far as possible from the hernia defect…"	Number "depended on the difficulty of the subsequent adhesiolysis." Location not mentioned
Gillian [48]	2002	100	Optical viewing trocar	Left subcostal	3–4; left abdomen, right side as needed
Heniford [16]	2003	850	Open Hassan 650, Veress 200	"usually just inferior to the tip of the eleventh rib."	Number "as needed"; location lateral abdominal wall for midline defects, dependent of defect location for non-midline defects
LeBlanc [34]	2000	100	Open Hassan, Veress, optical viewing	Not mentioned	No number; Location "…as far laterally as possible…"; scope port should be on same side as surgeon.
Mizrahi [98]	2003	231	Veress	Left subcostal	3; :location "along an imaginary semilunar line connecting the epigastrium with the left lower quadrant"
Morales-Conde [36]	2004	140	Subcostal Veress, optical viewing	Left subcostal	Number and location of secondary ports not mentioned
Moreno Egea [76]	2004	90	Veress	Not mentioned	"The position of the trocars depended on the size, location, and number of abdominal wall defects, usually three in a line along the left flank."

Table 2 continued

First author	Year	*n*	Access Technique	Location of initial entry site	Total number and location of ports
Palanivelu [20]	2007	721	Not mentioned	Not mentioned	3; epigastric port for scope, two lateral ports for working instruments; occasionally 3 ports on all one side laterally
Perrone [11]	2005	116	Veress 88 %, Open technique 12 % (only when Veress needle failed)	"…well away from the hernia, typically in either subcostal area or the lateral abdomen lateral to the rectus sheath."	No number mentioned; Additional ports placed "…as far from the hernia defect and as lateral as possible."
Rosen [38]	2003	100	Veress, open technique, or optical trocar	"…far from the defect…"	3–5; "…as far laterally as possible."
Saber [179]	2008	174	Open technique	Right or left upper quadrant and "away from the hernia"	2–3; "…away from the hernia defects to allow adequate surgical manipulations."
Sharma [82]	2011	1242	Veress	"…at least 10 cm away from the hernia/previous scar. The most preferred site … was Palmer's point—a point 2 cm below the left costal margin in the midclavicular line."	3, more for larger hernias; "Ports were placed in the form of an arc around the hernial defect…"
Toy [39]	1998	144	Veress, open	"…away from the hernia defect and any abdominal incisions…"	"…number and position are individualized." All placed "…as far laterally as possible."
Ujiki [26]	2004	100	Veress—primary hernia Open—previous abdominal surgery	Lateral, "on the side of the abdomen farthest from the hernia defect"	No number mentioned; Lateral, "on the side of the abdomen farthest from the hernia defect"
Yavuz [29]	2005	150	Veress—primary and trocar site hernias Open—all other incisional hernias	Left hypochondrium	3, with more "as necessary"; "…as laterally as possible…," usually all on the left side

Regarding placement location, it is desirable to have the ports as far lateral as possible to expose midline hernias and to be able to place a large piece of mesh without interference. The operation is usually accomplished using 3–5 ports. A larger port (10–12 mm) is typically utilized for the insertion of the prosthetic mesh. There are usually three ports placed in the left lateral abdominal wall and 1–2 ports placed on the right. This pattern is often reversed in patients who have had previous left-sided abdominal operations such as left colectomy or open splenectomy. Many authors report their entry techniques; however, none directly compare the techniques. One of the largest retrospective series described placement of a Veress needle at least 10 cm away from the prior scar, preferentially 2 cm below the left costal margin in the mid clavicular line (Palmer's point). The left upper quadrant (LUQ) is the most commonly reported initial entry site with all techniques.

Secondary ports should be placed far enough away from the hernia defect to allow for adhesiolysis and prosthetic placement and fixation. Longer, bariatric-length instruments may be necessary in obese patients. There may be interference with the instrument handles on the patient's arms or legs; therefore, optimal port placement is critical.

References for abdominal access and trocar placement: [5–7, 10, 11, 16, 20, 26, 29, 32, 34, 36, 39, 46, 48, 58, 60, 69, 76, 82, 93–101].

Adhesiolysis

Guideline 13 Adhesiolysis should be performed carefully with sharp and/or blunt dissection and sparing use of energy for hemostasis to avoid inadvertent delayed enterotomy. Use of sutures and hemostatic agents is preferable to energy application to achieve hemostasis near the bowel (Low quality, Strong recommendation).

Guideline 14 The adhesiolysis should include the entire old incision. Dependent on the hernia location, the falciform and umbilical ligaments should be taken down and the space of Retzius dissected to identify occult hernia defects and allow adequate exposure of the abdominal wall for placement of an appropriately sized prosthetic (Low quality, Strong recommendation).

Guideline 15 The surgeon should inspect the bowel after adhesions are taken down as the adhesiolysis progresses, and/or at the conclusion of the entire adhesiolysis to rule out any inadvertent enterotomies (Low quality, Strong recommendation).

Safe adhesiolysis is the most challenging step of LVHR. Although preoperative adhesion detection with ultrasound and cine MRI has been shown to be accurate in 76–92 % of cases, it is not used clinically with significant frequency in the USA for the purpose of estimating the quantity and/or quality of adhesions preoperatively. Review of the operative records can give a reasonable sense of the difficulty level of previous abdominal operations related to adhesions. Adhesions between bowel or omentum and the abdominal wall should be taken down to allow complete visualization of the defect and the abdominal wall, as well as provide an adequate area for placement of the appropriate-sized prosthetic. This should also include exposure of the entire old incision, even if the symptomatic or palpable defect is only a small portion of the old incision. This might expose occult fascial defects, which occur in almost half of cases, thus allowing adequate mesh coverage of all defects and the entire old incision.

Enterotomy during LVHR has been reported between 1 and 6 % and usually occurs during adhesiolysis. Several maneuvers facilitate safe adhesiolysis, including:

- Traction/counter traction technique.
- Use of angled or flexible laparoscope.
- Moving the scope among ports.
- Improved exposure utilizing outside pressure on the abdominal wall, particularly for adhesions within a hernia sac.
- Meticulous sharp dissection under direct vision close to the anterior abdominal wall.
- Limited use of an energy source, particularly near the hollow viscera.
- Working in a good ergonomic position.
- Repositioning/adding ports as needed to maintain appropriate ergonomic position and access to the operative field.
- Use of instruments with appropriate length (may need longer instruments to maintain the fulcrum near the middle of the instrument shaft).
- Avoiding too much torque on access ports during critical aspects of the adhesiolysis.
- Maintaining a clear camera image.
- Maintaining a conscious vigilance for the mucosa of the GI tract, as an enterotomy may only be visible for a fleeting moment.
- Repeat inspection of the bowel after adhesiolysis to look for enterotomies.

Use of an energy source for hemostasis should be kept to a minimum to avoid missed or delayed bowel injury. It is important to recognize that as the adhesiolysis progresses, vigilance regarding the proximity of the hollow viscera, particularly in the GI tract, must be in the forefront of the surgeon's mind. In fact, many experts will consciously look for the mucosa of the GI tract during a difficult adhesiolysis involving bowel, as an enterotomy may only be visible for a fleeting moment, and lack of alertness to this could lead to a missed enterotomy. In general, bleeding near the bowel should be controlled with sutures, clips, or a topical hemostatic agent rather than an energy source.

At the conclusion of the adhesiolysis, it is prudent to inspect the areas of the hollow viscera involved for evidence of partial thickness, full thickness, or thermal injury. This can be accomplished for each area separately as the adhesiolysis progresses, and/or at the conclusion of the adhesiolysis.

"Anatomic adhesions" such as the falciform and umbilical ligaments may also need to be taken down to adequately expose the abdominal wall for abdominal wall exploration and/or prosthetic placement. Mobilization of the urinary bladder may also be necessary to expose the symphysis pubis and ramus pubis for mesh fixation, particularly for lower midline defects. This may be done with more judicious use of an energy source, compared with adhesions between the abdominal wall and the GI tract, but care must be taken to avoid injury to the urinary bladder. Mobilization of the colon may be necessary for hernia defects in the lateral abdominal wall. The reader is also referred to the Fundamentals Use of Safe Energy (FUSE) program developed by SAGES for additional recommendations on safe energy use during laparoscopy.

References for adhesiolysis: [2, 9–11, 16, 17, 20, 28, 29, 31, 32, 35, 36, 44, 48, 57, 58, 73, 83, 102–106].

Measuring the hernia defect

Guideline 16 Surgeons should measure and document the size of the hernia defect they are repairing. The total area encompassing all the defects should be measured, and surgeons should be familiar with internal and external measurement techniques for all hernia locations, as well as

how to avoid common measurement errors (Moderate quality, Strong recommendation).

Accurate measurement of the defect is a key to ensuring adequate mesh coverage and minimizing recurrence. There are two main approaches to measuring the defect—externally on the abdominal wall and internally within the peritoneal cavity. This will in turn allow for selection of the most appropriately sized prosthetic, which should reduce the chance for a hernia recurrence. If there are multiple defects, it is important to measure the total area between the rectus muscles (for midline defects) that contain the multiple defects to determine which sized prosthetic is appropriate. The craniocaudal extent of the measurement will be the distance between the most superior defect and the most inferior defect. Measurement of each defect is not necessary and may lead to underestimating the defect and prosthetic size, thus leading to increased risk of recurrence.

External measurements This is typically accomplished using a (spinal) needle placed through the skin, hernia sac, and/or abdominal wall near the edges of the defect and observing the needle laparoscopically to make sure the needle tip is at or adjacent to the edge of the defect. The borders of the defect are then marked on the abdominal wall using a sterile marking pen. A sterile ruler is then used to measure the dimensions on the abdominal wall. Because the circumference of the abdominal wall is larger on the outside compared with the inside, this technique will typically overestimate the size of the defect. It is important to note that the thicker the abdominal wall, the larger the difference will be between measured and actual size of defect. Factors increasing this discrepancy include a fully insufflated abdomen, obesity, and a large hernia sac. In the setting of obesity and a large sac, the discrepancy will be greatest. Pitfalls of performing the external measurements include (1) angling the needle (either toward or away from the defect) through the abdominal wall rather than removing and re-inserting the needle when identifying the borders of the defect; and (2) performing the measurements with a fully insufflated abdomen, particularly if there is a large hernia sac. It is important to note that reducing the insufflation pressure may reduce but will not eliminate the overestimation of defect size.

Internal measurements This is accomplished laparoscopically. A variety of techniques have been employed, but the most common are utilizing an umbilical tape or sterile ruler. The measurement tool is placed on opposite sides of the defect in two dimensions, and the size is recorded. Regardless of what is used to measure the distance, it is important to measure the distance at the proper angles to accurately determine defect size. To minimize the problem of obtaining the proper angles for measurement, two spinal needles (or spinal needle trocars) can be used by placing them through the skin, hernia sac, and/or abdominal wall, similar to the external measurement technique but placing them on opposite sides of the defect and viewing the tips at the opposite edges of the defect laparoscopically. The measurement tool can then be placed adjacent to the needle tip, thus ensuring the defect is being measured at a proper angle.

Alternatively, the instrument tip (with or without the jaws open) can be useful for measuring the defect, especially when the defects are small, since the stainless steel portion of the jaws of the instrument tip usually has a known length and width. For defects larger than 4–5 cm in diameter, however, this technique may be inaccurate. Additionally, because there is a fixed fulcrum, and the instrument is often approaching the defect from an angle, this method is more error prone, especially as the defect becomes larger and more elliptical in shape.

Overestimating the defect size will result in the choice of a larger prosthetic size, which may be more difficult to handle and may have more laxity, allowing it to bulge into the defect more than if it was placed taut. The difficulty in prosthetic handling may also lead to errors in fixation, and the prosthetic can more easily sway between fixation points, due to the larger dimensions. On the other hand, a larger prosthetic is generally associated with a lower chance for hernia recurrence. Underestimating the defect size may lead to choosing a prosthetic that is too small, thus increasing the risk of hernia recurrence. While none of the current techniques are highly precise, knowledge of the inherent flaws in the measurement processes will allow surgeons to choose as appropriately sized prosthetic as possible to minimize their recurrence rate and maximize the ease of operation.

References for measuring the hernia defect: [2, 11, 13, 17, 26, 32, 44, 48, 49, 63, 70, 82, 83, 103, 107–109].

Closing the hernia defect

Guideline 17 Closure of hernia defect should be undertaken at the surgeon's discretion, as theoretical advantages exist but have not been proven definitively by good-quality comparative studies. Further evidence is needed (Weak quality, Weak recommendation).

Reasons to close the defect during LVHR prior to mesh insertion include the possibility of reduced seroma rate, reduced recurrence rate, improved abdominal wall "function," and improved abdominal wall contour postoperatively. Indeed, the International Endohernia Society guidelines for laparoscopic hernia repair recommend primary closure of the fascial defect with mesh overlay for

defects of limited size. In our opinion, none of these outcomes have been rigorously studied, and there is no general agreement on the definition of the term "abdominal wall function."

Techniques of defect closure are highly variable and include a variety of suture passer techniques through a series of mini incisions through the hernia sac and/or old scar, laparoscopic techniques utilizing both intra- and extracorporeal knot tying techniques, the use of barbed suture material, and the use of endoscopic "component separation" to assist defect closure. When LVHR is combined with component separation, care should be taken with regard to lateral port placement after component separation, as there is an increased risk of port site hernia if ports are placed through only two layers of muscle (internal oblique and transversus abdominis).

Palanivelu et al. reported laparoscopic-sutured closure of midline defect with mesh reinforcement of incisional hernias in 721 midline incisional hernias. Mean defect size was 96 cm^2. Recurrence rate was 0.55 % with a mean follow-up of 4.2 years. Several techniques of fascial closure have been reported including laparoscopic, open, and transfacial. Agarwal et al. reported on 29 patients with primary fascial closure using an overlapping repair with transfacial vertical mattress sutures. Orenstein et al. reported a "shoelacing" technique of sequential transfacial figure of eight sutures.

In summary, favorable outcomes have been reported utilizing a variety of closure techniques; however, prospective and comparative data are lacking.

References for closing the hernia defect: [20, 33, 38, 51, 58, 95, 110–118].

Prosthetic choice, overlap, and fixation

Guideline 18 The prosthetic used during LVHR should be designed to bridge a defect in the abdominal wall and sized with appropriate overlap for the size and location of the defect, considering clinical factors such as previous recurrences and obesity (Moderate quality, Strong recommendation).

Guideline 19 Fixation type and amount should be appropriate for the size, shape, and location of the defect. Increased fixation strength is required as the defect becomes larger and the prosthetic/defect ratio decreases (Moderate quality, Strong recommendation).

Guideline 20 Fixation to the bony/ligamentous portions of the pelvis should be used for defects near the symphysis (Moderate quality, Strong recommendation).

Guideline 21 Fixation into the rectus muscles and lateral/posterior abdominal wall should be used with caution to avoid injury to the epigastric vessels, peripheral nerves, ureters, and retroperitoneal vascular structures (Low quality, Strong recommendation).

Guideline 22 Fixation above the costal margin should be used with caution to prevent cardiac and lung injuries (Moderate quality, Strong recommendation).

Modern laparoscopic ventral hernia repair is always performed by placing a prosthetic in an intraperitoneal position. Therefore, the prosthetic will contact the abdominal viscera on the one side and abdominal wall on the other side. This concept has launched a large amount of ongoing research by clinicians and industry to develop of variety of absorbable and non-absorbable prosthetics for use with LVHR. It is beyond the scope of this guideline to catalog the available prosthetic choices along with all of their associated features, raw materials, and design characteristics. Rather, this guideline will focus on some general prosthetic characteristics, as well as sizing and overlap issues.

Traditionally, the LVHR technique did not include defect closure, and the prosthetic bridged the gap. Even in cases where the defect is closed, as suggested by recent publications, the rate of it reopening is poorly studied, and the prosthetic may be bridging a gap at some point after repair. In almost all instances, bridging a gap with a hernia prosthetic will have the best results in terms of hernia recurrence with a permanent prosthetic. Therefore, for LVHR, a permanent prosthetic should generally be used. There may be unique circumstances such as contaminated cases that bring the surgeon and patient to the decision to utilize an absorbable (biologic or synthetic) prosthetic to bridge a gap. Currently, there are no commercially available biologic meshes on the market for the laparoscopic approach.

The optimal amount of prosthetic overlap over the defect has been poorly studied and is not known. This is recognized by the Italian Laparoscopic Ventral Incisional Hernia Guidelines, but they do recommend a minimum of 3-cm overlap but note a trend to extend to at least 5-cm overlap, especially in larger defects. Generally, the larger the defect is, the more stress will be placed on the fixation points of the prosthetic. The more points of fixation there are, the more the tension will be distributed among them, hence the less the tension on each individual fixation point. Additionally, as the size of the prosthetic increases, the prosthetic area/defect area ratio will increase, and the tension on the prosthetic fixation sites will decrease. Since all defects are of different sizes and shapes and in a variety of locations, it is important that surgeons consider the total area encompassing all defects in a patient, rather than basing their prosthetic calculation on the largest or dominant defect. In patients with an incisional hernia from a

Table 3 Factors associated with higher versus lower recurrence rates

Recurrence rate higher	Recurrence rate lower
Low prosthetic/defect size ratio	Large prosthetic/defect size ratio
Prosthetic does not reach lateral to rectus muscles	Prosthetic reaches lateral to rectus muscles
Overlap from defect edges <3 cm	Overlap from defect edges >5 cm

Prosthetic/defect size ratio refers to a continuum dependent on the size of the hernia

previous midline incision with multiple hernia defects, it is more useful for choosing the right-sized prosthetic to refer to the entire area as a single defect, encompassing the entire gap between the rectus muscles.

Table 3 summarizes factors that are associated with choice of prosthetic size when considering recurrence as the primary outcome measure. Since there are few data available directly comparing the long-term outcomes of different prosthetics in humans, no recommendation can be made about a specific prosthetic. Selection of the prosthetic is typically based on surgeon's experience, intraoperative handling characteristics, and the purported features associated with the prosthetic. Post-market, continuous evaluation in terms of patient-centered outcomes of all prosthetics is needed. It is technically easier to achieve the parameters listed in Table 3 to reduce recurrence rates for smaller defects, and it is relatively less important to achieve these for smaller defects. As the defect becomes larger in size, these parameters will be more important in determining recurrence rates.

Fixation of the mesh Fixation of a hernia prosthetic to the abdominal wall is required as part of LVHR. Controversy exists regarding the amount, strength, and type (absorbable or permanent) of fixation required.

Currently, there are two main categories of fixation methods available for use in the operating room—tacks and sutures, both of which are available in absorbable or permanent varieties. Sutures are commonly anchored to the mesh with conventional instruments in combination with a suture-passing device. Tacks are usually deployed via a mechanical device typically referred to as a "tacker" (deploys a variety of anchoring devices collectively known as "tacks"). There are human and laboratory reports utilizing fibrin-based sealant for fixation during LVHR, but the available evidence is limited. Proponents of tacks-only fixation have cited the shorter operating time, fewer skin incisions, improved cosmesis, and less acute and chronic pain as the main advantages of this approach. Proponents of suture-only fixation cite as advantages the lower cost and stronger attachment of the prosthetic to the abdominal wall, which may minimize recurrences. Proponents of a combination of tack and suture fixation argue that the combination method affords the advantage of maximum fixation strength and reduced operative time compared with suture or tack fixation only. In a recent prospective, randomized study that compared tack versus suture fixation of prosthetic during LVHR, suture fixation was found to be more cost-effective with less early postoperative pain and quicker return to activity than tacker fixation in patients with small- to medium-sized defects. This study demonstrated that the two procedures were equally effective regarding recurrence rates, complications, hospital stay, chronic pain, quality of life, and patient satisfaction. In a collective literature review of 1211 patients who underwent laparoscopic ventral hernia with mesh fixation utilizing tacks with no transfascial sutures, hernia recurrence occurred in 32 patients (2.6 %). The follow-up ranged from 6 to 72 months. Pain was experienced in all patients but was well controlled by medications except in five patients (0.4 %) with moderate to severe pain. Non-absorbable transfascial sutures were used as the sole method for mesh fixation in 1095 patients with an overall recurrence rate of 0.5 %. The follow-up was short ranged, from 2 to 40 months. Pain was experienced by all patients, and two patients (0.18 %) experienced severe pain that necessitated suture removal. Another collective review of 49 articles reported the outcomes of 12,384 patients and revealed that using sutures in combination with tacks for mesh fixation led to a recurrence rate of 2.5 %. The follow-up ranged from 1 month to 7.5 years. Most cases did not close the hernia defect nor excise the hernia sac.

The location of fixation also determines the strength of attachment of the prosthetic to the abdominal wall independently of the fixation method used. Fixation into bony and ligamentous structures such as the symphysis pubis, Cooper's ligaments, ribs, and the iliac crest are generally considered to be stronger than fixation to the muscular abdominal wall anteriorly, which in turn is stronger than fixation to the musculature of the posterior abdominal wall. Further, taking down the preperitoneal fat and/or falciform ligament allows the prosthetic to oppose directly to the fascia and may provide stronger attachment as compared to fixating it to undissected preperitoneal fat or the falciform ligament.

Regardless of the method of fixation to the anterior abdominal wall, and considering midline defects only, fixing the prosthetic lateral to the rectus muscles may result in a better mechanical advantage compared with fixation in the middle of the rectus muscle. Another advantage of fixation lateral to the rectus muscles is reducing the risk of epigastric vessel injury that can result in hemorrhage and/or hematoma, both a potential etiology for re-operation, postoperative pain, and hernia recurrence due to prosthetic displacement.

Challenges of anatomic location of the hernia Fixation above the costal margins should not be accomplished with sutures placed between the ribs. Further, while fixation with tacks may be feasible, it should generally be avoided to prevent lung or cardiac injury or injuries to the neurovascular bundles running along the inferior surface of each rib. There are multiple known cases of cardiac tamponade after ventral and hiatal hernia repair, mostly from tacking devices, but also from sutures near the pericardium. The majority of these cases resulted in mortality. If fixation is deemed necessary near the pericardium, the diaphragm should be grasped and tented away from the pericardium, and a superficial suture, rather than a tack should be carefully placed. An alternative and safer option to prosthetic fixation above the costal margin during LVHR is to allow the prosthetic to drape over the diaphragm superiorly without fixation, and add full-thickness fixation to the edge of the costal margin and xiphoid process away from the edge of the prosthetic. There is almost always a small rim of either abdominal wall or scar tissue that will accommodate sutures. Even in the absence of this rim of tissue, full-thickness fixation could be placed at the closest area near the defect, and circumferentially around the defect, in addition to increasing the prosthetic/defect size ratio.

Defects near the symphysis pubis should be fixed to the pubic bone, pubic ramus, and Cooper's ligaments. Whether or not this is performed with permanent or absorbable fixation will depend on how close the defect is to the pubic symphysis, the size of the defect, and the body mass index (BMI). Increased fixation strength is required for larger BMI, larger defects, and defects closer to the symphysis. Permanent fixation can be placed with a tacking device, bone anchor, or suture material utilizing intra- or extracorporeal knotting techniques with anticipated equal effectiveness, although there are no data comparing these methods.

Fixation to the lateral and posterior abdominal wall should avoid injury to retroperitoneal structures such as peripheral nerves, major vascular structures, and the ureters. As with inguinal hernia repair, avoiding fixation inferior to the iliopubic tract will help avoid injury to the lateral femoral cutaneous nerve, genitofemoral nerve, and the external iliac vessels. Likewise, placing deep fixation superior to the iliopubic tract puts the ilioinguinal and iliohypogastric nerves at risk of injury. Proper exposure of these areas often requires lateral patient position that requires proper planning during the prepping and draping process.

Increasing fixation strength and amount and prosthetic size (particularly as it relates to the defect size) will likely lower recurrence rates. In summary, method of fixation depends on the size, shape, and location of the hernia defect, as well as patient-related factors such as previous known response to a particular prosthetic, collagen disorders, and body habitus to name a few. Increased fixation strength occurs with increasing the prosthetic/defect size ratio, depth of fixation, and fixation into bony/ligamentous structures. Increased fixation strength is generally required for larger defects.

References for prosthetic choice, overlap, and fixation: [1, 2, 9, 11, 14, 15, 17, 20, 27, 30, 32, 34–37, 41–44, 46, 47, 49, 51, 53, 57–59, 61–67, 69, 70, 74, 76, 78, 88, 89, 91, 94, 97, 99, 102, 107–110, 112, 119–144].

Postoperative management: avoiding and treating problems

Pain management

Guideline 23 Persistent pain following laparoscopic ventral hernia repair should be treated with analgesics, anti-inflammatory medications, steroids, trigger point injection, or nerve block (Low quality, Strong recommendation).

There is a high degree of patient variability regarding postoperative pain, and clinical experience has shown that acute postoperative pain should be resolved by 4–6 weeks. The incidence of protracted pain ranges from 1.6 to 28 %. Nonsteroidal anti-inflammatory medications have been utilized with success in the management of persistent postoperative pain. Elastomeric pumps continuously delivering bupivacaine in the hernia sac above the mesh have not been shown to influence acute postoperative pain. Topical anesthetic patches have been shown to reduce pain scores after LVHR, but the clinical significance of this is uncertain. Successful relief of protracted pain has also been demonstrated with injections of either a local anesthetic or a combination of local anesthetic and steroid. Intercostal nerve blocks have also been successfully employed in the treatment of chronic postoperative pain. Excision of sutures or tacks has been reported to result in pain resolution in some circumstances.

Seroma management

Guideline 24 Postoperative seroma following laparoscopic ventral hernia repair is common and should be anticipated. Asymptomatic seromas should be observed. Persistent symptomatic seromas may be aspirated under sterile conditions with a low risk of complications. Recurrent seromas after aspiration that are symptomatic should be treated with surgical drainage and excision of the seroma lining if possible (Low quality, Strong recommendation).

Guideline 25 Cauterization of the hernia sac, the use of pressure dressings (such as abdominal binders), or suture closure of the hernia defect may be utilized to reduce the incidence of postoperative seroma (Low quality, Weak recommendation).

Seroma formation following laparoscopic hernia repair should be considered an expected outcome, rather than a complication. Seromas that are persistent for prolonged periods of time or those that are symptomatic may require treatment. Clinically detectable seromas in the early postoperative period have been reported to occur in about 35 % of patients. Two prospective studies have evaluated the incidence of postoperative seroma formation following laparoscopic ventral hernia repair. The incidence of early postoperative seroma detected utilizing ultrasound or CT scan in these studies ranged from 95 to 100 % in the early postoperative period, while the rate of seroma persisting beyond 90 days decreased to 0–20 %, and the incidence of seroma formation not resolving spontaneously was reported to occur in 3–4 % of patients. Aspiration of the seroma fluid has been shown to reduce patient symptoms, although recurrence following aspiration is common. Spontaneous seroma resolution may be anticipated in the majority of cases, and persistent seromas may be drained percutaneously or surgically with success.

Aspiration of a postoperative seroma carries a potential risk of bacterial inoculation. However, retrospective studies have demonstrated the safety of seroma aspiration. Similarly, conservative seroma management is not associated with an increased risk of infectious complications. Chronic seromas that fail to respond to aspiration and/or drainage have been reported to be successfully treated with either mesh excision or laparoscopic excision of the mesothelial layer surrounding the seroma.

Techniques for prevention of seromas may be employed to minimize the likelihood of developing this persistent problem. A prospective study of 51 patients undergoing laparoscopic ventral hernia demonstrated a reduction in seroma formation following cauterization of the hernia sac. The use of abdominal pressure dressings and abdominal binders may reduce the incidence of postoperative seroma. Retrospective studies have demonstrated a reduction in postoperative seroma formation in patients treated with these measures. Laparoscopic defect closure at the time of laparoscopic ventral hernia repair has been performed to help restore the contour of the abdominal wall, reduce abdominal bulging as well as reduce seroma formation. Reports of this technique have demonstrated a beneficial impact upon seroma formation with a low or absent incidence of clinically significant seromas. In a retrospective study comparing laparoscopic hernia repair without defect closure to repair with defect closure with either continuous or interrupted sutures, the incidence of seroma formation beyond 8 weeks was decreased. A larger series of 176 hernia repairs demonstrated a reduction in the incidence of seroma formation from 28 to 6 % in patients in which the hernia defect was closed percutaneously.

References for seroma management: [53, 58, 95, 115, 145, 146].

Postoperative ileus

Guideline 26 Laparoscopic ventral hernia repair is associated with a low incidence of postoperative ileus. Patients developing a postoperative ileus should be initially treated non-operatively with fluid administration, bowel rest, and/or gastric decompression (Low quality, Weak recommendation).

There is no uniformly accepted definition of prolonged ileus following laparoscopic ventral hernia repair, but no return of bowel activity for more than 5 days is infrequent.

A prospective trial of 144 patients undergoing laparoscopic ventral hernia repair reported a mean time of 1.8 days to return of bowel function with a range of 0–8 days. A retrospective study demonstrated a 1.3 % incidence of postoperative ileus with a duration greater than 7 days. Other authors who defined prolonged ileus as ones occurring longer than 24 h have reported rates of 20 %. A study of 819 laparoscopic hernia repairs reported a 3 % incidence of prolonged ileus, although the duration of the ileus was not defined. In each of these studies, postoperative ileus resolved uneventfully.

Among others, common factors that may prolong return of bowel activity after LVHR include extensive adhesiolysis, especially when bowel is involved, size of prosthetic used, and amount of postoperative opioid analgesics used. Minimal manipulation of the intestine during the procedure may reduce the rate of postoperative ileus. Patients developing a postoperative ileus should be treated non-operatively with fluid administration, bowel rest, and/or gastric decompression.

Management of enterotomies

1. Recognized intraoperative enterotomy

Guideline 27 The laparoscopic repair of a hernia with a permanent synthetic mesh immediately following an enterotomy should be carefully considered in light of a paucity of evidence and the potential for infectious complications. A tailored approach may include open or laparoscopic techniques and should be based upon operative findings, degree of contamination, surgeon experience, and patient interests. The possibility of enterotomy and

management options should be discussed with the patient preoperatively (Low quality, weak recommendation).

Adhesiolysis involving the GI tract is frequently required during LVHR. Although enterotomies occur infrequently, immediate recognition and treatment is essential to successful outcomes. The incidence of enterotomy in laparoscopic ventral hernia repair is reported to occur in up to 6 % of patients, with injuries to the small intestine occurring much more commonly than injuries to the colon. Increasing surgical experience has been associated with a reduced risk of enterotomy as well as a reduced incidence of postoperative death. Recognized intestinal injuries may be approached by any of several methods under two main categories: (1) enterotomy repair with hernia repair (lap or open; with or without permanent mesh) and (2) enterotomy repair with delayed hernia repair (lap or open; short or long delay; permanent mesh). When delayed hernia repair is chosen, it is usually accomplished either before or after the proliferative wound healing phase, i.e., within the first week, or after 6–8 weeks postoperatively, respectively.

Successful outcomes have been reported following enterotomy repair and concomitant implantation of a permanent synthetic mesh. This practice is further corroborated by animal and human studies documenting the safety and efficacy of placing permanent synthetic mesh at the time of other clean-contaminated procedures such as colectomy, creation of a stoma, and gastric bypass. Many of these studies were prospective randomized trials that resulted in lower hernia rates without mesh-related complications. Successful outcomes have also been reported following laparoscopic or open repair of the visceral injury followed by primary closure of the hernia defect. This approach will obviously eliminate the risk of mesh-related complications but carries a high risk of hernia recurrence.

There have been some studies attempting to compare cases of various wound classifications where ventral hernia repair with or without mesh was performed at the same time bowel resection was performed. These have all been retrospective and included mostly open hernia repairs. Additionally, the hernia repairs in these studies, both with and without mesh, were performed on a heterogeneous group of patients and utilized a variety of undefined techniques as well as a variety of prosthetics. Additionally, these studies included both elective and emergency cases. None of these studies, however, specifically addressed small enterotomy during LVHR, which represented the minority of cases in these reviews. The largest of these studies reviewed administrative data of 33,832 patients and recommended avoidance of the use of mesh at any level of contamination; this study documented a wound complication rate of 21.2 % when mesh was used versus 17.5 % ($p < 0.001$) without mesh in clean-contaminated cases, but no difference in wound complications was found in contaminated cases (31.2 vs. 27.3 %, respectively; $p = 0.875$). This study did not report the rate of mesh infection or need for mesh removal. In another series of 1071 open and laparoscopic ventral hernia repairs with concomitant intraabdominal procedures using a variety of prosthetics and techniques, factors associated with the need for mesh explantation were analyzed. The authors found that 4.6 % (4/88) of LVHR cases with PTFE prosthetics had to be removed a median of 1 year postoperatively, two of which were for infection, and two of which were not defined. They concluded permanent prosthetic mesh should be used with caution when incisional hernia repair is performed with concomitant intraabdominal procedures. In a retrospective study of 1124 elective incisional hernia repairs utilizing a variety of techniques and prosthetics, unplanned enterotomy or bowel resection due to incarceration or other factors during ventral hernia repair (for LVHR it was 7.9 %) was found to increase postoperative complications, return to the operating room, risk of enterocutaneous fistula, length of hospitalization, and operative time. This study, however, did not analyze the impact of prosthetic usage in this setting.

One of the primary concerns during LVHR is what to do when a small enterotomy occurs during adhesiolysis with limited contamination of the operating field. There has been no study to date that has directly addressed this concern. There is a moderate amount of anecdotal and retrospective evidence and clinical experience with a variety of management strategies, all of which can be safe and effective.

References for recognized intraoperative enterotomy: [34, 47, 71, 87, 100, 116, 130, 137, 147–173].

2. Delayed enterotomy

Guideline 28 Patients with a delayed intestinal injury following laparoscopic hernia repair should be returned to the operating room for bowel repair, resection, and/or GI tract diversion. Consideration should be given to mesh removal at the time of re-operation (Low quality, Weak recommendation).

A delayed enterotomy is considered an enterotomy that manifests clinically during the postoperative period and was either unrecognized or not present during the operation. This group would include intraoperative enterotomies that were unrecognized, thermal injuries that were not full thickness at the time of occurrence, and enterotomies that occurred in the postoperative period due to fixation devices such as mechanical tacks. Intestinal injuries occurring following laparoscopic ventral hernia repair represent one of the most serious complications

reported. Numerous reports include descriptions of the management of these delayed injures. The majority of these reports describe management to include exploration with intestinal repair and mesh removal. One report includes a description of two cases in which intestinal injuries were repaired without the removal of the mesh, although the long-term outcomes associated with the mesh were not reported. No prospective trials are available to guide management following this complication. Management should be guided by sound surgical judgment. Decisions to remove mesh should be guided by the patient's physiologic status, extent of contamination, and type of mesh.

3. Surgical-site infections

Guideline 29 Laparoscopic ventral hernia repair leads to fewer surgical-site infections compared with open repair and should therefore be considered in patients with higher risk of infection (High level, Strong recommendation).

Compared with open ventral hernia repair, LVHR has been reported to lead to fewer superficial and deep surgical-site infections in several randomized clinical trials. In a recent multicenter randomized trial of laparoscopic versus open ventral incisional hernia repair in 162 patients, surgical-site infections were significantly fewer in the laparoscopic group (2.8 vs 21.9 %; OR 10.5; 95 % CI 2.3–48.2; $p = 0.003$). A meta-analysis of eight randomized trials comparing laparoscopic and open incisional or ventral hernia repair with mesh revealed that laparoscopic hernia repair was associated with decreased SSI rates (relative risk, 0.22; 95 % CI 0.09–0.54) and a trend toward fewer infections requiring mesh removal

4. Cellulitis

Guideline 30 Postoperative cellulitis following laparoscopic ventral hernia repair may be treated with a short course of antibiotics (Low quality, Weak recommendation).

Cellulitis following laparoscopic ventral hernia repair occurs infrequently, in 2–4 % of patients. The etiology of cellulitis overlying the surgical mesh has been postulated to occur as a result of either infection or an inflammatory response related to the prosthetic mesh.

Successful resolution of cellulitis with administration of antibiotics has been demonstrated in retrospective studies. Fever of unknown origin has been reported following laparoscopic ventral hernia in 5–60 % of patients, all of whom responded to antibiotics without sequelae. The etiology of these postoperative febrile events is not clear.

Prophylactic antibiotics are administered prior to laparoscopic hernia repair to reduce the risk of wound and mesh infections. A single retrospective study demonstrated a reduction in abdominal wall cellulitis overlying the postoperative seroma in patients who were administered postoperative antibiotics for 7 days following laparoscopic hernia repair.

There was no difference in mesh infections between those patients receiving preoperative antibiotics and those receiving a longer duration of antibiotics.

5. Mesh infection

Guideline 31 Infected prosthetic mesh salvage may be successful with a combination of antibiotics, percutaneous drainage, and/or wound debridement with negative pressure wound therapy placement. When this approach fails (or in septic patients), mesh excision should be undertaken (Low quality, Strong recommendation).

Prosthetic mesh infections following laparoscopic hernia repair represent a significant source of morbidity. Numerous strategies for dealing with mesh infection have been reported. Successful management strategies include antibiotics, local wound care with mesh salvage, and mesh removal with or without concomitant hernia repair. Successful laparoscopic removal of the infected mesh and placement of a biologic mesh has been described, but long-term outcomes were not reported. This strategy minimizes the risk of bowel incarceration into the hernia defect and allows for a temporary hernia repair. Numerous retrospective case series have described the successful treatment of mesh infections after laparoscopic hernia repair with open mesh excision.

In the largest series of laparoscopic hernia repairs included, the incidence of mesh infection was less than 1 %. One patient was successfully treated with mesh salvage utilizing a strategy including antibiotics and percutaneous drainage. This patient remained free of hernia recurrence and infection 2 years following treatment.

There are no prospective trials specifically evaluating the management of patients with infected mesh following laparoscopic incisional hernia repair. The decision to attempt mesh salvage should be based on the incorporation of the mesh and the patient's clinical condition. Expert opinion suggests that meshes that incorporate with encapsulation are less likely to be successfully treated with conservative measures and typically require removal. Further, septic patients require immediate removal of the infected prosthetic. The single-stage management of patients with infected mesh has been described utilizing techniques of component separation with the adjunctive use of biologic mesh materials. Further, mesh salvage has been successful in a small case series with wound debridement and the use of a negative pressure wound therapy (VAC).

References for surgical-site infections, cellulitis, and mesh infections: [11, 16, 23, 26, 29, 34, 36, 38–40, 46, 48, 51, 58, 63, 68, 69, 75, 77, 109, 174–177].

Compliance with ethical standards

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