The SAGES University Masters Program Series
Editor-in-Chief: Brian Jacob

The SAGES Manual of Hernia Surgery

Second Edition

S. Scott Davis Jr.
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ISBN 978-3-319-78410-6 ISBN 978-3-319-78411-3 (eBook)
https://doi.org/10.1007/978-3-319-78411-3

Library of Congress Control Number: 2018961396

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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SAGES University MASTERS PROGRAM: Hernia Pathway

1

Daniel B. Jones, Linda Schultz, and Brian Jacob

The MASTERS Program organizes educational materials along clinical pathways into discrete blocks of content which could be accessed by a surgeon attending the SAGES annual meeting or by logging into the online SAGES University (Fig. 1.1) [1]. The SAGES MASTERS Program currently has eight pathways including: Acute Care, Biliary, Bariatrics, Colon, Foregut, Hernia, Flex Endoscopy, and Robotic Surgery (Fig. 1.2). Each pathway is divided into three levels of targeted performance: Competency, proficiency, and mastery (Fig. 1.3). The levels originate from the Dreyfus model of skill acquisition [2], which has five stages: novice, advanced beginner, competency, proficiency, and expertise. The SAGES MASTERS Program is based on the three more advanced stages of skill acquisition: competency, proficiency, and expertise. Competency is defined as what a graduating general surgery chief resident or MIS fellow should be able to achieve; proficiency is what a surgeon approximately 3 years out from training should be able to accomplish; and mastery is what more experienced surgeons should be able to accomplish after several years in practice. Mastery is applicable to SAGES surgeons seeking in-depth knowledge in a pathway, including the following: Areas of controversy, outcomes, best practice, and the ability to mentor colleagues. Over time, with the

Adopted from Jones, DB, Stefanidis D, Korndorffer JR, Dimick JB, Jacob BP, Schultz L, Scott DJ, SAGES University Masters Program: a structured curriculum for deliberate, lifelong learning. Surg Endoscopy, 2017, in press.

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S. S. Davis Jr. et al. (eds.), *The SAGES Manual of Hernia Surgery*,
https://doi.org/10.1007/978-3-319-78411-3_1

Fig. 1.1 MASTERS Program logo

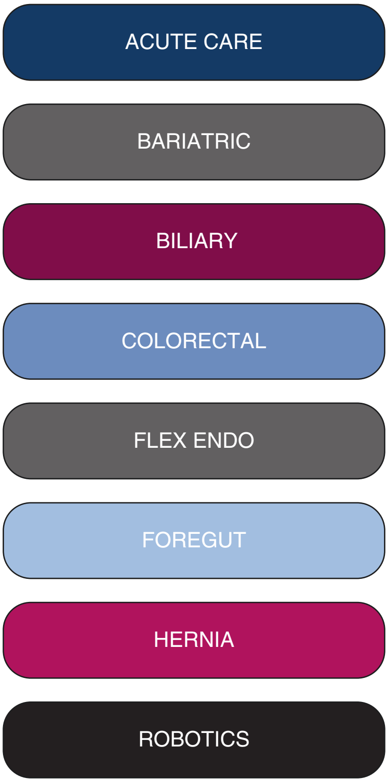

Fig. 1.2 MASTER Program clinical pathways

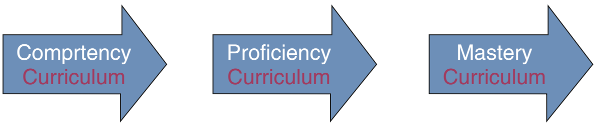

Fig. 1.3 MASTERS Program progression

utilization of coaching and participation in SAGES courses, this level should be obtainable by the majority of SAGES members. This edition of the SAGES Manual—Hernia Surgery aligns with the current version of the new SAGES University MASTERS Program Hernia Surgery pathway (Table 1.1).

Table 1.1 Hernia surgery curriculum

Curriculum elements	Competency
Anchoring Procedure—Competency	2
CORE LECTURE	1
CORE MCE 70%	1
Annual meeting content	2
Guidelines	1
SA CME Hours	6
Sentinel articles	2
Social Media	2
SAGES Top 21 video	1
FLS	12
PEARLS	1
Hernia task force tool	2
Sages manual	2
CREDITS	**35**

Curriculum elements	Proficiency
Anchoring Procedure—Proficiency	2
CORE LECTURE	1
CORE MCE 70%	1
Annual meeting content	5
FUSE	12
Outcomes database enrollment	2
SA CME Hours (ASMBS electives, SAGES or SAGES-endorsed)	6
Sentinel articles	2
Social Media	2
SAGES Top 21 video	1
PEARLS	1
CREDITS	**35**

Curriculum elements	Mastery
Anchoring Procedure—Mastery	2
CORE LECTURE	1
CORE MCE 70%	1
Annual meeting content	6
Fundamentals of Surgical Coaching	4
Outcomes database reporting	2
SA CME Credits (ASMBS electives, SAGES or SAGES-endorsed)	6
Sentinel articles	2
Serving as video assessment reviewer and providing feedback (FSC)	4
Social Media	6
SMART Enhanced Recovery	1
CREDITS	**35**

Hernia Surgery Curriculum

The key elements of the Hernia Surgery curriculum include a core lectures for the pathway, which provides a 45 min general overview including basic anatomy, physiology, diagnostic workup, and surgical management. As of 2018. all lecture content of the annual SAGES meetings are labeled as follows: Basic (100), intermediate (200), and advanced (300). This allows attendees to choose lectures that best fit their educational needs. Coding the content additionally facilitates online retrieval of specific educational material, with varying degrees of surgical complexity, ranging from introductory to revisional surgery.

SAGES identified the need to develop targeted, complex content for its mastery level curriculum. The idea was that these 25 min lectures would be focused on specific topics. It assumes that the attendee already has a good understanding of diseases and management from attending/watching competency and proficiency level lectures. Ideally, in order to supplement a chosen topic, the mastery lectures would also identify key prerequisite articles from *Surgical Endoscopy* and other journals, in addition to SAGES University videos. Many of these lectures will be forthcoming at future SAGES annual meetings.

The MASTERS Program has a self-assessment, multiple choice exam for each module to guide learner progression throughout the curriculum. Questions are submitted by core lecture speakers and SAGES annual meeting faculty. The goal of the questions is to use assessment for learning, with the assessment being criterion-referenced with the percent correct set at 80%. Learners will be able to review incorrect answers, review educational content, and retake the examination until a passing score is obtained.

The MASTERS Program Hernia Surgery curriculum taps much of the SAGES existing educational products including FLS, FUSE, SMART, Top 21 videos, and Pearls (Fig. 1.4). The Curriculum Task Force has placed the aforementioned modules along a continuum of the curriculum pathway. For example, FLS, in general, occurs during the Competency Curriculum, whereas the Fundamental Use of Surgical Energy (FUSE) is usually required during the Proficiency Curriculum. The Fundamentals of Laparoscopic Surgery (FLS) is a multiple choice exam and a skills assessment conducted on a video box trainer. Tasks include peg transfer; cutting; intracorporeal and extracorporeal suturing; and knot tying. Since 2010, FLS has been required of all US general surgery residents seeking to sit for the American

Fig. 1.4 SAGES educational content: FLS, FUSE, SMART

Board of Surgery qualifying examinations. The Fundamentals of Endoscopic Surgery (FES) assesses endoscopic knowledge and technical skills in a simulator. FUSE teaches about the safe use of energy devices in the operating room and is available at FUSE.didactic.org. After learners complete the self-paced modules, they may take the certifying examination.

The SAGES Surgical Multimodal Accelerated Recovery Trajectory (SMART) Initiative combines minimally invasive surgical techniques with enhanced recovery pathways (ERPs) for perioperative care, with the goal of improving outcomes and patient satisfaction. Educational materials include a website with best practices, sample pathways, patient literature, and other resources such as videos, FAQs, and an implementation timeline. The materials assist surgeons and their surgical team with implementation of an ERP.

Top 21 videos are edited videos of the most commonly performed MIS operations and basic endoscopy. Cases are straightforward with quality video and clear anatomy.

Pearls are step-by-step video clips of ten operations. The authors show different variations for each step. The learner should have a fundamental understanding of the operation.

SAGES Guidelines provide evidence-based recommendations for surgeons and are developed by the SAGES Guidelines Committee following the Health and Medicine Division of the National Academies of Sciences, Engineering, and Medicine standards (formerly the Institute of Medicine) for guideline development [3]. Each clinical practice guideline has been systematically researched, reviewed, and revised by the SAGES Guidelines Committee and an appropriate multidisciplinary team. The strength of the provided recommendations is determined based on the quality of the available literature using the GRADE methodology [4]. SAGES Guidelines cover a wide range of topics relevant to the practice of SAGES surgeon members and are updated on a regular basis. Since the developed guidelines provide an appraisal of the available literature, their inclusion in the MASTERS Program was deemed necessary by the group.

The Curriculum Task Force identified the need to select required readings for the MASTERS Program based on key articles for the various curriculum procedures. Summaries of each of these articles follow the American College of Surgeons (ACS) Selected Readings format.

Facebook™ Groups

While there are many great platforms available to permit online collaboration by user generated content, Facebook(™) offers a unique, highly developed mobile platform that is ideal for global professional collaboration and daily continuing surgical education (Fig. 1.5). The Facebook groups allow for video assessment, feedback, and coaching as a tool to improve practice.

Based on the anchoring procedures determined via group consensus (Table 1.2) participants in the MASTERS Program will submit video clips on closed Facebook

Fig. 1.5 Hernia Facebook group

Table 1.2 Anchoring procedures for Hernia Pathway

Anchoring procedure by pathway	Level
FOREGUT SURGERY	
Lap ventral hernia repair	Competency
Lap inguinal hernia repair	Proficiency
Lap redo inguinal	Mastery

Fig. 1.6 SAGES Robot Facebook group

groups, with other participants and/or SAGES members providing qualitative feedback. For example, for the Hernia Curriculum, surgeons would submit the critical views during a laparoscopic inguinal hernia repair with identification of the direct, indirect, and femoral hernia and triangle of pain. Using crowdsourcing, other surgeons would comment and provide feedback.

Eight, unique vetted membership-only closed Facebook groups were created for the MASTERS Program, including a group for bariatrics, hernia, colorectal, biliary, acute care, flexible endoscopy, robotics, and foregut. The Hernia Surgery Facebook group is independent of the other groups and will be populated only by physicians, mostly surgeons or surgeons-in-training interested in abdominal and inguinal hernia surgery (Fig. 1.6).

The group provides an international platform for surgeons and healthcare providers interested in optimizing outcomes in a surgical specialty to collaborate, share, discuss, and post photos, videos, and anything related to a chosen specialty. By embracing social media as a collaborative forum, we can more effectively and transparently obtain immediate global feedback that potentially can improve patient outcomes, as well as the quality of care we provide, all while transforming the way a society's members interact.

For the first two levels of the MASTERS Program, Competency, and Proficiency, participants will be required to post videos of the anchoring procedures and will receive qualitative feedback from other participants. However, for the mastery level, participants will submit a video to be evaluated by an expert panel. A standardized video assessment tool, depending on the specific procedure, will be used. A benchmark will also be utilized to determine when the participant has achieved the mastery level for that procedure.

Once the participant has achieved mastery level, he/she will participate as a coach by providing feedback to participants in the first two levels. MASTERS Program participants will therefore need to learn the fundamental principles of surgical coaching. The key activities of coaching include goal setting, active listening, powerful inquiry, and constructive feedback [5, 6]. Importantly, peer coaching is much different than traditional education, where there is an expert and a learner. Peer coaching is a "co-learning" model where the coach is facilitating the development of the coachee by using inquiry (i.e., open-ended questions) in a noncompetitive manner.

Surgical coaching skills are a crucial part of the MASTERS curriculum. At the 2017 SAGES Annual Meeting, a postgraduate course on coaching skills was developed and video recorded. The goal is to develop a "coaching culture" within the SAGES MASTERS Program, wherein both participants and coaches are committed to lifelong learning and development.

The need for a more structured approach to the education of practicing surgeons as accomplished by the SAGES MASTERS Program is well recognized [7]. Since performance feedback usually stops after training completion and current approaches to MOC are suboptimal, the need for peer coaching has recently received increased attention in surgery [5, 6]. SAGES has recognized this need and its MASTERS Program embraces social media for surgical education to help provide a free, mobile, and easy to use platform to surgeons globally. Access to the MASTERS Program groups enables surgeons at all levels to partake in the MASTERS Program Curriculum and obtain feedback from peers, mentors, and experts. By creating surgeon-only private groups dedicated to this project, SAGES can now offer surgeons posting in these groups the ability to discuss preoperative, intraoperative, and postoperative issues with other SAGES colleagues and mentors. In addition, the platform permits transparent and responsive dialogue about technique, continuing the theme of deliberate, lifelong learning.

To accommodate the needs of this program, SAGES University is upgrading its web-based features. A new learning management system (LMS) will track progression and make access to SAGES University simple. Features of the new IT infrastructure will provide the ability to access a video or lecture on-demand in relation to content, level of difficulty, and author. Once enrolled in the MASTERS Program, the LMS will track lectures, educational products, MCE, and other completed requirements. Participants will be able to see where they stand in relation to module completion and SAGES will alert learners to relevant content they may be interested in pursuing. Until such time that the new LMS is up and running, it is hoped that the SAGES Manual will help guide learners through the MASTERS Program Curriculum.

Conclusions

The SAGES MASTERS Program HERNIA SURGERY PATHWAY facilitates deliberate, focused postgraduate teaching and learning. The MASTERS Program certifies completion of the curriculum but is NOT meant to certify competency, proficiency or mastery of surgeons. The MASTERS Program embraces the concept of lifelong learning after fellowship and its curriculum is organized from basic principles to more complex content. The MASTERS Program is an innovative, voluntary curriculum that supports MOC and deliberate, lifelong learning.

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Laparoscopic Ventral Hernia Repair

2

Alisa M. Coker and Gina L. Adrales

Laparoscopic ventral hernia repair (LVHR) was developed as a minimally invasive approach to the gold standard Rives-Stoppa repair. The Rives-Stoppa repair revolutionized abdominal wall reconstruction by markedly decreasing hernia recurrence with widely overlapping retromuscular mesh [1]. The first description of laparoscopic ventral herniorrhaphy was published by LeBlanc in 1993 [2]. By 1999, there were 40 manuscripts highlighting this advance in hernia repair and several comparative analyses noting reduced hospitalization and a decrease in wound complications and surgical site infection [3]. However, it was not until after 2000 that the technique was popularized with the publication by Heniford, Park, Ramshaw, and Voeller of a large multicenter series of laparoscopic ventral hernia repairs with a low complication rate and hernia recurrence rate of 3.4% [4]. While the landscape of ventral hernia repair has shifted remarkably since that landmark publication due to increasing patient complexity, obesity, and innovative technology, laparoscopic ventral hernia repair continues to play a major role in the care of ventral hernia patients.

Patient Selection and Preparation

The laparoscopic approach may be applied broadly to both initial and recurrent ventral and incisional hernias. Specifically, its benefits have been shown in the obese patient population among whom open repair is associated with a higher rate of wound complications and infection [5].

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S. S. Davis Jr. et al. (eds.), *The SAGES Manual of Hernia Surgery*,
https://doi.org/10.1007/978-3-319-78411-3_2

A repair that is satisfactory for both surgeon and patient requires preoperative discussion of the patient's goals for repair. If skin excision is needed or primary fascial closure is not feasible for the patient lacking truncal support, a laparoscopic approach is not optimal. Other relative contraindications include contaminated cases and prohibitive intraperitoneal adhesions in the multiply recurrent incisional hernia patient.

Preoperative evaluation includes a comprehensive history and physical exam and review of prior operative reports. Knowledge of previous component separation, enterotomies, mesh type and positioning, and mesh fixation is critical for preoperative planning. Computed Tomography is a useful adjunct for most patients to assess the size and location of the hernia defect, proximity to bony structures, bowel involvement, and loss of domain. Imaging is particularly important for atypical ventral hernias, located away from the midline such as parastomal and subxiphoid hernias.

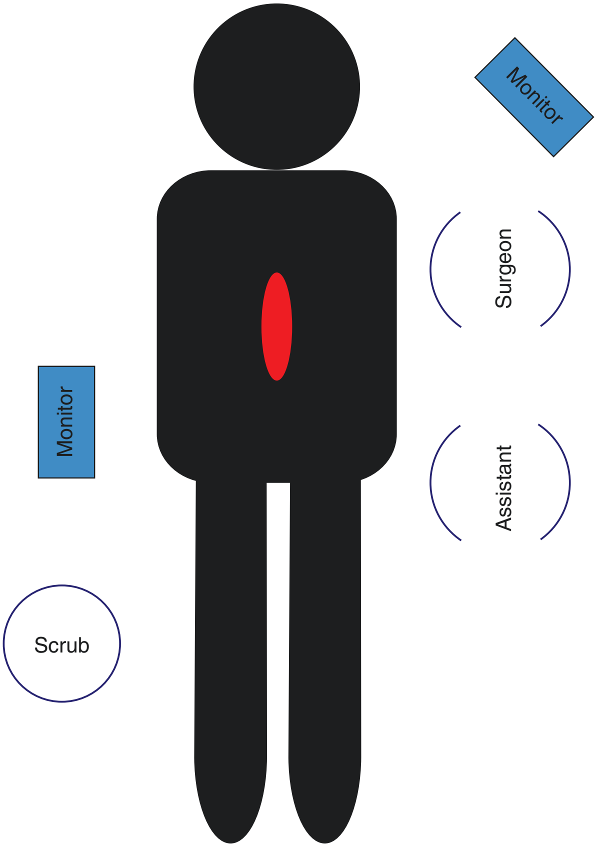
Modifiable risk reduction to improve perioperative outcomes and hernia recurrence is advisable in the elective setting. This includes smoking cessation, weight loss for patients with morbid obesity, glycemic control, treatment of chronic skin conditions, and MRSA clearance [6–9]. In the authors' experience, this is best achieved in partnership with the patient with utilization of educational resources and support from nurse educators, dieticians, and health coaches. Postoperative complications are an independent risk factor for hernia recurrence after laparoscopic hernia repair [10]. While not always possible in the setting of escalating hernia symptoms, such prehabilitation may break the "vicious cycle" of hernia repair complications and hernia recurrence [11].

Operative Setup and Instrumentation

Laparoscopic ventral hernia repair can be ergonomically challenging. Alignment of the surgeon, camera, and target anatomy will facilitate an efficient operation. As the majority of ventral hernias are located in the midline, the surgeon and assistant typically should stand at the patient's side and view the monitor on the opposite side of the patient (Fig. 2.1). Tucking both arms affords greater mobility of the surgeon about the patient and operative field. This includes moving to the contralateral side when needed for mesh fixation while avoiding working against the camera which can be difficult and time-consuming. All of the ventral hernias can be approached in this fashion, though one may consider lower abdominal port placement and surgeon placement between the split legs of the patient for the subxiphoid hernia. Likewise, mid- to upper abdominal port placement with the camera view of the pelvis is a more favorable ergonomic setup for the isolated suprapubic hernia, though the patient's chest may limit the range of motion of the instruments. Flexion of the table may ameliorate that limitation.

Standard sterile draping is used but should provide a wide operative field. This allows lateral port placement with adequate distance between the hernia defect and the ports. This also provides flexibility should additional ports be needed to conduct

Fig. 2.1 Operative setup for laparoscopic ventral hernia repair of a midline incisional hernia



extensive adhesiolysis. Additional hernia defects are often discovered during the procedure, and a wide sterile prep ensures adequate space for working port placement away from the defects. A sterile occlusive drape may be used. While there is no evidence to suggest that this drape decreases the risk of surgical site infection, it facilitates mapping out the defect and mesh sizing on the drape and avoidance of contact of the mesh with the skin.

Laparoscopic ventral hernia repair requires a modest amount of instrumentation. Use of a 5 mm angled laparoscope allows movement of the laparoscope to various ports to maintain the best ergonomic advantage during adhesiolysis, mesh insertion, and mesh fixation. Basic instrumentation includes two to three blunt, bowel-safe, graspers, laparoscopic Metzenbaum scissors with monopolar cautery, and a suture passer. Finer grasper, clip applier, and suction/irrigation devices are useful secondary instruments. The selection of a more advanced electrosurgical instrument is based on the discretion and experience of the operating surgeon. Ultrasonic dissection is helpful in subxiphoid hernia repair in taking down the falciform ligament which is often associated with bleeding.

Abdominal Access and Port Placement

The method of abdominal access is based primarily on surgeon experience and preference. There is no substantial advantage of either closed Veress or Hasson open-access technique. Vascular and intestinal injuries can occur with either method [12, 13]. Optical trocar access without pre-insufflation is another option. The first site of peritoneal access should be made in an area away from previous incisions. For the Veress technique, Palmer's point below the left costal margin is the safest area of placement [14]. Ensuring full muscle relaxation and gastric decompression prior to insertion is important to lessen the risk of visceral injury. After access is established along with the first trocar placement, the abdomen should be inspected for bleeding and visceral injury, both of which would warrant further laparoscopic exploration or conversion to laparotomy if needed.

A minimum of three trocars are placed. For the midline hernia defect, three lateral trocars along the anterior to mid-axillary line are used including two 5 mm ports and one larger 10–12 mm port through which the mesh will be inserted. Alternatively, the larger trocar may be placed closer to or within the defect to allow coverage of the site with mesh. While caution should be exercised with assessment of the quality of the skin overlying the hernia defect for closure of the central port site, this method addresses the risk of trocar site hernia. The incidence of trocar site hernia, particularly in this population of patients who may have risk factors for hernia development, is likely underreported. While shorter-term retrospective series note an incidence of trocar site hernia after laparoscopy at 1–6%, the longer-term incidence associated with laparoscopic cholecystectomy is as high as 26% at 3 years [15].

The described lateral port placement provides camera visualization and two working ports to facilitate efficient adhesiolysis. An additional 5 mm trocar on the contralateral side allows better positioning for tack fixation on the side of the initial ports. In cases of extensive adhesions, two 5 mm trocars (working port and camera port) on the contralateral side may be needed for a different vantage point to complete the adhesiolysis and hernia contents reduction. Each of the ports should be placed under laparoscopic camera visualization.

Additional port placement is often required for atypically located ventral hernias. As mentioned previously, the trocar's arrangement should allow targeting of the camera and instruments toward the hernia site when possible. As patients can have incidentally found hernias at prior incisions, initial lateral port placement as described may be the most efficient to address all hernia defects.

Adhesiolysis Tips and Tricks

Adhesiolysis is often the lengthiest portion of ventral hernia repair. Adhesions should be expected during the course of incisional hernia repair as intra-abdominal adhesions are common after laparotomy, estimated to occur in almost 70–97% of patients [16–19]. The magnified view of the abdominal wall and the suspension of adherent intestine created with the pneumoperitoneum facilitate safe adhesiolysis during laparoscopic repair. Adjustment of patient positioning and external pressure on the hernia sac can provide additional advantage. Except for thin, areolar adhesions, the majority of adhesions require sharp dissection. This should be performed with limited use of electrosurgery. One must be aware of the proximity of the surrounding intestine which may be hidden from view. Clips, rather than cautery or ultrasonic dissector use, provide hemostasis. The impact of the thermal spread in the closed working space of LVHR may be substantial. While the overall complication rate of LVHR is low, inadvertent enterotomy and, particularly, *missed* bowel injury are a significant cause of morbidity and potentially mortality [20].

A strategic plan for adhesiolysis enables safe dissection. Dissection at the hernia defect and hernia content reduction are achieved via atraumatic grasping of the hernia contents and hand-over-hand reduction (Fig. 2.2). Hernia sac adhesive bands are sharply divided as they are encountered. As adhesions are taken down and the contents are reduced, immediately afterward, the affected intestine and omentum should be inspected closely for hemostasis and bowel injury. Inspection should be performed at the end of the hernia repair as well. Documentation of this inspection and confirmation of lack of bowel injury are recommended.

The falciform ligament in subxiphoid hernias is divided to allow broad mesh overlap. The falciform ligament is vascular and should be clipped or divided with ultrasonic dissection. Peritoneal fat that would hinder intraperitoneal onlay mesh (IPOM) incorporation should be removed. For suprapubic hernias, the peritoneum is incised similar to transabdominal pre-peritoneal inguinal hernia repair. The bladder is mobilized down, and this allows secure mesh fixation at Cooper's ligament. Placement of a three-way Foley catheter allows filling of the bladder for identification and inspection for bladder injury.

Prior intraperitoneal mesh can pose a challenge. Removal of prior mesh allows better incorporation of the index mesh, but this is not always possible. When prior mesh removal is deemed too destructive to the abdominal wall, care should be taken to ensure wide overlap of the index mesh beyond the prior mesh with transfascial sutures through healthy abdominal wall. The intestine may be densely adherent to

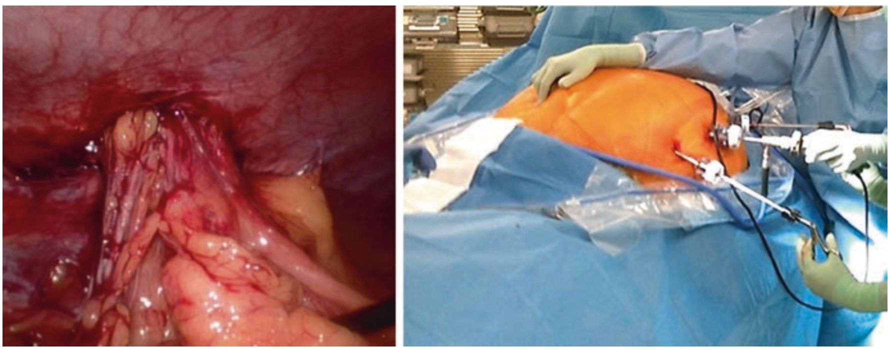


Fig. 2.2 Reduction of hernia contents

prior mesh. If there is no clear plane between the mesh and the intestine, a portion of the mesh should be excised and left adherent on the bowel rather than risking an enterotomy.

Hernia Defect Assessment

Accurate measurement of the fascial defect is an essential step in successful LVHR as this will allow an estimation of the appropriate-sized prosthetic to be placed. Extracorporeally, the defect can be defined by palpation, but this is often inaccurate. Laparoscopy, in contrast, allows a direct visualization of the defect. A measurement is then obtained by intracorporeal placement of a ruler or an umbilical tape with 2 cm markings [21]. Spinal needles, utilized to mark the edges of the defect, can assist in accurate measurement [5]. Alternatively, a suture is inserted and held across the distance between the two spinal needles and then is measured extracorporeally.

A significant advantage of LVHR over open repair is the ability to evaluate for additional defects that could not be palpated. Several studies have demonstrated high rates of these occult defects that are appreciated only at the time of LVHR [22, 23]. In this case, measurement should encompass all visible defects so that adequate mesh coverage can be achieved. In the case of incisional hernias, consideration should also be given to measuring and covering the entirety of the scar to prevent new hernias from forming [24].

Defect Closure

In its early conception, LVHR did not involve closure of the defect but was essentially a bridging repair. There are now several methods of defect closure described in the literature. A chapter in this book is devoted to the pros and cons of traditional IPOM versus that with defect closure, so it is mentioned only briefly here. Probably the most commonly applied method is the “shoelacing technique” described by Orenstein et al. This is an extracorporeal closure utilizing a suture passer to create a series of figure-of-eight stitches [25]. Intracorporeal closure and hybrid techniques for defect closure have been described as well [23, 26, 27]. Potential benefits of defect closure include reconstruction of a functional abdominal wall, closure of dead space that can lead to seroma formation, reduction in recurrence rate, and prevention of mesh eventration and bulging [27, 28].

Mesh Selection and Sizing

Many hernia surgeons are in favor of utilizing mesh for their open repairs in an effort to reduce recurrence rates. There are surgeons, however, who favor a primary repair and avoid the use of prosthetics when possible. There is no room for debate when it comes to laparoscopic hernia repair, as the technique can only be accomplished with the use of mesh. The topic of which mesh could fill the pages of an entire book. Indeed, there are four chapters in this book devoted to the topic of prosthetics and mesh selection, so we will refer the reader to those for details regarding the subject. In brief, the principal selection criteria for a laparoscopic repair are based on whether the mesh will be directly exposed to the bowel. When performing an IPOM repair, the mesh is in direct contact with the bowel, and, thus, a mesh with an adhesion barrier is critical in the pursuit of avoiding complications of small bowel obstructions and fistulae [29]. Most manufacturers of polypropylene or polyester meshes offer a product with an adhesion barrier on the visceral side. Typically, this is a hydrophilic component that resorbs over time. Alternatively, expanded polytetrafluoroethylene (ePTFE) is less adhesiogenic, and thus prosthetics composed of this do not have an additional adhesion barrier [30]. In contrast, the parietal side of the mesh should facilitate tissue ingrowth to provide secure fixation. In an effort to achieve this ideal mesh, there are products composed of two different components available as well. If a transabdominal pre-peritoneal approach is utilized, a non-coated mesh is preferred. The peritoneum protects the viscera from the mesh, so no other barrier is needed, and some would argue anything else would interfere with ingrowth and potentially increase risk for seroma formation.

Whatever mesh is chosen, the size must provide adequate overlap of the defect. Obviously, this could be approached by choosing very large mesh for all defects. This, however, would be expensive, and the increased surface area requires more fixation and thus potential for complications such as chronic pain. The larger prosthetic would also be problematic if complications were to arise such as infection requiring explanation. The goal then is to utilize a mesh that provides enough overlap to account for potential shifting of the mesh as well as shrinkage. The increased surface area with overlap allows for more ingrowth and, thus, biologic fixation. Additional support occurs from the effect of intra-abdominal pressure on the increased surface area of a larger mesh [28].

There is little high-level evidence to dictate what the minimal amount of overlap should be for a LVHR. Studies are limited by variations in technique and small sample sizes [28]. One of the largest series of LVHR utilized a 3 cm overlap early in the series and then shifted to a 4 cm overlap [31]. Many surgeons now prefer a 5 cm overlap of the defect, and recurrence rates have been acceptable with this technique [5]. Thus, after measuring the defect size, 6–10 cm is added to the transverse and vertical dimensions to determine the minimum mesh size that should be utilized in the repair. There is general consensus that the larger the defect size, the larger the overlap should be [28].

As it becomes more common practice to close the hernia defect, there is some debate as to whether a smaller-sized mesh will suffice. Most commonly, a mesh size is selected based on the initial defect size as measured prior to closure. In doing so, if the fascial closure breaks down, one can be assured effective overlap remains.

Prior to inserting the mesh, the surgeon may wish to place marks in order to orient the mesh with more ease. Some manufactures have marking for this purpose. Most importantly, if adhesion barrier mesh is utilized, one must be able to identify which is the coated visceral side and which is the peritoneal side. If transfascial sutures are to be used, part or all of these can be secured to the mesh prior to insertion as well.

Introducing the mesh to the abdomen can be accomplished by placing the rolled mesh directly through a trocar. This has the benefit of avoiding any skin contact with the prosthetic. This does, however, require a larger trocar as it would be a struggle to insert coated mesh through a 5 mm port. If the surgeon wishes to use only 5 mm trocars or needs to insert a very large mesh, this is accomplished by passing a grasper out directly through a trocar from the contralateral side. The trocar is then removed and the mesh pulled into the abdomen through the port site, prior to replacing the trocar.

Mesh Fixation

Positioning the mesh, especially larger sizes of mesh, is aided by the use of either a commercially available positioning device or simply by use of sutures placed prior to insertion. A suture passer is utilized to externalize the sutures and, thus, suspend the mesh. These can be subsequently removed, once methods of fixation are in place, or utilized as transfascial fixation points.

After the mesh is positioned, with appropriate overlap confirmed, the options for securing the mesh to the abdominal wall are tacks, transfascial sutures, glue, or some combination of these. The traditional technique involves placement of at least four transfascial sutures at equidistant points. Additional transfascial sutures may be placed, as deemed necessary, to secure larger prosthetics. The perimeter is then tacked to the posterior fascia at approximately 1 cm intervals [31]. The edge of the mesh should be secured close to the perimeter to avoid exposing bowel to the non-coated side of the mesh, if applicable. With any method of fixation, care should be taken to avoid injury to the epigastric vessels.

While suture is categorized as only absorbable or nonabsorbable, tacking options vary in design and material. Typically, tacks are helical or pronged, and available products vary in depth of penetration as well. There is evidence that, at least in short term follow-up, acute and chronic postoperative pain is not significantly different between the absorbable and nonabsorbable categories of tacks [32]. The tacking device can be utilized to secure the mesh around the perimeter between transfascial sutures, or can be utilized without transfascial sutures, often in a "double-crown" fashion. A randomized study evaluating acute postoperative pain found similar postoperative pain and quality-of-life findings between the double-crown technique with no sutures and transfascial sutures (either absorbable or nonabsorbable) with tacks. The same study noted decreased operative time in the group without transfascial sutures [33].

This is yet another controversial topic, and there is a paucity of high-level evidence regarding the best method to prevent recurrence and optimize the patient experience. Studies have demonstrated that suture fixation achieves the highest tensile strength in comparison to alternative devises and decreases mesh shrinkage [34, 35]. Still, this has failed to consistently demonstrate a reduction in recurrence rates.

A meta-analysis comparing only suture fixation, only tack fixation, and a combination of sutures and tacks failed to detect a significant difference regarding the recurrence rates at follow-up periods of at least 2 years [28].

Postoperative Care and Outcomes

Laparoscopic ventral hernia repair is associated with shorter hospitalization, decreased wound complications, and reduced surgical site infection rate compared to open repair [36–38].

In a systematic review and meta-analysis, the laparoscopic approach consistently reduced the risk of wound infection. (RR = 0.26; 95% CI 0.15–0.46; I(2)= 0%) [39]. While the minimally invasive approach may be associated with a longer operative time and higher operative cost, this lower risk of surgical site infection can reduce substantially the overall cost and burden on the patient associated with readmission and wound care.

Bowel Injury

The serious morbidity and mortality rate associated with LVHR is low. However, inadvertent enterotomy significantly increases the mortality risk. A literature review assessed that bowel injury occurs in almost 2% of patients, and large bowel injury comprises 8.3% of these cases. These injuries are identified and repaired approximately 80% of the time during the hernia repair. Enterotomy increased the mortality risk from 0.05 to 2.8% [20]. Despite the technical advances of magnified visualization, the rate of bowel injury remains higher for LVHR compared to open repair in at least two systematic reviews [38, 39].

Meticulous adhesiolysis to avoid thermal bowel injury as well as traction injury and close inspection for injury during laparoscopic repair are warranted. Identified injuries must be repaired immediately either laparoscopically or via laparotomy depending on the comfort of the surgeon. Gross contamination precludes permanent mesh placement. Postoperatively, patients may have significant incisional pain but should be hemodynamically stable. Fever, tachycardia, fluid sequestration, and erythema are all worrisome signs of a missed enterotomy.

Seroma

Seroma is common after laparoscopic ventral hernia but few require intervention [4, 31]. This can occur with transfascial sutures and with the double-crown technique of mesh fixation. The seroma is often within the old hernia sac but may occur as a retroprosthetic seroma in almost half of patients in the early recovery period [40]. Primary fascial closure reduces the seroma rate [41].

Pain Management

Enhanced recovery pathways with multimodal pain management reduce the narcotic usage and subsequent adverse effects such as ileus. Preoperative anti-inflammatory medication and acetaminophen as well as local anesthetic injection during the procedure may reduce postoperative pain. Pain has been associated with both transfascial sutures and tack fixation, without a demonstrable difference between absorbable and permanent tacks [42].

Hernia Recurrence

In a single series, the hernia recurrence rate after laparoscopic ventral hernia repair varies from 3 to 20%, though follow-up is limited. In a recent Cochrane review, the recurrence rate was comparable between laparoscopic and open repair, but the follow-up was shorter than 2 years in half of the included trials [39]. Mesh overlap of the defect is critical in reducing the rate of hernia recurrence. The risk of hernia recurrence is inversely correlated with increasing mesh overlap in laparoscopic repair. In laparoscopic procedures, the pooled estimation of risk for recurrence of hernia decreased with increasing area of mesh overlap (<3 cm, incidence rate 0.086; 3–5 cm, incidence rate 0.046; >5 cm, incidence rate 0.014) [43].

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