

Laparoscopic Repair of Ventral Hernias

Nine Years' Experience With 850 Consecutive Hernias

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Objective: To evaluate the efficacy and safety of laparoscopic repair of ventral hernias.

Summary Background Data: The recurrence rate after standard repair of ventral hernias may be as high as 12–52%, and the wide surgical dissection required often results in wound complications. Use of a laparoscopic approach may decrease rates of complications and recurrence after ventral hernia repair.

Methods: Data on all patients who underwent laparoscopic ventral hernia repair (LVHR) performed by 4 surgeons using a standardized procedure between November 1993 and October 2002 were collected prospectively (85% of patients) or retrospectively.

Results: LVHR was completed in 819 of the 850 patients (422 men; 428 women) in whom it was attempted. Thirty-four percent of completed LVHRs were for recurrent hernias. The patient mean body mass index was 32; the mean defect size was 118 cm². Mesh, averaging 344 cm², was used in all cases. Mean operating time was 120 min, mean estimated blood loss was 49 mL, and hospital stay averaged 2.3 days. There were 128 complications in 112 patients (13.2%). One patient died of a myocardial infarction. The most common complications were ileus (3%) and prolonged seroma (2.6%). During a mean follow-up time of 20.2 months (range, 1–94 months), the hernia recurrence rate was 4.7%. Recurrence was associated with large defects, obesity, previous open repairs, and perioperative complications.

Conclusion: In this large series, LVHR had a low rate of conversion to open surgery, a short hospital stay, a moderate complication rate, and a low risk of recurrence.

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One result of the 2 million laparotomies performed in the United States each year is an incisional hernia rate of 3% to 20%,¹ necessitating repair of approximately 90,000 ventral hernias annually. Factors associated with formation of an incisional hernia include wound infection, immunosuppression, morbid obesity, previous operations, prostatism, and surgery for aneurysmal disease. Abdominal wall defects are typically observed within the first 5 years after the surgical incision is made, but they may develop long afterward.² These hernias contribute importantly to the long-term morbidity of conventional surgery. Until techniques for the prevention of hernias are established, repair of these defects will remain an important problem for all abdominal surgeons.

Many hernia repair methods have been described. Traditional primary repair entails a laparotomy with suture approximation of strong fascial tissue on each side of the defect. However, recurrence rates after this procedure range from 41% to 52% during long-term follow-up.^{2–4} Herniorrhaphies in which large prosthetic meshes are implanted appear to have lower failure rates (12–24%), but the required dissection of wide areas of soft tissue contributes to an increased incidence of wound infections and wound-related complications (12% or higher).^{3,5,6} These problems have stimulated a continuing search for new techniques for repairing ventral hernias.

The interest in less morbid herniorrhaphies and the appeal of minimally invasive surgery encouraged development of laparoscopic methods for repairing incisional hernias. These techniques are based on the same physical and surgical principles as the open underlay procedure described by Stoppa,³ Rives et al,⁷ and Wantz.⁸ Since the first report of laparoscopic ventral hernia repair (LVHR) in 1992,⁹ the operation has grown in popularity with the belief that it may offer shorter hospital stays, improved patient outcomes, and fewer complications than traditional open procedures. Several comparative studies are now available that support this assertion.^{10–14} Limiting factors in most of these and the noncomparative series that describe LVHR include limited sample size, varying techniques, and restricted follow-up.^{15–18}

We here describe a study of outcomes achieved with LVHR performed by 4 attending surgeons using the same

surgical technique and standardized perioperative regimens and follow-up protocols. The reported series includes every patient in whom the operation was performed or attempted. Data on most patients were collected prospectively, and the follow-up time extends to more than 8 years. The goal of the study was to assess the safety and efficacy of LVHR.

METHODS

Patients

Between November 1993 and February 2003, 850 consecutively seen patients were scheduled to undergo LVHR with mesh implantation by 4 surgeons in 4 different academic medical centers. Patients with ventral hernias were considered candidates for LVHR if they were morbidly obese, or if the hernia defect was at least 4 cm in any dimension or recurrent. For each patient, the following demographic, perioperative, and postoperative data were collected either prospectively (85% of patients) or retrospectively: age, sex, body mass index (BMI), number of previous abdominal operations and hernia repairs, American Society of Anesthesiologists (ASA) classification, size of fascial defect, size and type of prosthetic mesh implanted, operating time, estimated blood loss during surgery, length of hospital stay, operative and postoperative complications, and hernia recurrences.

Operative Procedure

LVHR was performed by using an angled (30- or 45-degree), 5-mm or 10-mm laparoscope, 5-mm bowel graspers, scissors, and clip applicators. An antibiotic, usually a first-generation cephalosporin, was given prophylactically before the incision was made and often again if the operation continued for more than 2 hours. General anesthesia was induced, and the patient was positioned; most remained supine with their arms at their sides. Patients with hernias in the flank or lumbar area were placed in the lateral decubitus or semilateral position. In most cases, the bladder and stomach were decompressed with catheters.

Pneumoperitoneum was established by using a Veress needle in approximately 200 cases and an open abdominal access technique in the others. Most often, a window of access is present, even in the multiply operated abdomen, between the patient's costal margin and iliac crest on one side or the other. The initial entry site was usually just inferior to the tip of the eleventh rib. In many cases in which the open access method was used, a balloon-tipped trocar was inserted to avoid air leakage. After exploration of the abdomen, additional trocars were typically placed laterally in the abdomen, as needed, under direct visualization. Port placement for non-midline defects depended on the location of the hernia. Adhesions to the anterior abdominal wall surrounding the hernia were lysed, and the hernia contents were reduced. The peritoneal sac was left in situ.

After completion of the dissection, the hernia defect was measured and an appropriately sized prosthetic mesh was tailored to overlap all margins of the defect by at least 3 cm early in the series. As the surgeons' experience increased, an overlap of at least 4 cm was considered desirable. Expanded polytetrafluoroethylene (ePTFE) mesh (Gore-Tex DualMesh Biomaterial; W.L. Gore & cjs0038; Associates, Flagstaff, AZ) was used in 97% of cases. At least 4 nonabsorbable monofilament or ePTFE sutures were placed equidistantly along the mesh. Points of reference on the mesh and corresponding points on the abdominal wall were marked to aid in orienting the mesh after its introduction into the abdomen. The mesh was rolled up and pushed or pulled into the abdomen through a 5- or 10-mm trocar site.

After the mesh was positioned intracorporeally, the sutures placed in the material before its insertion into the abdomen were pulled through the abdominal wall with a suture passer and tied with the knots buried in subcutaneous tissues. Additional full-thickness stitches were placed circumferentially every 3 to 6 cm by using the suture passer. The perimeter of the mesh was then stapled (with 5-mm spiral tacks) to the posterior fascia at locations no more than 1 to 1.5 cm apart. Early in the series, tacks alone were used to secure the mesh in several cases, but this practice was subsequently discontinued. No drains were inserted. Fascial closure using sutures was performed at all 10-mm trocar sites.

Data Analysis

Follow-up surveillance was performed by attending surgeons at 1 to 2 weeks, 3 months, and 6 months postoperatively, and yearly thereafter. We grouped patients into various categories as part of the statistical analysis, including age (<40, 40–59, and 60+ years), body mass index (<30, 30–39, and 40+), defect size (<150 cm², 150 cm²+), and history of previous ventral hernia repair.

χ^2 analysis was used to compare the relationships among categorical variables. In those cases where we were comparing means of continuous variables for 2 groups and where there were significant differences between the variances for the 2 groups, we used the *t* test to determine if means were significantly different. When comparing the means of 3 or more groups, we used the analysis of variance to determine if there were significant differences among the means. If we detected an overall significant difference, we use the Student-Newman-Keuls posthoc test to determine significance between pairs of means. In cases where non-normal distributions existed when comparing 2 or more groups, we used the Kruskal-Wallis nonparametric analysis of variance approach. *P* < 0.05 was considered to represent statistical significance for all comparisons.

RESULTS

Patient Characteristics

The demographic and perioperative data are shown in Table 1. Most patients were obese, and many had coexistent medical problems, as indicated by the high mean ASA value. In general, the hernia defects were large, and they were repaired with a large piece of mesh. The mesh-to-defect ratio was 2.9. Although the mean hospital stay was about 2 days, some patients were discharged the day of surgery.

Conversion to open surgery was necessary in 31 (3.6%) of the 850 patients, for the following reasons: severity of adhesions (15 patients), inability to reduce incarcerated intestine (7), enterotomy (3), lateral extent of the defect (2), loss of abdominal domain (1), need to resect strangulated intestine (1), bladder involvement in the hernia (1), and discovery of a fistula into previously implanted mesh (1). Older patients had significantly more conversions than younger patients ($P = 0.02$).

About one third of LVHRs were performed for recurrent defects after one or more open hernia repairs (Table 1). In many of the patients with recurrence, polypropylene mesh had been placed intraabdominally during the open procedure. Compared with patients undergoing a first hernia repair, the conversion rates were equal. However, those with recurrent hernias had larger defects, required a 35% longer operating time, and had a higher complication rate. The incidence of hernia recurrence following LVHR was more than 3 times higher (Table 2) in the previously repaired group.

Morbidly obese patients (BMI > 40) in the series were younger than other patients (mean age, 46.6 versus 56.7 years; $P < 0.01$) and were more often female ($P < 0.01$). They had longer operating times (mean, 156 versus 114 min; $P < 0.01$), larger defects (mean size, 167 versus 105 cm²;

TABLE 1. Patient Characteristics

Characteristic	Value
Male/Female	422/428
Age (y)	54 (13–94)
Body mass index	32.1 (22–67)
ASA classification	2.3 (1–4)
Previous open hernia repairs	
Proportion of all cases	34%
No. of previous open repairs	1.9 (1–11)
Defect size (cm ²)	118 (1–1600)
Mesh size (cm ²)	344 (24–2500)
Operating time (min)	120 (11–420)
Estimated blood loss (mL)	49 (10–200)
Postoperative hospital stay (d)	2.3 (0–33)

Values are mean (range) unless otherwise indicated. ASA, American Society of Anesthesiologists.

TABLE 2. Relation Between Previous Open Hernia Repair and Operative Experience and Outcome

Variable	Patients with Previous Repair	Patients without Previous Repair
Operating time (min)	134*	111
Conversions to open surgery	10 (3.4%)	21 (3.8%)
Complication rate	53 (17.8%)*	59 (10.4%)
Hernia recurrence rate	7.1%*	2.3%

*Significantly different from results in patients without previous repair ($P \leq 0.05$).

$P < 0.01$), and were nearly 4 times more likely to have a recurrence after LVHR (7.8% versus 2.0% recurrence rate; $P = 0.05$). These patients tended to have more complications (18.6% versus 11.5%; $P = 0.09$), but these trends did not reach statistical significance.

Complications

A total of 822 patients underwent a completed LVHR or conversion to open repair because of a complication, and 112 of those patients (13.2%) had a total of 128 perioperative or postoperative complications (Table 3). Considering both wound and mesh infections, the overall infection rate was 1.8%. The 9 cases of trocar site infection or cellulitis were treated successfully with oral or intravenous antibiotic therapy. Five of the six patients with mesh infection underwent mesh removal. Three of these patients previously had mesh infections after open repair and no apparent source of contamination during LVHR. The fourth patient had a break-

TABLE 3. Operative and Postoperative Complications

Complication	No. (%) of Patients
Prolonged ileus	25 (3.0)
Prolonged seroma (>8 wk)	21 (2.6)
Intestinal/bladder injury	14 (1.7)
Prolonged pain (>6 mo)	13 (1.6)
Urinary retention or urinary tract infection	10 (1.2)
Cellulitis at trocar site	9 (1.1)
Respiratory distress	8 (1.0)
Trocar site herniation	7 (0.9)
Mesh infection	6 (0.7)
Cardiac event	6 (0.7)
Hematoma or postoperative bleeding	3 (0.4)
Fever of unknown origin	3 (0.4)
<i>Clostridium difficile</i> infection	3 (0.4)

down of thin skin over the mesh, which resulted in prosthetic infection and necessitated mesh removal. In the fifth patient, mesh infection developed several weeks postoperatively. The sixth patient presented several weeks after an uneventful LVHR with 2 abscesses, 1 above and 1 below the mesh. The fluid collections resolved after percutaneous, CT-guided drainage and systemic antimicrobial therapy. Two years later, the patient has no clinical or radiologic signs of infection and no hernia recurrence.

Fourteen intestinal or bladder injuries occurred. Ten enterotomies or deep submucosal injuries, 2 colotomies, and a cystotomy were identified at surgery. In another patient, a small intestinal injury was diagnosed the day after surgery after a physical examination yielded suspicious results. One of the patients with a colotomy underwent conversion to open surgery. Three patients with a small intestinal injury and 1 with a colon laceration underwent laparoscopic repair of the enterotomy, completion of laparoscopic adhesiolysis, and delayed or staged herniorrhaphy. These patients were admitted to the hospital and given intravenous antibiotics, without undergoing laparotomy or hernia repair. Three to fourteen days later, they underwent completion of LVHR. One of the staged hernias recurred, but no infection was found. Five of the patients with a small bowel injury and no intestinal spillage underwent repair of the injury and completion of LVHR. In 1 patient, a small bowel enterotomy was exteriorized through a small laparotomy incision, enterorrhaphy, and reinserted into the abdomen; no contamination occurred, and LVHR was completed. One patient had a small laceration of the bladder; this was repaired and LVHR completed. No patient in whom the bowel or bladder was injured and repaired and mesh was placed at LVHR developed an infection. The patient in whom the enterotomy was missed at surgery underwent laparotomy and resection of a short segment of small intestine and the mesh; she required an 18-day hospital stay.

One patient presented 9 months after LVHR of a recurrent defect with an apparent urinary bladder fistula. At reoperation, no mesh, tacks, or sutures were found in the bladder or considered to represent a source for the fistula. The patient had a generalized reaction to all foreign materials in her abdomen.

In most patients, a seroma over the mesh at the site of the retained hernia sac developed, although many were not noticed by the patient and most resolved without intervention. However, in 21 patients (2.6%), seromas persisted for more than 8 weeks or created symptoms sufficiently severe to warrant intervention. One surgeon performed sterile aspiration of many palpable seromas during office visits early in the postoperative period. No long-term complications due to seromas were observed, regardless of whether they were aspirated early or allowed to persist for 8 weeks or longer. In 3 patients, a long-term fluid collection did develop under the

mesh, in association with an extensive peel or rind that separated the mesh and underlying fluid from the abdominal contents. These patients had discomfort and mild abdominal distention. One patient required removal of the mesh and rind through a laparotomy after several attempts to aspirate the fluid had failed. Another patient underwent laparoscopic excision of what was described as hypertrophic mesothelium below the mesh. The seroma resolved, but the origin of the problem remains unknown.

Thirteen (1.6%) of the 819 patients who underwent LVHR had pain for 6 months or longer, frequently at the site of a transabdominal suture. In most patients, discomfort occurred only with movement, but a few had persistent pain. Patients with prolonged pain were treated with nonsteroidal antiinflammatory agents or oral narcotics. Two surgeons began to treat patients who had suture-site pain early after surgery with subfascial injections of a combination of lidocaine and bupivacaine, with good results.¹⁹

Prolonged ileus developed postoperatively in 25 patients (3.0%), all of whom required hospitalization until oral intake could be tolerated. Eight patients (1%) had postoperative respiratory distress because of exacerbation of acute asthma or chronic obstructive pulmonary disease or the presence of congestive heart failure. These patients required observation in an intensive care or step-down unit for at least 24 hours; their symptoms resolved with medical management. Six patients had a cardiac event (arrhythmia, angina, or myocardial infarction [MI]); the 1 patient with MI died the day after surgery. Urinary retention and urinary tract infections were uncommon. High fever of unknown origin developed early in the postoperative period in 3 patients, 2 of whom underwent exploratory laparoscopy that found no intraabdominal source for the fever. The patients recovered quickly, without additional problems. Three patients had postoperative bleeding or hematoma. One required a transfusion of packed red blood cells, but none required reoperation.

Comparing patients who had complications with those who did not revealed significant associations between complications and larger hernias, previous herniorrhaphy, longer operating times, and longer hospital stays (Table 4). In addition, patients who had a complication were more than 3 times more likely to have a hernia recurrence. There was a trend toward a higher chance of complications in patients who were morbidly obese, but this did not reach statistical significance ($P = 0.09$).

Hernia Recurrences

During a mean follow-up time of 20 months (range, 1 to 96 months), recurrent ventral hernias developed in 35 patients (4.7%) of those who were available for assessment. Despite vigorous attempts to encourage return visits and examination, 75 patients were lost to follow-up. In addition, 31 patients were converted to open surgery. To assure a more

TABLE 4. Relation Between Complications, Patient Characteristics, Perioperative Experience, and Recurrence

Variable	Patients with Complications	Patients without Complications
Mean defect size (cm ²)	202	105
Mean operating time (min)	142	116
Mean length of hospital stay (d)	4.7	1.8
Previous hernia repair (% of patients)	47	32
Hernia recurrence rate (%)	10.6	3.2

All differences between the two patient groups were significant ($P \leq 0.05$).

conservative estimation of hernia rates, these 2 groups of patients were not included in the overall patient total (744 patients) when recurrence rate was calculated.

Five of these recurrences were in patients who had a postoperative infection and underwent mesh removal. The patient in whom the bowel injury was diagnosed after surgery subsequently underwent mesh resection and had an immediate hernia recurrence. Six recurrences were early in the series in patients in whom the prosthetic mesh was secured only with tacks or staples (no sutures), or sutures were not used on 1 side of the mesh near a sensitive area, such as along the costal margin. One patient had a recurrence after a motor vehicle accident that occurred less than 4 weeks after surgery and resulted in tearing of 1 side of the mesh from the abdominal wall. In 2 patients, the hernia recurred outside the original mesh placement area. In the remainder of the patients with recurrence, the mesh appeared to have torn away from the abdominal wall because the sutures had broken or for unknown reasons.

Comparing patients who had a hernia recurrence with those who did not found significant associations between recurrence and larger hernias, longer operating times, previous hernia repairs, and higher complication rates (Table 5). Patients who were morbidly obese (BMI > 40; $P = 0.05$) were also more likely to have their hernia recur as compared with those of more normal weight.

DISCUSSION

In this large series (850 patients), LVHR using prosthetic mesh was associated with a low rate of conversion to open surgery (3.4%), a short hospital stay (2.3 days), a moderate complication rate (13.2%), and a low hernia recurrence rate of 4.7% during a mean follow-up time of 20 months. The series represents up to 9 years of experience with LVHR, which has varied little since 1993. All patients in the authors' practices who underwent LVHR between No-

TABLE 5. Relation Between Recurrence, Patient Characteristics, and Operative and Perioperative Experience

Variable	Patients with Hernia Recurrence	Patients without Hernia Recurrence
Mean defect size (cm ²)	184	124
Mean operating time (min)	149	118
Previous hernia repair (% of patients)	63	35
Complication rate (%)	32	12

*All differences between the two patient groups were significant ($P \leq 0.05$).

vember 1993 and February 2003 were included in the series. For more than 700 of these patients, data were collected prospectively. A systematic follow-up protocol was used by all researchers. The large number of patients, the long follow-up period, the standardized data collection methods employed, and the consistent use of a specific operative technique represent the principal strengths of this study.

The current study does suffer from the lack of randomization of its patients and a comparison to an open surgery group. Consequently, it might be assumed that selection bias implemented by the authors could improve the overall outcomes of the patients described herein and be responsible for a moderate complication figure, short hospital stay, and low recurrence rate. However, these limitations are somewhat mitigated by the large, consecutive sample size and the characteristics of the patient population. The large patient BMI, the size of the hernias, and the number of recurrent defects make it less likely that this problem played a significant role in the reported outcomes. Another form of selection bias may have played a role in this study. This would be from the referring physician. Many of the patients on whom the authors operated were sent by other surgeons, who possibly chose those to be referred on the basis of the above-mentioned complicating surgical factors. In fact, if this is true, it might suggest the minimally invasive results may be of greater consequence because there is a selection bias toward more difficult or complicated cases being managed laparoscopically.

Whether LVHR is safer and more effective than open repair is not yet known. Several series of LVHRs have been reported by North American and European researchers (Table 6). The results show a marked consistency with respect to low perioperative morbidity and low rates of hernia recurrence during follow-up.^{10-12,14} Other advantages of LVHR over open repair were cited but remain speculative. A few studies comparing LVHR and open repair directly have been published, although these have generally included small numbers

TABLE 6. Studies Comparing LVHR and OVHR

Variable	Study Author and Year				
	Holzman et al 1997 ¹⁴	Park et al 1998 ¹⁰	Ramshaw et al 1999 ¹¹	DeMaria et al 2000 ¹³	Carbajo et al 1999 ¹²
No. of patients					
LVHR	21	56	79	21	30
OVHR	16	49	174	18	30
Mean hospital stay (d)					
LVHR	2	3	2	1	2
OVHR	5	7	3	4	9
Complication rate (%)					
LVHR	23	18	19	19	7
OVHR	31	37	31	50	57
Hernia recurrence rate (%)					
LVHR	10	11	3	5	0
OVHR	13	35	20	0	5

LVHR, laparoscopic ventral hernia repair; OVHR, open ventral hernia repair.

of patients and most have been nonrandomized and based on data only partly prospectively accrued (Table 6). Nevertheless, these investigations have also consistently indicated that LVHR has advantages over the open procedure in regard to perioperative complications, hospital stay, and hernia recurrences.

In addition, the only published prospective randomized study comparing LVHR and open repair provided evidence for the existence of many of the advantages mentioned in the reports on noncomparative investigations. In that study, Carbajo et al¹² randomly assigned 60 patients to undergo either LVHR or open surgery. The 2 groups did not differ significantly in age, sex distribution, incisional hernia type, or size of defect. Both operating times and hospital stays were significantly shorter in the LVHR group, although it is important to note that, in contrast to most practitioners of LVHR, Carbajo et al did not use transabdominal wall sutures to secure the mesh and this omission probably contributed to shorter operating times. Carbajo et al¹² also found that the patients in the LVHR group had fewer complications and a significantly lower hernia recurrence rate during a mean follow-up period of 27 months. Although these results are encouraging, larger, long-term, multicenter studies comparing LVHR and open repair are needed.

The open repair technique on which LVHR is based (Rives-Stoppa operation)^{3,7,8} involves placement of a large prosthetic mesh in a retro-muscular, extraperitoneal location. The mesh overlaps the margins of the hernia by several centimeters and is secured by multiple, interrupted, transabdominal sutures placed along the edge of the biomaterial.

Placement of a large mesh in this preperitoneal location allows an even distribution of forces along the surface area of the mesh, which may account for the strength of the repair and the decreased recurrence rates associated with it. However, because of the extensive dissection required for the development of flaps in this open repair, the operation is associated with a marked risk of morbidity. Wound complication or infection rates of 12% to 20% have been reported,^{3,7} and these problems often require reoperation.^{3,7} We believe that the elimination of the need for broad soft tissue dissection and drain placement in LVHR is the reason that the infection-related complication rate in our series was low (2%). The minimally invasive approach does incorporate the idea that a retro-muscular placed mesh may be more stable, but it applies the mesh one layer deeper than its open counterpart (intraperitoneally). Certain other fundamental components of the open technique remain intact when performed laparoscopically; these include a wide overlap of the defect and the use of interrupted, transabdominal sutures as the primary mechanism to secure the mesh in position.

The specific LVHR technique used in our series is probably the most popular laparoscopic approach to repair of ventral hernias currently employed, although some surgeons have attempted to reduce operating time and possibly postoperative discomfort by discontinuing the use of transabdominal sutures entirely, or substantially reducing their numbers and relying primarily on a laparoscopic tacker. However, since most of the meshes used for LVHR are approximately 1 mm thick and the spiral tacks employed are 4-mm-long and take up a 1-mm profile on the surface of the patch, a perfectly

placed tack can be expected to penetrate only 2 mm beyond the mesh; thus, tacks will probably not provide the same holding strength provided by full-thickness abdominal wall sutures. In fact, van't Riet et al²⁰ demonstrated in a porcine model that the tensile strength of sutures in intraabdominal mesh is up to 2.5 times greater than that of tacks. In addition, higher hernia recurrence rates have been observed clinically in some cases in which only tacks were used,^{21,22} though not in others.²³ We believe that suture fixation of the mesh in LVHR is mandatory.

Although complications occurred less frequently in our series than in series of open herniorrhaphies, they remain an important consideration in LVHR. One of the most common complications we observed was symptomatic or prolonged seroma. Most seromas developed above the mesh and within the retained hernia sac, and many of our patients had them. The majority resolved spontaneously without intervention, but 3% of our patients continued to have a clinically apparent seroma for more than 8 weeks postoperatively. Regardless of whether the seromas were aspirated under sterile conditions or allowed to resolve, most did not cause any long-term problems. We recommend that surgeons discuss the possibility of a seroma with their patients preoperatively and, if one becomes clinically evident after surgery, that it be watched unless it causes discomfort or becomes persistent.

Enterotomies, which are known complications of surgery in patients who have previously undergone abdominal surgery, occurred infrequently in our series (less than 2%), even though many of our patients had a history of laparotomy and, for many, a previous open hernia repair. The principal strategies we used to avoid bowel injury were to take advantage of pneumoperitoneum as a retraction instrument and to employ sharp dissection with limited use of electrothermal (cautery) and ultrasonic energy. Injuries that do occur can be treated in several ways, and there is controversy regarding the optimal method. We managed injuries by (1) conversion to laparotomy without mesh placement; (2) repair, completion of adhesiolysis, and LVHR 3 to 14 days later; or (3) in 6 selected patients, repair of the enterotomy with very little contamination and completion of LVHR. No patient in whom the bowel was injured and repaired and mesh was placed at LVHR developed an infection. However, despite this favorable outcome in a selected group, we do not advocate inserting a foreign body if contamination is present; instead, decisions regarding management of an enterotomy should be made on a case-by-case basis. We always advise patients preoperatively that enterotomy is possible and discuss the decisions that must be made if one occurs, along with their possible outcomes. Enterotomies not observed at operation appear to be associated with the most serious morbidity and have led to deaths in other series of LVHRs.^{24–26} The 1 patient in our series in whom enterotomy was diagnosed postoperatively underwent reoperation on the first postoper-

ative day. After bowel resection and mesh removal, the patient recovered uneventfully, although the hernia recurred immediately.

The recurrence rate in our series is low. Interestingly, but not surprisingly, we found that morbid obesity, previous failed open repair, large defect size, and postoperative complications are associated with an increased risk of recurrences. A smaller study by Rosen et al²⁸ also reported that a prior repair failure was predictive of recurrence. These findings, with the fact that 2 of these groups (large defects and recurrent hernias) are associated with higher complication rates, raise the question of whether these patients should be considered for a laparoscopic repair or open repair. Several investigators, however, have found similar results with the OVHR. Sugerma and colleagues²⁷ found severe obesity to be the greatest risk factor for the hernia recurrence after open repair. Hesselink² et al also demonstrated that as patients underwent their second, third, and fourth open hernia repairs their recurrence rates were higher. Given the increased morbidity in the open approach, as well, in these categories, we continue to perform LVHR as our preferred procedure. However, those surgeons with little experience with laparoscopy might consider avoiding these groups in their early experience with LVHR.

One of the original concerns of laparoscopic ventral hernia repair was the requirement that the mesh be placed intraabdominally, directly adjacent to the intestine. An ongoing debate continues to center on appropriate mesh choices. Prosthetic biomaterials elicit inflammatory responses that are dependent on the unique properties (porosity, electrical charge, surface chemistry, texture) of each individual mesh.²⁹ The various forms of polypropylene and polyester mesh have been documented to induce severe bowel adhesions with the subsequent devastating complications of intestinal obstruction or erosion and fistulization.^{3,6,10,30–36} We have seen this in laboratory experiments³⁷ as well. Most surgeons or researchers believe that these meshes should be separated from the intestine if at all possible,^{3,9,18,21,34,38} although this opinion is contested by some.^{14,39}

Laparoscopic ventral hernia repair and novel biomaterials have evolved together over the past decade, with each entity lending some facet to the other to propel its development. The most commonly used mesh in laparoscopic ventral hernia repair has been an expanded polytetrafluoroethylene material with a smooth, microporous (3- μ m pores) surface on one side and a corrugated (rough) surface on the other (Goretex Dual Mesh). The smooth side faces the intestine and serves as an adhesion barrier, while the rough side is applied against the abdominal wall and promotes mesh fixation via cellular and collagen ingrowth. Other meshes have been developed along the same lines: tissue ingrowth material on one side and nonadhesive on the other. Two popular meshes have combined a PTFE coating on a polypropylene base

(Composix, Bard, Inc.) and Seprafilm on polypropylene (Sepramesh, Genzyme, Inc.). A study sponsored by a Society of American Gastrointestinal Endoscopic Surgeons' grant compared these products in a randomized, blinded trial in rabbits. The products combined with polypropylene had significantly more intestinal adhesions and no greater abdominal wall ingrowth than the pure e-PTFE product.⁴⁰ These findings along with the lack of reported bowel obstruction or fistula formation have dictated our prosthetic choices.

CONCLUSION

Our experience with 850 LVHRs accumulated over 9 years has demonstrated it to be an effective and safe approach to the abdominal wall hernia. It can be performed in complex surgical patients with a low rate of conversion to open surgery, a short hospital stay, a moderate complication rate, and a low risk of recurrence. Although these results are encouraging, larger, long-term, multicenter studies comparing LVHR and open repair are needed.

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Discussions

DR. JOHN G. HUNTER (Portland, Oregon): In an era of sexy new surgical technologies, stent grafts, LVAD's, lymphoscintigraphy, and equally sexy new techniques, such as minimally invasive esophagectomy, who in their right mind would want to put together a series addressing the lowly, dull, and distinctly unsexy topic of ventral hernia? The answer is: The young turks of laparoscopy, Parks, Henniford, Ramshaw, and Voeller. And I'm glad they did. As pointed out by Dr Parks, 90,000 ventral hernias are repaired annually by general surgeons. I think that makes the operation the 4th or 5th most common general surgery procedure performed, unless gastric bypass and banding have passed by within the last week. Ventral hernia repair performed open is painful, slow to recover from, and fraught with complications including high rates of infection and recurrence. Enter laparoscopic hernia repair and a number of small studies demonstrating its significant benefits over open ventral hernia repair. This large, 4 center shared experience cements lap ventral hernia repair as the procedure of choice for the reasons that should be clear to all from the presentation and very clearly articulated in a well written manuscript.

I have 3 general questions and several questions of the operative technique:

1. Is there anyone in whom you would not offer a laparoscopic ventral hernia repair? Is there a size that is too large? Adhesions too dense? Site unaccessible to the laparoscope?

2. While it is fundamental to first demonstrate safety and effectiveness, is it not time -now- to assess how ventral hernia repair impacts functional status and quality of life. Was this done at any of your sites?

3. I was trained to repair ventral hernias with prolene mesh, and as long as there were no enterotomies made, fistulas and graft infection were rare events. Now I hear surgeons say that the use of prolene constitutes malpractice. Are these proclamations based on sufficiently strong level 1 evidence, or is this the medical industrial complex wishing us to discard \$15 pieces of mesh for \$1000 composite wonder mesh?

4. Now the technical questions: How do you fix the mesh in the large flank hernias, where 1 boundary of the hernia defect is bone, which will not allow percutaneous suture passage?

5. Is a 4 cm overlap a rigid criteria, or does it only apply only to large defects?

6. The manuscript states that sutures are placed 3 to 6 cm apart. What is the optimal distance between sutures, the greatest distance allowable without increasing the risk of recurrence?

I would like to thank Dr. Park for the honor of the floor, and thank the ASA program committee for putting together a diverse and fascinating program.

DR. ADRIAN E. PARK (Lexington, Kentucky): Thank you very much, Dr. Hunter.

Firstly, is there anyone in whom a laparoscopic repair should not be considered. This, as with any surgical technique, comes down to surgeon experience and training and comfort, and what the authors may be comfortable with in terms of hostile abdomen may not be the same type of abdomen that somebody simply embarking upon this technique may be comfortable with. When we teach and train surgeons in this approach we usually suggest that the initial patients are selected carefully, that perhaps recurrent umbilical hernias or central defects in nonmorbidly obese patients be the first patient selected in that individual surgeon series. A history of previous abdominal surgeries and the possibility of adhesions certainly is not considered a contraindication to proceeding laparoscopically with the repair. It really does come down to a point of surgical judgment, experience, and expertise.

The second question had to do with quality of life assessments and have we measured these in the study. In the early stages of the study we were following patient satisfaction data points within the database. But unfortunately it became increasingly difficult to do so over time. This is an excruciatingly difficult patient population to follow longitudinally, as anybody who has tried to do this will find, and it is something that I think we absolutely need to address, and perhaps we will be a little bit more creative about it now and in the world of electronic connectivity we can do a better job. But when we tried to do it early in the study we had great problems with getting the kind of return input that we wanted. So it is a point well taken.

The next question was about the mesh used. There is certainly no level I data at this point available to suggest that polypropylene or mersilene meshes shouldn't be used. However, the empiric and anecdotal data is becoming increasingly compelling, and I think that it is increasingly difficult to defend the use of a biomaterial that has no adhesion barrier in direct contact with the abdominal viscera.

In terms of some of the more challenging meshes, how is the mesh secured in a flank hernia where there is not much fascia muscle tissue to secure to? There are several flank hernias, lumbar hernias, in this series. And what we did is we put the patient in the lateral cubitus position, we mobilized the colon and the kidney, and have on occasion drilled through the iliac crest and secured the mesh to the iliac crest. We tend not to do so on a costal margin. That carries with it definite morbidity.

The issue of overlap. We suggest at least 3 cm. And again, even in the recurrence data we don't have enough data to make comments regarding statistical significance in terms of the degree of defect overlap. But as we have gained experience in this procedure, our tendency is clearly for more and not less defect overlap when we undertake this repair.

The same thing with the intervals of suture around this patch. There are some authors now who are advocating that no suture fixation is required. And it is our very strong opinion that that is not the case, that long-term durability of this repair rests in large part upon good fascial fixation of this patch.

DR. ROBERT J. FITZGIBBONS, JR. (Omaha, Nebraska): Dr. Park, your group is certainly to be congratulated because you are obviously master surgeons. But I can assure you not everybody is going to get these kinds of results. Disastrous complications have been reported with this operation because of bowel perforation. You reported 14 enterotomies in this series. What did you do with those patients? Did you abandon the procedure or did you close the enterotomy and then go ahead and do the ventral hernia repair? Many would consider the latter a risky strategy.

I am wondering if you are aware of any complications of placing such a large prosthesis in the abdomen. Even if it is Gortex or 1 of the adhesion barrier composites, I remain concerned.

Again, thanks very much for this wonderful presentation.

DR. ADRIAN E. PARK (Lexington, Kentucky): The issue of enterotomy is a very important one. As Dr. Fitzgibbons points out, this is not a benign procedure. There have been well in excess of 50 deaths around this country related to this procedure, and specifically related to the missed enterotomy. And so we spend a great deal of time counseling patients preoperatively about this.

Our intraoperative decision tree is such that if there is an enterotomy, a deep sero-muscular cut where there is no spillage and it is recognized immediately, then we have on a few occasions repaired and continued following enterotomy with adhesiolysis and repair of the hernia. However, we have an extremely low threshold to abandon herniorrhaphy. If there is any evidence of spillage whatsoever, then the patient understands preoperatively that we will deal with the injury, continue adhesiolysis, but stage or delay the hernia repair. So those patients come back anywhere there from 3 days to several weeks later for the hernia repair.

The second question was, have there been any complications related to the mesh? There have been no bowel erosions with the ePTFE, with the 1 you had mentioned, the Gore-Tex. There have been no recorded incidences of bowel fistula related to purely ePTFE mesh. There are all manner of patients who have incompatibility with bio materials, but I can't speak to all the other adhesion barriers.