Surg Endosc (2008) 22:1935–1940
DOI 10.1007/s00464-008-9981-1

ORIGINAL ARTICLES

Laparoscopic versus open ventral hernia repairs: 5 year recurrence rates

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Received: 16 January 2008 / Accepted: 5 May 2008 / Published online: 5 June 2008

Abstract
Background Current studies with 2-3 year follow-up favor laparoscopic ventral hernia repair due to lower recurrence rates, fewer wound infections, and shorter hospital stays. There is scant data in the literature for this group of patients regarding longer follow-up. This study compares the actual 5 year recurrence rates of laparoscopic versus open techniques and determines factors that may affect recurrence.
Methods A retrospective analysis of ventral hernia repairs at a tertiary center between January 1996 and December 2001 was performed. In this era, the method of repair often depended on which surgeon evaluated the patient. All patients were followed for a minimum of 5 years (median 7.5 years). Demographic and clinical parameters were analyzed using Kaplan–Meier analyses and the multivariate Cox proportional hazard model.
Results Of 331 patients, 119 underwent laparoscopic ventral hernia repair (LAP), 106 open hernia repair with mesh (O-M), 86 open suture repair (O-S), and 20 laparoscopic converted to open (LCO). Statistical analyses showed equal parameters among groups except defect sizes (mean ± standard error on the mean [SEM]): LAP (9.8 ± 1.2 cm), O-M (11.2 ± 3.3 cm), LCO (16.6 ± 5.4 cm) versus O-S (4.6 ± 1.6 cm) ($p < 0.02$). Actual recurrence rates at 1 and 5 years were LAP (15% and 29%), O-M (11% and 28%), O-S (10% and 19%), and LCO (35% and 60%). Multivariate analysis identified larger defects to have higher recurrence rates, particularly in the O-S group ($p < 0.02$). With the exception of the LCO group, surgical technique did not predict recurrence, nor did body mass index, diabetes, smoking, or use of tacks versus sutures.
Conclusion This is the first study to compare 5 year actual recurrence rates between laparoscopic and open ventral hernia repairs. Contrary to prior reports, our longer-term data indicates similar recurrence rates, except for higher rates in the laparoscopic converted to open group. Due to the continued recurrences over the period studied, longer-term follow-up is necessary to appreciate the true rate of hernia recurrence.

Keywords Ventral hernia · Long-term outcomes · Laparoscopy

Laparoscopy has revolutionized our approach to hernia repairs since the early 1990s. Its inherent short-term benefits have been well studied and published [1–13]. However, the ultimate measure of a hernia repair remains its recurrence rate. It is well understood that long-term follow-up is essential to report recurrence data accurately, as evidenced by the abundance of literature reporting 5 year outcomes of inguinal hernia repairs approached both open and laparoscopically [14–16]. A similar 5 year follow-up is seen with open ventral hernia repairs, but is lacking for its laparoscopic counterpart [6–11, 17–19]. Motivated by this discrepancy in data and paucity of studies evaluating long-term follow-up of laparoscopic ventral hernia repairs, our study attempts to address this issue by reporting our 5 year actual recurrence rates for both those approached open and laparoscopically.

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Materials and methods

A retrospective analysis of ventral hernia repairs at the Cleveland Clinic between January 1996 and September 2006 was performed. Accrual was limited to patients with repairs prior to December 2001, enabling all patients to have a minimum of 5 year actual data. Follow-up ranged from 5 to 10 years with a median follow up of 7.5 years. A total of 331 patients were assessed for demographic and clinical data. Preoperative factors assessed included: age, gender, body mass index (BMI), comorbidities (hypertension, diabetes, immunosuppression, ascites, and smoking). The type and number of previous surgeries, particularly hernia repairs were recorded and evaluated as a risk factor for recurrence. Intraoperative factors evaluated: operating times, estimated blood loss (EBL), number and size of fascial defects (measured by length and width in centimeters), presence and severity of adhesions (none, mild, moderate, and severe), size and type of mesh used, method of fixation (sutures, spiral tacks, or both), the degree of underlay (measured in centimeters), complications, and need for conversion. The groups used for analysis were open suture repair group, open repair with mesh group, and laparoscopic intent to treat group (with patients requiring conversion remaining in the laparoscopic arm). Further subgroup analysis was performed between the laparoscopic cohort completed laparoscopically and those requiring conversion.

Postoperative data analyzed included: complications (seroma requiring intervention, wound infection, recurrence), length of hospital stay, and long-term follow-up. Initial follow-up data was collected from documented clinic visits performed by the primary surgeon. Long-term follow-up was performed utilizing a standardized phone interview by a single physician. In our questionnaire, recurrence was defined by the presence of a new or similar bulge which increased in size upon straining. Vague symptoms of abdominal pain or change in bowel habits were also recorded. All patients were encouraged to return for a follow-up physical examination.

Statistical analysis

All statistical analyses were performed using JMP 5.1. Basic demographic distribution data between groups was analyzed using unpaired *t*-tests and chi square. Kaplan–Meier recurrence data were calculated on an intent to treat basis (open repair with suture group, open repair with mesh group, and laparoscopic intent to treat group, which includes the laparoscopic completed laparoscopically group and laparoscopic converted to open group). Logistic regression analysis using a fit model was utilized for comparing recurrence rates across surgical techniques controlling for hernia defect size. One-way analysis of variance (ANOVA) and Tukey–Kramer analysis were utilized for comparing defect size versus hernia repair method. Statistical significance was set for p values <0.05.

Operative technique

Although the surgery was performed by 15 different surgeons over a 5 year period, the choice of techniques were similar. The following is a summary of the most commonly used methods for each approach:

Laparoscopic approach: Peritoneal access was obtained using an open Hassan technique or optical trocar with or without a Veress needle. Although most cases were completed using three trocars (one 10-mm and two 5-mm trocars), additional 5-mm trocars were utilized when needed. An appropriately sized mesh was fashioned to ensure a 3–5 cm underlay (overlap of mesh around the fascial defect edges). The preferred method of mesh fixation during the study period was anchoring the four corners of the mesh with transfixation sutures and circumferential tacks placed 2 cm apart in two rows: the double crown technique [18]. The fascia was closed for trocar sites $\geq$10 mm. The mesh used varied over the time period and by surgeon preference.

Open approach: An incision was performed over the hernia site. A meticulous and wide dissection was routinely performed to ensure that at least 5 cm of fascia was available for either primary suture repair or fixation of mesh. The primary suture repair entailed using a 0 nonabsorbable suture. When mesh was utilized, the preference was an underlay placement anchoring it with a continuous running nonabsorbable suture. Drains were routinely used for large defects that required extensive dissection [1–3]. The mesh used varied over the time period and by surgeon preference.

Results

A total of 331 patients underwent ventral hernia repair between January 1996 and December 2001. Of these 331 patients, 172 were female and 159 men. Their mean $\pm$ SEM age was 57 $\pm$ 1.5 years, body mass index (BMI) was 31.9 $\pm$ 1.2 kg/m^2, and size of defect 88.9 $\pm$ 14.6 cm^2; median size of defect as measured by length of greatest dimension was 6 cm. Table 1 details these variables by surgical technique. Amongst our study population 44% were smokers, 52% had hypertension, 13% diabetes, 10% immunosuppression, and 3% ascites.

Of 331 patients, 86 (26%) underwent open suture repair, 106 (32%) open hernia repair with mesh, and 139 (42%) laparoscopic intent to treat group. Of the 139 patients in the laparoscopic intent to treat group, 119 (72%) patients had the procedure completed laparoscopically while the

Table 1 Comparison of patient demographics by surgical technique

	n	Age mean (years)	BMI mean (kg/m^2)	Size of defect mean (cm)
Open suture repair	86	56	31	4.6
Open mesh repair	106	58	34	11.2
Laparoscopic intent to treat	139	57	31	9.43
Laparoscopic completed laparoscopically	119	58	30	9.8
Laparoscopic converted to open	20	54	34	16.6

Note: Size of hernia defect, measured as largest linear dimension, clearly varied between groups: open suture repair versus open mesh repair ($p = 0.0013$) and laparoscopic completed laparoscopically versus laparoscopic converted to open ($p = 0.0051$). However, there was no statistical significance between the open mesh repair versus laparoscopic intent to treat groups ($p = 0.69$)

Table 2 Demographic distribution by method of repair

	Smokers	Diabetes	Hypertension	Immunosuppression	Ascites
Open suture repair	40%	9%	47%	9%	1%
Open mesh repair	44%	12%	49%	12%	2%
Laparoscopic intent to treat	45%	16%	57%	9%	3%
Laparoscopic completed laparoscopically	44%	16%	57%	8%	1%
Laparoscopic converted to open	47%	15%	55%	15%	*20%*
p-value	0.99	0.69	0.60	0.85	*0.01*

Note: The significantly increased rate of ascites noted in the laparoscopic converted group may have contributed to their higher rate of recurrence (60%) ($p = 0.01$)

remaining 20 underwent a conversion to an open procedure (18%). Statistical analysis illustrated an even distribution of demographics and comorbidities between the study groups (Tables 1 and 2). Mean body mass index was greater for both the open mesh repair and conversion groups (32.5 and 33.9 kg/m^2, respectively), compared to the open suture and laparoscopic repair groups (27.5 and 29.6 kg/m^2, respectively) ($p = 0.078$).

The open repair with suture only versus mesh had a statistically significant disparity in defect size (4.6 versus 11.2 cm, $p = 0.001$). The laparoscopic intent to treat group had a mean defect size of 9.4 cm, compared with the open mesh repair group of 11.2 cm ($p = 0.112$). The laparoscopic converted group to have a statistically larger defect size (16.6 cm) than those that were completed laparoscopically (9.8 cm) ($p = 0.04$).

Of the laparoscopic group 5% had primary ventral hernias, 10% umbilical hernias, and 85% incisional hernias. The mean number of ports used was three, number of defects 2 (1–17), estimated blood loss 54.5 ml (0–350 ml), length of stay 2 days (0–15 days), and resumption of regular diet 1.5 days (0–5 days).

The observed seroma rate was 16% for the laparoscopic group and 9% for the open mesh repair group. However, in the majority of these patients the seroma resolved without the need for intervention. Our definition of a wound infection was quite liberal and based on National Surgical Quality Improvement Program (NSQIP) recommendations for surgical site infections. Wound infection rates were 7.5% for the laparoscopic group and 9% for the open repair group. The hematoma rate was 2% in the open mesh group and 1% for the laparoscopic group.

Of the 331 patients, 5 year actual recurrence data was available for 291 patients (88%). Median follow up was 7.5 years, with some patients having up to a 10 year follow-up. The recurrence rates were calculated at 1 and 5 years for each of our groups. The open suture repair group had the lowest recurrence rates at both 1 and 5 years, 10% and 19%, respectively. The laparoscopic converted to open subgroup had the highest recurrence rates at 1 and 5 years, 35% and 60%, respectively. Recurrence data are illustrated in Table 3 and Fig. 1. Among those repairs that were completed laparoscopically, 38% were for recurrent

Table 3 Actual recurrence rates at 1 and 5 years, without controlling for size of defect

	1 year recurrence rates (%)	5 year recurrence rates (%)
Open suture repair	10	19
Open mesh repair	11	28
Laparoscopic intent to treat	20	37
Laparoscopic completed laparoscopically	15	29
Laparoscopic converted to open	35	60

Note: Although the open suture repair group demonstrates the lowest recurrence rates, this data does not control for defect size, which was statistically smaller for the open suture repair group. Likewise, the laparoscopic converted subgroup demonstrates the highest recurrence rates at both 1 and 5 years but includes the largest sized defects

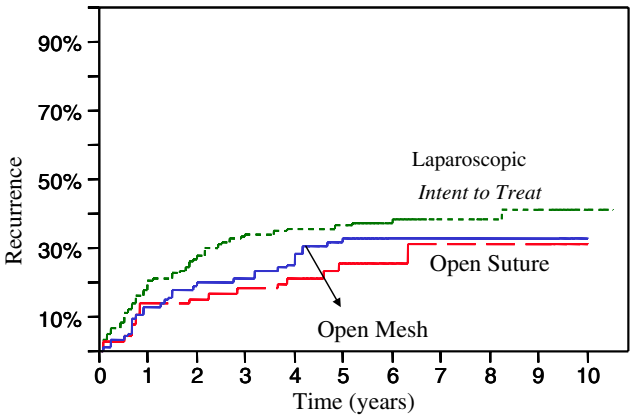

Fig. 1 Kaplan–Meier analyses helps us to appreciate the patterns of recurrence across methods of repair. While the early steep phase of these curves may suggest recurrences due to technical failure, all curves demonstrate a plateau at approximately 5 years. This further emphasizes that long-term follow-up is paramount in accurately reporting recurrence data

hernias. The 5 year recurrence rates among the laparoscopic group were not statistically different between first time repairs and recurrent hernias, 31% versus 28%, respectively.

Analysis of mesh types and durability were not a primary focus of this study and therefore it was not powered to address issues of mesh performance. We did note that the preference of mesh used in open repairs was polypropylene (75%). In the laparoscopic group the choice of mesh was mostly Gortex (47%), followed by Composix (27%), and then polypropylene (25%). Contingency analysis demonstrated no statistical difference in choice of mesh used for repair and outcomes for either the laparoscopic or open repair ($p = 0.42$).

Discussion

This retrospective study critically analyzes recurrence rates of ventral hernia repairs across methods, with the longest follow-up to date in the literature. The distribution of comorbidities in the study was rather uniform. However, the laparoscopic converted subgroup had a large percentage of patients that were immunosuppressed (15%, $p = 0.85$) and suffered ascites (20%, $p = 0.01$) (Table 2). Recurrence rates comparing those with and without the following comorbidities were not found to be statistically different: diabetes ($p = 0.737$), hypertension ($p = 0.208$), immunosuppression ($p = 0.774$), and smoking ($p = 0.428$) [13, 20, 21]. The presence of ascites was noted to be significantly greater in the laparoscopic converted to open group, 20% versus 1–2% for the other groups, which may have contributed to the significantly higher recurrence rate.

On an intent to treat basis, data including all patients planned for a laparoscopic repair regardless of the need for conversion was analyzed. This data accurately predicts long-term recurrence rates when planning a laparoscopic approach. Postoperative recurrence rates may vary depending on the need for conversion. Data for the laparoscopic converted subgroup revealed a higher rate of immunosuppression, ascites, and a significantly larger size defect, all potentially contributing to the 60% recurrence rate at 5 years. This highlights the importance of preoperatively identifying this cohort for consideration of an alternative repair. Dr. Goldfarb devised the "hostile abdomen index" to address this issue and potentially select "the safest choice for abdominal operative access, pre- and intraoperatively" [21].

Actual and actuarial recurrence data was calculated by means of Kaplan–Meier statistics. Although Kaplan–Meier survival curves are traditionally used for oncologic analysis, we feel that these survival curves offer insightful and informative data. The morphology of the Kaplan–Meier curves provides an invaluable insight into the survival of hernia repairs (Fig. 1). The early part of the curves (<1 year) regardless of surgical technique show a sharp rise, which may represent technical failures. The second portion of the curves (1–5 years) shows a slower rate of failure, which can be attributed to tissue or mesh factors that that deteriorate and limit durability over time. The third portion of the curves (>5 years) demonstrates a plateau, which emphasize the need for at least 5 years of actual follow-up. Of the patients that failed in the laparoscopic group, 50% failed within the first year, presumably due to technical failures. The recurrence rate for the open repair with mesh at 1 year was 11% versus 15% for the laparoscopic group completed laparoscopically. At 5 years the recurrence rates continue to parallel each other: 28% for the open repair with mesh group versus 29% for the laparoscopic group completed laparoscopically.

Further emphasis needs to be made on the importance of utilizing Kaplan–Meier analysis for reporting of hernia recurrence data. The current method of reporting recurrences at one point in time only illustrates a small part of the picture. Furthermore, it fails to elucidate the pattern of recurrence and the rate of future recurrences, and makes it difficult to compare recurrence data from different studies. If future studies utilized this method, overlapping the Kaplan–Meier curves would enable us to make valid comparisons. Understanding the importance of Kaplan–Meier analysis and the insight it affords would enable standardization of reporting recurrence data and assist in tackling this difficult problem.

The recurrence rates at 1 and 5 years were evaluated for each of the subgroups. The open repair with suture only group had a 10% recurrence rate at 1 year and 19% at

5 years. In comparison the open repair with mesh cohort experienced more recurrences at both 1 and 5 years (11% and 28%, respectively) (Table 3). These two groups had a similar patient profile but the median size of defect was statistically different. The open suture repair group had a median size of defect measuring 4.6 cm, while the open mesh repair group measured 11.2 cm ($p < 0.02$) (Fig. 2). When controlling for size of defect (using logistic regression analysis), the open suture repair group had the highest rate of failure, followed by the laparoscopic group, and finally by the open repair group with mesh ($p = 0.004$). While suture repair was an adequate technique for smaller defects, its durability clearly decreased as the size of the defect enlarged. Consistent with current literature, hernias amongst this cohort less than 2.5 cm were adequately addressed with open suture repair alone. For defects greater than 2.5 cm, long-term follow-up (5 years) demonstrated no statistical difference between ventral hernias repaired open with mesh versus those completed laparoscopically (Fig. 3).

As the nature of this study was retrospective, particular details including the number of transfascial sutures, the mode of recurrence, the nature of wound infections, learning curves, etc. were difficult to discern. Operative notes varied in both length and content, making it difficult to capture all data points from each dictation. Another limitation of this study was the method used for follow-up. Although the ideal means of follow-up entails that the treating surgeon reexamine the hernia for evidence of recurrence, this proves to be difficult 5 years postoperatively. In our cohort less than one-third of patients returned for long-term surgical follow-up, and when they did it was typically prompted by another medical issue. This may reflect the nature of our referral pattern, which includes a wide catchment area. We were, however, able to contact 88% of our study group and conduct a standardized telephone interview. We believe that this is an accurate means

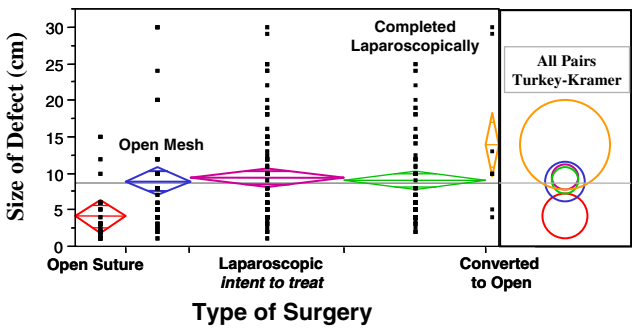

Fig. 2 This Venn diagram graphically depicts that the size of hernia defect was statistically different between methods of repair ($p < 0.05$). The smallest defects preferentially underwent open repair with suture only (4.6 cm), whereas those that were in the laparoscopic converted arm exhibited the largest size defects (16.6 cm)

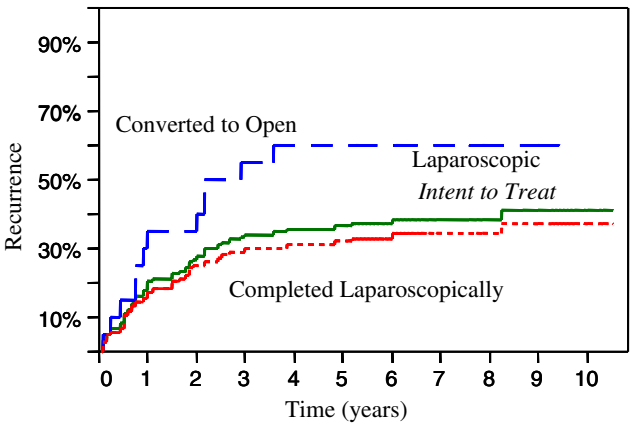

Fig. 3 Intent to treat analysis provides accurate recurrence data when planning a surgical approach. Postoperatively, subdividing the intent to treat arm may aid in identifying both risk factors for recurrence as well as risk factors for conversion. Patients that underwent conversion faced a significantly higher rate of recurrence than those that were completed laparoscopically

to detect recurrence because these patients all suffered from a previous hernia and would therefore be more likely to identify its recurrence. However, we do understand that the sensitivity of this method may be low, thus still underestimating the true recurrence rate.

Although long-term follow-up provides a more accurate picture of true hernia recurrences, a disadvantage of this approach is the exclusion of the most up-to-date techniques or technologies available. In our study, the preferred method of repair entailed the use of four point sutures for accurate placement of the mesh, while tacks remained the primary means of fixation. A recent review of the literature demonstrates a clear trend and preference for the use of circumferentially placed fixation sutures. More recently, some of the surgeons in our study group have adopted the use of transfixation sutures as the primary means of laparoscopic hernia repair [18, 22]. We await long-term data for a valid comparison of this group.

Conclusion

Contrary to prior reports, our longer-term data indicates similar recurrence rates for all hernias whether approached laparoscopically or by open technique (when controlled for size). Our data also suggests that higher failure rates may be avoided if a suture repair is only used for small hernias (<2.5 cm). Similarly, management of large ventral hernias (>16 cm) is unsatisfactory, with high recurrence rates, despite newer laparoscopic techniques. Due to the continued recurrences over the period studied, longer-term follow-up may yield more information. The current trends advocate the use of circumferential fixation sutures;

however long-term prospective analysis will be needed to address this issue. The standardization of hernia recurrence reporting and the use of appropriate length of follow-up will yield the information necessary to conquer this complex issue.

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