Background: Although laparoscopic repair of ventral hernia has become increasingly popular, its outcomes relative to open repair have not been well characterized. For this reason, we performed a meta-analysis of studies comparing open and laparoscopic ventral (including incisional) hernia repair.

Hypothesis: Laparoscopic ventral hernia repair results in better short-term outcomes than open ventral hernia repair.

Data Sources: Structured MEDLINE search for published studies. One unpublished study was also identified.

Study Selection: Studies were selected on the basis of study design (comparison of laparoscopic and open ventral hernia repair). The 3 main outcome measures were perioperative complications, operative time, and length of hospital stay. Of 83 potential studies identified by abstract review, 8 (10%) met the inclusion criteria.

Data Extraction: Two reviewers assessed each article to determine eligibility for inclusion and, where appropriate, abstracted information on patient characteristics and main outcome measures.

Data Synthesis: Across 8 studies, 390 patients underwent open repair and 322 underwent laparoscopic repair. Perioperative complications were less than half as likely to occur in patients undergoing laparoscopic repair (14% vs 27%; \( P = 0.03 \); odds ratio, 0.42; 95% confidence interval, 0.29-0.68). Average length of stay was shorter in the laparoscopic group (2.0 vs 4.0 days; \( P = 0.02 \)). No statistically significant difference in operative times was noted between laparoscopic and open repair (99 vs 96 minutes; \( P = .38 \)).

Conclusions: Laparoscopic ventral hernia repair offers lower complication rates and shorter length of stay than open repair. However, randomized controlled trials and studies with long-term follow-up are needed to confirm these findings and to assess long-term rates of hernia recurrence.

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Approximately 90,000 ventral hernias are repaired yearly in the United States, including incisional, epigastric, and spigelian defects. Although open repair, preferably with mesh, has long been the standard approach, laparoscopic repair is becoming increasingly popular among surgeons and patients following the development of minimally invasive techniques. Several observational studies have raised the possibility that laparoscopic ventral hernia repair may be associated with fewer complications, decreased length of postoperative hospital stay, and lower recurrence rates. Although numerous studies have described outcomes of laparoscopic ventral hernia repair, there remains uncertainty about the relative outcomes of laparoscopic and open ventral hernia repair. Most studies have been case series, lacking control groups. Studies with control groups have been relatively small, single-center series. To better understand the outcomes of these 2 techniques, we performed a meta-analysis of studies evaluating both laparoscopic and open ventral hernia repair.

See Invited Critique at end of article

Materials and Methods

Study Selection and Data Abstraction

Studies were selected from MEDLINE using the strategy described in Figure 1. We searched with the medical subject headings terms ventral hernia and umbilical hernia, and then we combined these studies with those with the medical subject headings term laparoscopy. In addition, we hand searched references of
included articles for other relevant studies. One unpublished study was identified.\(^{20}\) After excluding non-English articles, we were left with 83 studies. We then systematically reviewed abstracts. Studies without explicit comparison of laparoscopic and open ventral hernia repair were excluded. Eight studies met the inclusion criteria.

Two reviewers (P.P.G. and C.M.B.) independently reviewed the 8 studies and extracted information about the study design, sample size, patient characteristics, hernia characteristics, and outcomes. Rate of complications was the primary outcome measure. In addition, we abstracted information on operative time and length of hospital stay.

**STATISTICAL ANALYSIS**

We compared the odds of developing complications for patients treated laparoscopically and those treated with the open approach. Complication rates were weighted inversely with the variance and event rates across studies, related to the overall sample size. Because most studies did not provide confidence intervals, we conservatively calculated these using the Fisher exact method.\(^{21}\) In primary analysis, we aggregated these results across studies using the Mantel-Haenszel method\(^ {22}\) and used a fixed-effects model to determine confidence intervals. We also analyzed the data using a random-effects model. However, because this approach changed the point estimates minimally, we present only the former. Study uniformity was assessed using the test of homogeneity.

We calculated the mean operative time and length of hospital stay from each study, weighted by the number of patients in each study. The unpaired \(t\) test was then used to determine significance between the weighted averages. All tests of significance are at the 5% level, and all \(P\) values are 2-tailed. All calculations were performed using Stata (Stata Corp, College Station, Tex).

**RESULTS**

**PATIENT AND STUDY CHARACTERISTICS**

We included 1 randomized controlled trial\(^ {19}\) and 7 cohort studies\(^ {17,18,20,23-26}\) (Table 1). One cohort study\(^ {17}\) used historical controls (open repair cases from an earlier period). Patient characteristics, such as demographics, body mass index, comorbidities, and previous attempt at hernia repair, were abstracted when available. However, only information on patient age and sex was consistently available in most studies. Average patient age ranged from 46 to 60 years (Table 2). Other than the study by Holzman et al.,\(^ {20}\) patient age was similar in the laparoscopic and open groups. Similar trends were noted for patient sex, with the exception of the study by Robbins et al.\(^ {18}\) Last, patients undergoing laparoscopic repair were more likely to have undergone previous (failed) hernia repair in all studies in which that information was available; this difference was statistically significant in 2 of 5 studies.

The operative technique used for open repair varied across studies (Table 1). Whereas 7 of 8 studies used

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Table 1. Characteristics of the 8 Studies Included in the Meta-analysis of Studies Comparing Open With Laparoscopic Ventral Hernia Repair

<table>
<thead>
<tr>
<th>Study and Year</th>
<th>Study Design</th>
<th>Patients, No.</th>
<th>Open Technique</th>
<th>Outcomes Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Laparoscopic</td>
<td>Open</td>
<td>Mesh Used in All Patients</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repair</td>
<td>Repair</td>
<td>Yes/NR</td>
</tr>
<tr>
<td>Carboja et al.,(^ {19}) 1999</td>
<td>Randomized controlled trial</td>
<td>30</td>
<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>Chari et al.,(^ {17}) 2000</td>
<td>Retrospective cohort study(^ {†})</td>
<td>14</td>
<td>14</td>
<td>Yes</td>
</tr>
<tr>
<td>DeMaria et al.,(^ {23}) 2000</td>
<td>Prospective cohort study</td>
<td>21</td>
<td>18</td>
<td>Yes</td>
</tr>
<tr>
<td>Holzman et al.,(^ {24}) 1997</td>
<td>Retrospective cohort study</td>
<td>21</td>
<td>16</td>
<td>No</td>
</tr>
<tr>
<td>McGrew et al.(^ {25}) 1998</td>
<td>Retrospective cohort study</td>
<td>65</td>
<td>71</td>
<td>Yes</td>
</tr>
<tr>
<td>Park et al.,(^ {26}) 1998</td>
<td>Retrospective cohort study</td>
<td>56</td>
<td>49</td>
<td>Yes</td>
</tr>
<tr>
<td>Ramshaw et al.,(^ {24}) 1999</td>
<td>Retrospective cohort study</td>
<td>79</td>
<td>174</td>
<td>Yes</td>
</tr>
<tr>
<td>Robbins et al.,(^ {18}) 2001</td>
<td>Prospective cohort study</td>
<td>36</td>
<td>18</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>322</strong></td>
<td><strong>390</strong></td>
<td></td>
</tr>
</tbody>
</table>

*OR indicates operating room; LOS, length of stay.
\(^{†}\)Onlay indicates mesh placed in a prefascial position; inlay, mesh sewn to edges of fascial defect, with overlap; and underlay, mesh placed retromuscular to the rectus sheath.
\(^{‡}\)Historical controls.
mesh in all open repairs, some open procedures in one study involved primary repair with nonabsorbable sutures. The position of the mesh placement was either not noted explicitly or varied from onlay to inlay to underlay. Onlay was defined as placed anteriorly to the fascia, inlay was defined as sewn to the edges of the fascial defect, and underlay was defined as placed retro muscular to the rectus sheath.

### COMPLICATIONS

Of the 6 studies included in the complications summary measure, 5 (83%) reported trends toward decreased risks of complications with laparoscopy (Table 3 and Figure 2). Three of these reductions were statistically significant. The only study showing no benefit with laparoscopic repair was the smallest study, with only 14 patients in each arm. In evaluating complication rates, 2 studies were excluded from meta-analysis. The first excluded study recorded only wound complications, excluding any other type of complication, such as pulmonary embolism or pneumonia. They reported wound complication rates of 28% in the open group and 16% in the laparoscopic group. The other excluded study reported only total number of complications, not number of patients with complications. They identified 2 complications in 30 laparoscopic patients compared with 15 in 30 open patients.

In pooled analysis, the summary odds ratio was 0.42 (95% confidence interval, 0.29–0.68; \( P = .03 \)) for risk of complications with laparoscopic relative to open repair. In other words, patients undergoing laparoscopic ventral hernia repair were 58% less likely to experience a complication as those undergoing open repair. Our test of homogeneity had a \( P \) of .59, demonstrating that the outcomes from these studies were consistent enough for aggregation.

### LENGTH OF STAY

Seven studies reported shorter postoperative hospital stays for patients undergoing laparoscopic repair (Figure 3). Three studies reported statistically significant re-
productions in length of stay, 3 studies\textsuperscript{17,24,26} did not assess statistical significance, and the final study\textsuperscript{20} found a statistically nonsignificant reduction. One study\textsuperscript{18} did not report data on length of stay. In pooled analysis, average length of stay was shorter in the laparoscopic group (2.0 vs 4.0 days; \(P = .02\)). The study showing the largest reduction in length of stay was the only randomized controlled trial\textsuperscript{19} in our analysis.

**OPERATIVE TIME**

Six studies compared operating room times in the 2 groups (Figure 4). Four\textsuperscript{17,20,25,26} of the 6 studies noted longer operative time (range, 17-46 minutes longer) with laparoscopic repair. The 2 remaining studies\textsuperscript{19,23} found average operating room times 24 and 29 minutes shorter with laparoscopy. In pooled analysis, we found no statistically significant difference in operative times between the laparoscopic and open groups (99 vs 96 minutes; \(P = .38\)).

**COMMENT**

This study examined the current surgical literature comparing laparoscopic and open ventral hernia repair. Eight studies, with a total of 712 patients, were identified in the meta-analysis. Compared with open repair, laparoscopic surgery was found to have lower risks of complication, longer operative times, and shorter length of hospital stay.

This study has several limitations. First, it is difficult to rule out unmeasured differences in case-mix as an explanation for the findings, particularly since 7 of the 8 studies reviewed had observational designs. However, there is little reason to believe that differences in case-mix explain the findings. Measured patient characteristics did not imply that “sicker” patients were undergoing open repair. In fact, more patients in the laparoscopic group had undergone previous (failed) attempts at hernia repair. Also, the only randomized controlled trial\textsuperscript{19} in our analysis, in which patient characteristics did not imply that “sicker” patients were undergoing laparoscopic repair, most complications tend to be wound related, only infrequently requiring reoperation and rarely causing permanent disability. In contrast, the risk of unrecognized enterotomy in laparoscopic repair is significant (2%-4%).\textsuperscript{8,9,14} and delay in diagnosis can result in intra-abdominal contamination and life-threatening sepsis. Therefore, although complications are less frequent in laparoscopic repair, their sequelae may be more severe. Furthermore, several studies used different definitions of what constituted a complication, making comparison across studies difficult. Future trials should use consistent definitions and scales to account for the differences in complications between laparoscopic and open repair.

Fourth, there was significant variability in operative technique, particularly in open ventral hernia, across the 8 studies included in our analysis. Seven studies used mesh in all open repairs. However, the mesh location varied across studies, with 2 studies using an onlay technique,\textsuperscript{20,23} 1 an inlay technique,\textsuperscript{22} and 2 a retromuscular technique.\textsuperscript{17,18} Despite this variation, we find little reason to believe that mesh location would affect short-term complications; mesh location in open repair is much more likely to affect recurrence rate.\textsuperscript{3}

Finally, we did not assess hernia recurrence rates, which is one of the most important outcomes of ventral hernia repair. Considerable uncertainty exists surrounding recurrence rates in open and laparoscopic ventral hernia repair. The 3-year cumulative recurrence rate in a large randomized controlled trial of open ventral hernia repair was 24%. This study used retromuscular mesh placement with a 2- to 3-cm overlap, considerably less overlap than that described by Stoppa\textsuperscript{4} and Rives.\textsuperscript{3} Uncontrolled studies\textsuperscript{2,7-9,27-30} using the Stoppa/Rives technique have reported recurrence rates as low as 2% to 6%. In laparoscopic repair, retrospective studies\textsuperscript{10,31,32} have reported recurrence rates as low as 3% to 4%. Of the 8 studies included in our meta-analysis, only 3\textsuperscript{23-25} contained data regarding recurrence rates for the laparoscopic technique (range,
3%-13%). These data were short term (usually <2 years) and often were not evaluated by independent examiners or objective measures (eg, imaging). Given uncertainty about long-term recurrence rates after laparoscopic repair, trials with long-term follow-up are needed to compare the durability of open and laparoscopic repair.

In conclusion, laparoscopic ventral hernia repair offers lower complication rates and shorter length of hospital stay compared with traditional open repair. However, randomized controlled trials are necessary to confirm these findings and to provide information on long-term recurrence rates.

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Corresponding author: Philip P. Goodney MD, VA Outcomes Group (111B), Department of Veteran Affairs Medical Center, 215 N Main St, White River Junction, VT 05009 (e-mail: philip.goodney@hitchcock.org).

REFERENCES


Invited Critique

Having demonstrated the feasibility of laparoscopic ventral hernia repair, surgeons are performing this procedure before its efficacy has been established by randomized controlled trials. In this meta-analysis, the authors evaluated the existing literature to determine whether superior outcomes have been demonstrated for laparoscopic ventral hernia repair. They found only 8 studies that compared open ventral hernia repair with the laparoscopic approach. Of these, only half were prospective. The outcome that the authors focused on, presumably because they were the end points that they were able to measure in most studies, were perioperative complications, operative time, and length of hospital stay. They concluded that complication rates were lower and length of stay was shorter in the laparoscopic group and that operative times were not significantly different between the 2 groups.

It is surprising that these studies did not adequately address the differences in postoperative pain or hernia recurrence rates between the 2 groups. Because a decrease in postoperative pain is a strong argument for the use of minimally invasive technology in other procedures, one would assume that this outcome would be carefully assessed in these comparative analyses. Shorter length of stay may be a surrogate for diminished postoperative pain. However, because well-described tools are available to study pain, this variable should have been addressed. Hernia recurrence, one of the most important outcomes to measure when determining efficacy of repair, requires longer follow-up to be adequately addressed. Nevertheless, the fact that only 3 of the 8 studies even looked at this outcome is unexpected.

Considerable controversy still exists regarding the superiority of laparoscopic inguinal hernia repair over the tension-free anterior approach. I suspect that this same controversy will persist for laparoscopic ventral hernia repair. This study illustrates the need for large, well-designed studies with the power to demonstrate the long-term benefits of the laparoscopic approach.

Diana Marie Weber, MD
Washington, DC