Hypothesis: Laparoscopic incisional hernia repair (LIHR) is efficacious in transplant recipients.

Design: Retrospective review.

Setting: University hospital.


Main Outcome Measures: Operative complications and incisional hernia recurrence.

Results: The mean (SD) mesh size required for LIHR was 611 (307) cm². Median (range) hospital stay was 4 (1-28) days, with follow-up of 589 (22-953) days. Eighteen patients developed a postoperative complication, most frequently seroma formation, which occurred in 13 patients (72%). The mesh size required for LIHR was significantly larger in patients with a postoperative complication (n=18; 706 [319] cm² vs n=13; 480 [244] cm²; P=.04). Seroma formation was not associated with previous open hernia repair, diabetes mellitus, or corticosteroid use. No statistically significant relationship was noted between the transplanted organ and seroma development. There were no post-LIHR wound infections. In 7 patients (23%), hernia recurred.

Conclusions: Laparoscopic incisional hernia repair in solid-organ transplant recipients is associated with a high rate of seroma formation but minimal long-term morbidity. The recurrence rate after LIHR is equivalent to that after open hernia repair. These results suggest that LIHR is a safe and effective alternative to open repair in this patient population.

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IN THE LAST DECADE, THE NUMBER of solid-organ transplantation procedures performed in the United States has increased dramatically. According to the United Network for Organ Sharing database, the total number of intra-abdominal organ transplantation procedures performed in the United States has increased 53%, from 16 089 in 1995 to 24 541 in 2005. This growth is based on many factors including extended criteria for organ donors, an increase in the number of solid-organ transplantation centers, and technical improvements in liver and pancreas transplantation.

See Invited Critique at end of article

Similarly, the field of laparoscopy has evolved with the growing acceptance of laparoscopic incisional hernia repair (LIHR). A recent retrospective study comparing LIHR and open ventral hernia repair demonstrated a decrease in wound complications, recurrence rates, and hospital stay after LIHR. Although it is difficult to quantify the number of LIHRs performed annually in the United States, a MEDLINE search of all articles with laparoscopic hernia in the title yielded 180 articles in 1995 and 240 in 2005. The growing popularity of laparoscopy coupled with these and other highly favorable outcomes have led to expanded indications for this technique.

The incisional hernia is a common complication after solid-organ transplantation, with an incidence of greater than 17% in liver transplant recipients. In these patients, the recurrence rate after open surgical repair is greater than 20%. However, a recent retrospective review of open incisional hernia repair in liver transplant recipients demonstrated a decreased recurrence rate in those with hernias repaired with polypropylene mesh compared with those closed with suture alone (6% vs 33%). This confirmed earlier published results of decreased hernia recurrence after mesh repair. Moreover, Vardanian et al confirmed the safe use of mesh in transplant recipients. It remains
largely undemonstrated in the literature whether LIHR is efficacious and safe in these complicated, immuno-compromised patients. We queried our retrospective database for patients who underwent LIHR after solid-organ transplantation.

**METHODS**

From July 9, 2004, through October 27, 2005, a total of 31 solid-organ transplant recipients underwent LIHR at Indiana University Medical Center, Indianapolis. With institutional review board approval, retrospective reviews of the laparoscopic and transplantation databases were undertaken. Patient and treatment characteristics were catalogued, and the association of these variables with postoperative complications and recurrence was demonstrated.

All continuous variables were tested for normality. If they were normally distributed, a 2-sided t test or analysis of variance was performed; values are given as mean (SD). If the variable was not normally distributed, a Kruskal-Wallis test was performed; values are given as median (range). Depending on the expected cell sizes, Fisher exact or χ² tests were used to examine the association between any 2 categorical variables.

The approach to large abdominal wall hernias was similar to that for small umbilical or incisional hernias. All patients underwent routine cardiopulmonary evaluation. To evaluate the complex hernia defect and the aberrant anatomy underlying the abdominal skin, all patients underwent preoperative computed tomography of the abdomen and pelvis. All patients underwent preoperative bowel preparation to decrease intraluminal gas and facilitate manipulation of the bowel during dissection. Immunosuppressive medications were administered on the morning of surgery, and a dose of prophylactic antibiotic was given before the start of the operation. Patients with midline or unilateral hernias were positioned supine with 1 arm tucked. In these cases, both the surgeon and the assistant stood on the same side of the patient during surgery. The initial port was placed as laterally as possible using a direct view or an open technique. All remaining ports were placed to provide visualization of the defect, enable insertion of instruments safely, and allow the surgeon and assistant to stand in a comfortable and ergonomic position. In patients with bilateral incisional hernias (eg, hernias in the bilateral subcostal incision after liver transplantation), the patient’s arms remained abducted and the surgeon and assistant stand on opposite sides of the patient.

Large abdominal wall defects were challenging and routinely required 2 pieces of mesh for adequate coverage (Figure). Although it was possible to secure 2 pieces of mesh together before inserting them into the abdomen, this was unwieldy and made the operation difficult. We preferred to insert separate pieces of mesh with overlapping components secured with fasteners internally. The mesh was affixed to the anterior abdominal wall with a combination of nonabsorbable polypropylene sutures and metallic fasteners. All LIHR procedures were performed by the same surgeon (D.J.S.). Synthetic mesh (expanded polytetrafluoroethylene), expanded polytetrafluoroethylene, expanded polytetrafluoroethylene, or polypropylene and oxidized regenerated cellulose) was used in all procedures and extended at least 3 cm beyond the fascial defect. Mesh fixation was completed with a combination of nonabsorbable abdominal sutures and metallic fasteners.

**RESULTS**

**PATIENT CHARACTERISTICS**

In none of the 31 patients who underwent LIHR was conversion to open repair required. However, in 1 patient, an initial attempt at LIHR was necessarily aborted because of a superficial liver injury; after approximately 6 weeks, the repair was successfully performed laparoscopically. Patient and demographic data are given in the Table. Twenty-one patients (68%) in this study had undergone previous liver transplantation. One liver transplant recipient had previously undergone kidney transplantation; this patient was categorized in the liver transplantation group. Five patients underwent kidney transplantation and 5 patients underwent pancreas transplantation, either simultaneously with a kidney transplant or after kidney transplant; these patients were all placed in the pancreas transplant group.

The incisional hernia was localized along the chevron incision in the liver transplantation group and along...
the midline incision in the pancreas transplantation group. Of the 5 patients who underwent only kidney transplantation, the site of incisional hernia was along the iliac fossa incision in 3 and in the periumbilical region in 2. Patients with periumbilical incisional hernias had previously received peritoneal dialysis.

In all patients, their established immunosuppressive regimen was maintained postoperatively. The most common agents administered were tacrolimus, sirolimus, and mycophenolate mofetil, either alone or in combination. Although 22 of the 31 patients (71%) received corticosteroid therapy immediately after organ transplantation, only 7 patients (23%) were receiving corticosteroid therapy at the time of LIHR. No statistically significant association was noted between corticosteroid use or immunosuppressive agent and post-LIHR complications. There were no postoperative wound infections. Postoperative follow-up, performed by the operating surgeon (D.J.S.), included an initial follow-up of 4 to 6 weeks after surgery, a second follow-up at 3 to 6 months after surgery, and annually thereafter. The median (range) follow-up in this study was 589 (22-953) days.

**LIVER TRANSPLANT RECIPIENTS**

In many of the liver transplant procedures performed at the Indiana University School of Medicine, only the skin is closed at transplantation and the abdominal fascia is closed after 2 to 4 days. This 2-stage closure is used to allow time and space for graft and abdominal compartment swelling to resolve and, thus, reduce the adverse effects of pressure on vascular flow. In this study population, 14 patients underwent delayed fascial closure and 7 underwent primary fascial closure at the time of transplantation. The mean (SD) mesh size used to repair the hernia defect in the 14 patients who underwent delayed fascial closure was 731 (314) cm² compared with 538 (344) cm² in the 7 patients who underwent primary fascial closure ($P = .20, t$ test). The complication rate after LIHR was higher in liver transplant recipients who underwent delayed fascial closure (10 of 14 patients [71%]) compared with those who underwent primary fascial closure (3 of 7 [43%]). Similarly, seroma formation was more frequent in patients who underwent delayed fascial closure (8 of 14 patients [57%]) compared with those who underwent primary closure (2 of 7 [29%]). The recurrence rate was also higher in those who underwent delayed closure (5 of 14 patients [36%]) compared with those who underwent primary closure (0 of 7 [0%]). However, none of these variables reached statistical significance.

Within the group of liver transplant recipients, 9 (43%) had undergone previous open hernia repair and 12 (57%) had undergone initial repair. The mean (SD) mesh size used to repair recurrent hernias was 586 (233) cm² compared with 739 (351) cm² in liver transplant recipients undergoing primary LIHR ($P = .27, t$ test). After LIHR, there were no hernia recurrences in patients who underwent previous open hernia repair compared with recurrence in 5 patients (42%) who had not undergone previous hernia repair ($P = .04$). The overall recurrence rate in patients who underwent LIHR after liver transplantation was 24% (5 of 21 patients). Of the 9 patients who underwent previous open hernia repair, delayed fascial closure after transplantation affected the mesh size necessary to repair the hernia (delayed closure: $n = 5, 631 [119]$ cm² vs primary closure: $n = 4, 530 [344]$ cm²; $P = .55, t$ test).

**COMPLICATIONS AFTER LIHR**

Eighteen of 31 patients (58%) developed postoperative complications after LIHR (Table). Age, sex, presence of diabetes mellitus, corticosteroid use, previous hernia repair, type of mesh or number of pieces of mesh used for LIHR, or type of transplantation were not predictive of

### Table. Patient Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Patients (N=31)</th>
<th>Liver Transplant Recipients (n=21)</th>
<th>Pancreas Transplant Recipients (n=5)</th>
<th>Kidney Transplant Recipients (n=5)</th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>52.5 (9.4)</td>
<td>54.5 (9.3)</td>
<td>42.2 (3.4)</td>
<td>54.6 (8.1)</td>
<td>.02</td>
</tr>
<tr>
<td>Sex, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.38</td>
</tr>
<tr>
<td>Male</td>
<td>21 (68)</td>
<td>16 (76)</td>
<td>2 (40)</td>
<td>3 (60)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>10 (32)</td>
<td>5 (24)</td>
<td>3 (60)</td>
<td>2 (40)</td>
<td></td>
</tr>
<tr>
<td>Time from transplantation to hernia repair, median (range), d</td>
<td>553 (119-3431)</td>
<td>631 (119-3431)</td>
<td>398 (302-917)</td>
<td>592 (335-2068)</td>
<td>.57</td>
</tr>
<tr>
<td>Length of hospital stay, median (range), d</td>
<td>4 (1-28)</td>
<td>5 (1-28)</td>
<td>4 (3-9)</td>
<td>4 (2-7)</td>
<td>.96</td>
</tr>
<tr>
<td>Follow-up, median (range), d</td>
<td>589 (22-953)</td>
<td>548 (46-818)</td>
<td>850 (693-953)</td>
<td>795 (22-842)</td>
<td>.02</td>
</tr>
<tr>
<td>Mesh size, mean (SD), cm²</td>
<td>611 (307)</td>
<td>674 (309)</td>
<td>433 (133)</td>
<td>526 (377)</td>
<td>.24</td>
</tr>
<tr>
<td>Blood loss, median (range), mL</td>
<td>25 (5-100)</td>
<td>25 (5-100)</td>
<td>10 (5-25)</td>
<td>25 (5-100)</td>
<td>.07</td>
</tr>
<tr>
<td>Operative time, mean (SD), min</td>
<td>136 (57)</td>
<td>143 (51)</td>
<td>100 (18)</td>
<td>143 (95)</td>
<td>.30</td>
</tr>
<tr>
<td>Complications, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>18 (58)</td>
<td>13 (62)</td>
<td>3 (60)</td>
<td>2 (40)</td>
<td>.86</td>
</tr>
<tr>
<td>Seroma</td>
<td>13 (42)</td>
<td>10 (47)</td>
<td>1 (20)</td>
<td>2 (40)</td>
<td>.66</td>
</tr>
<tr>
<td>Hernia recurrence</td>
<td>7 (23)</td>
<td>5 (24)</td>
<td>1 (20)</td>
<td>1 (20)</td>
<td>.99</td>
</tr>
<tr>
<td>Bowel obstruction</td>
<td>1 (3)</td>
<td>1 (5)</td>
<td>0</td>
<td>0</td>
<td>.99</td>
</tr>
<tr>
<td>Prolonged ileus</td>
<td>1 (3)</td>
<td>1 (5)</td>
<td>0</td>
<td>0</td>
<td>.99</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>2 (6)</td>
<td>2 (10)</td>
<td>0</td>
<td>0</td>
<td>.99</td>
</tr>
<tr>
<td>Gastroparesis</td>
<td>1 (3)</td>
<td>0</td>
<td>1 (20)</td>
<td>0</td>
<td>.32</td>
</tr>
</tbody>
</table>

*Liver vs pancreas transplant recipients.*
overall complications. However, in patients with postoperative complications, mesh size was significantly larger than in patients without complications (n=18; 706 [319] cm² vs n=13; 480 [244] cm²; P = .04).

One patient required reoperation. In this patient, a 66-year-old man without diabetes, a recurrent incisional hernia developed after liver transplantation and previous open incisional hernia repair. While the patient was recovering from LIHR, a high-grade partial small-bowel obstruction developed that required open adhesiolysis. The patient did well after this intervention.

Early postoperative seroma formation was the most common complication, occurring in 13 of 31 patients (42%) and accounting for 72% of the overall postoperative complications (13 of 18 patients). The development of an early postoperative seroma was not associated with age, sex, type of transplantation, previous hernia repair, use of corticosteroids at the time of LIHR, or type, size, or number of pieces of mesh used for LIHR (P > .20).

In these 13 patients, seroma formation was detected at the first postoperative visit but had completely resolved in 5 patients (38%) before the most recent follow-up (mean [SD], 684 (164) days). Four patients with postoperative seromas also developed a recurrent incisional hernia, although seroma formation was not predictive of hernia recurrence (P = .40). One of these 4 patients, a 56-year-old liver transplant recipient, underwent a redo-LIHR and is symptom free. Three patients had a persistent seroma at last follow-up (493 [276] days). In 2 of these patients, the seroma was asymptomatic and managed conservatively, and 1 patient underwent successful laparoscopic drainage of the seroma. One patient died of previously undetected lymphoproliferative disease 2 months after LIHR; a seroma was detected at the first postoperative visit.

**HERNIA RECURRENCE**

Seven of 31 patients (23%) demonstrated hernia recurrence at a median follow-up of 1.6 years. Four of these patients had minimal symptoms and refused additional surgery, 1 patient moved away, and 2 patients underwent a successful redo-LIHR. Five patients had hernia recurrence after liver transplantation, 1 after simultaneous kidney-pancreas transplantation, and 1 after kidney transplantation. Of the 5 hernias that recurred after liver transplantation, 4 were along the lateral aspects of the chevron incision and 1 was in the midline, just below the xyphoid process.

**COMMENT**

To date, to our knowledge, this is the largest study to examine the feasibility of LIHR in patients who had undergone previous solid-organ transplantation. Stratification of risk factors for development of incisional hernia in patients after liver transplantation has been published by Janssen et al. In their series of 290 patients, the presence of diabetes mellitus or previous abdominal surgery was not predictive of incisional hernia development. In addition, stratification on the basis of body mass index, operative time at transplantation, or postoperative immunosuppressive regimen demonstrated no difference in those patients who did or did not develop an incisional hernia. Of the 50 patients who underwent liver transplantation in their study who developed an incisional hernia, 11 (22%) had hernia recurrence after open repair, which is below previously published rates of 25% to 52% in patients who have not undergone organ transplantation.

Several studies comparing open repair with LIHR demonstrate improved patient outcomes with the laparoscopic approach. Commonly, surgeons shy away from undertaking large abdominal operations in patients who are immunocompromised for fear of postoperative complications. Moreover, use of prosthetic mesh with the open approach was associated with increased numbers of infections and other wound-related complications even in patients with intact immune systems. Therefore, mesh has been largely avoided in transplant recipients. However, recent retrospective studies in kidney and liver transplant recipients undergoing incisional hernia repair with polypropylene mesh reported minimal postoperative complications and a wound infection rate of less than 2%. Furthermore, the current recommendation is that “the use of polypropylene mesh should now be given first preference over primary wound closure for repair of incisional hernias following [orthotopic liver transplant].”

Our results suggest that solid-organ transplant recipients are at no greater risk of adverse events after complicated LIHR than is the general population. In our study, there were no wound infections, and the hernia recurrence rate of 23% is similar to that reported in both patients who have undergone transplantation and those who have not using the open technique but is higher than published rates for uncomplicated LIHR. Incisional hernias that develop after solid-organ transplantation are often large. In liver transplant recipients, successful mesh repair may involve replacement of the entire upper abdominal wall, extending from the costal margins to the umbilicus and from the left anterior axillary line to the right anterior axillary line (Figure). In the 3 large series of LIHRs reported in patients who have not undergone transplantation, the mean mesh size required for successful hernia repair was appreciably smaller (287, 294, and 344 cm²) than the mean size required in our series of transplant recipients (611 [307] cm²). To maintain consistency with these and other published articles, we use mesh size as an indirect measure of the fascial defect. It is our practice to extend the mesh circumferentially at least 3 cm beyond the fascial edge to provide adequate repair. Although mesh size was not a statistically significant predictor of recurrence, the mesh size used in patients who had recurrent hernia was 701 (335) cm² compared with 546 (277) cm² (P = .28) in those who did not.

Early seroma formation was the most frequent complication in our patients, occurring in 13 of 31 and accounting for 72% of the overall complications. Many seromas are self-limited and resolve in weeks to a few months after surgery. Persistent symptomatic seromas can usually be managed with percutaneous aspiration in the...
cillin setting. If the seroma recurs after multiple percutaneous aspiration procedures, operative intervention is warranted. In managing persistent symptomatic seromas in non–transplant recipients, we find that laparoscopic drainage is well tolerated and successful. After creating small slits in the mesh with laparoscopic scissors, we obliterate this dead space between the mesh and the anterior abdominal wall with a combination of additional tacking anchors and fibrin glue sealant. This approach was used successfully in 1 of our transplant recipients who had a recurrent symptomatic seroma.

Authors of a recent retrospective review of liver transplant recipients undergoing open incisional hernia repair with mesh demonstrated a 2% rate of seroma formation. They advocate leaving a subcutaneous drain brought out through a remote incision. Similar to most of the LIHR reports in the literature, we have not placed percutaneous drains for fear of introducing infection; however, this is a potential area for future study.

After liver transplantation, there is associated graft and bowel edema coupled with an organ-abdominal domain mismatch that can make primary wound closure difficult. In addition, there are several reports of complications associated with tight primary abdominal wall closure including vascular compression, thrombosis, and liver necrosis. In an attempt to ameliorate these complications, the Division of Transplantation at Indiana University School of Medicine has implemented a modification of the abdominal incision closure first described for use in pediatric liver transplantation. The Indiana University School of Medicine modification eliminates the synthetic patch described for use in pediatric liver transplantation and closes only the skin with a running polypropylene suture at the time of transplantation. The patient is returned to the operating room after 2 to 4 days for definitive fascial closure.

Our 5 patients who underwent liver transplantation in whom hernia recurred all had delayed fascial closure at the time of transplantation and all underwent primary hernia repair. The mean size of the mesh required to repair the hernia defect in this subgroup of patients was larger (832 [396] cm²) than that required to repair the defect in those in whom hernia did not recur (624 [273] cm²). We believe that the size of the hernia defect and the size of subcutaneous flaps raised at the time of delayed fascial closure contribute to hernia recurrence. This hypothesis is further supported by the lack of hernia recurrence after second LIHR procedures in which the fascial defect is smaller and surrounded by scar tissue from the previous repair. Our recurrence rate of 24% in the liver transplantation group is similar to the previously published rate of 22% after open surgical repair in this population. Although the patients with delayed fascial closure demonstrated a higher incidence of post-LIHR seroma formation in our study, the overall patient benefits insofar as graft function and survival outweigh the usually self-limited annoyance of seroma.

The LIHR approach in which the abdomen is entered in an area remote from the previous incisional limits the risk of enterotomy and avoids previously manipulated or compromised skin incisions, limiting the risk of infection. Despite several hours of pneumoperitoneum and frequently minor manipulation of the transplanted organ, we identified no adverse effects on graft function. Our median hospital stay of 4 days is comparable to that in the first published study comparing open (3.5 [2.9] days) and laparoscopic (3.2 [2.8] days) hernia repair in liver transplant recipients. Often, transplant recipients require a longer hospital stay than patients from the general population to ensure continued allograft function and adequate immunosuppression levels. On the basis of our early experience, we believe that LIHR is a safe and effective alternative to open incisional hernia repair in patients who have undergone solid-organ transplantation. Similar to other laparoscopic procedures, with increased experience, we expect that results will surpass those with open repair.

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Author Contributions: Drs Kennealey and Selzer had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Kennealey, Tector, and Selzer. Acquisition of data: Kennealey, Tector, and Selzer. Analysis and interpretation of data: Kennealey, Johnson, Tector, and Selzer. Drafting of the manuscript: Kennealey, Johnson, Tector, and Selzer. Critical revision of the manuscript for important intellectual content: Kennealey, Johnson, Tector, and Selzer. Statistical analysis: Johnson. Administrative, technical, and material support: Kennealey, Johnson, and Selzer. Study supervision: Selzer.

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REFERENCES

Laparoscopic repair of incisional hernias is increasingly becoming the procedure of choice over the open approach. Advantages of laparoscopic repair include lower rates of recurrence and complications as well as shorter hospital stay. Laparoscopic incisional hernia repair in solid-organ transplant recipients, however, is still unproved, and its safety and efficacy in these immunocompromised patients is unknown. This article describes the outcomes of LIHR in 31 transplant recipients, 21 of whom underwent liver transplantation. Only a minority of patients (23%) were receiving corticosteroid therapy. The superlative laparoscopic skills were evident in that operative times were relatively short, blood loss was minimal, and no conversion to open repair was required. Although the overall complication rate was 58%, the most frequent complication was the occurrence of seroma, which was managed expectantly. No bowel injuries occurred, and there was notably no occurrence of any mesh or wound infections. The results were even more commendable after taking into account that the hernias repaired were unconventionally large (mean [SD] mesh size, 611 [307] cm²). This may explain the relatively prolonged median (range) hospital stay (4 [1-28] days) in this series and the high overall recurrence rate (23%) within a relatively short follow-up (median, 589 days), including an even higher recurrence rate (42%) for initial repairs in liver transplant recipients. The results of this study indicate that laparoscopic repair of large incisional hernias and the use of mesh in solid-organ transplant recipients is safe in experienced hands. It is too early, however, to conclude that the laparoscopic approach is the preferred method of repairing incisional hernias in these patients, though it is probably just a matter of time before additional studies further demonstrate its efficacy and cost-efficiency.

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