Laparoscopic-Assisted Right Lobe Donor Hepatectomy

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The major impediment to a wider application of living donor hepatectomy, particularly of the right lobe, is its associated morbidity. The recent interest in a minimally invasive approach to liver surgery has raised the possibility of applying these techniques to living donor right lobectomy. Herein, we report the first case of a laparoscopic, hand-assisted living donor right hepatic lobectomy. We describe the technical aspects of the procedure, and discuss the rationale for considering this option. We propose that the procedure, as described, did not increase the operative risks of the procedure; instead, it decreased potential morbidity. We caution that this procedure should only be considered for select donors, and that only surgical teams familiar with both living donor hepatectomy and laparoscopic liver surgery should entertain this possibility.

Key words: Laparoscopic, minimally invasive surgery, right lobe donor

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Introduction

Live donor liver transplantation (LDLT) comprises an alternative therapeutic modality to liver transplantation from deceased donors. While live donor hepatectomy (LDH) is well described (1,2), and can be performed safely in the vast majority of cases, donor risk in general and complications inherent to the procedure in particular (3) form the highest barrier to the routine use of LDLT. Most notably, abdominal wall complications have been identified in a significant amount of donors, including hernia, loss of function, disfigurement and prolonged recovery (4–8). Minimally invasive techniques, such as laparoscopic and hand-assisted laparoscopic surgery have evolved over the past two decades. Specifically, the more recent development of laparoscopic liver resection (LLR) has shown the potential for a reduction in morbidity as compared to standard open techniques (9–12).

We describe herein, the first published report of a live donor right hepatectomy utilizing a minimally invasive laparoscopic technique.

Case Report

A single, healthy 32-year-old female volunteered to be a live donor to her brother. Her brother had end-stage liver disease secondary to progressive sclerosing cholangitis but exhibited a low MELD score. The donor underwent all phases of our institutional informed choice process including combination MRI, MRA, MRV and MRCP which showed normal vascular and biliary anatomy, with excellent detail. The potential for the use of laparoscopic techniques was raised during the informed consent process. The donor did not seek this possibility but was not averse to its use when our team raised it as a possibility. The risk of open conversion was discussed and we made it clear to her that despite our significant experience with LLR, we had not yet performed a laparoscopic LDH. She agreed to proceed with live donation using a minimally invasive approach with the clear understanding that donor and graft safety would take precedence over the use of these techniques.

The donor was placed in supine position, arms adducted and urinary catheter, arterial and central venous lines were inserted under general anesthesia. Pneumoperitoneum (CO₂ at 12 mmHg) was established through a 12 mm umbilical port and the abdomen explored utilizing a 30°, 10 mm laparoscope (Hopkins, Karl Storz Endoscopy, Culver City, CA, USA) for optimal optics. Once the liver was visualized one additional 10 mm port was placed at the right midclavicular line and a 5 cm subxiphoid midline incision created for hand assistance during right lobe manipulation and for graft extraction (see Figure 1), using a GelPort hand port device (Applied Medical, Rancho Santa Margarita, CA, USA) for optimal optics. Once the liver was visualized one additional 10 mm port was placed at the right midclavicular line and a 5 cm subxiphoid midline incision created for hand assistance during right lobe manipulation and for graft extraction (see Figure 1), using a GelPort hand port device (Applied Medical, Rancho Santa Margarita, CA, USA). This configuration enabled the surgeon, who stands on the left side of the patient, to use the hand port for graft manipulation, with simultaneous use of the midclavicular line port for dissection. Using LigaSure™ (Valley Lab, Boulder, CO, USA) the ligamentum teres, falciform, coronary and right triangular ligaments were divided. The hepatic bare area was completely mobilized, the right lobe was elevated, exposing the length of the retrohepatic inferior vena cava (IVC). The posterior vena cava ligament and short hepatic veins were divided using Ligasure separating the IVC and right lobe allowing visualization of the right hepatic vein (RHV) as it entered
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Figure 1: Port placement during laparoscopic, right lobe LDH.

the IVC. An umbilical tape was passed around the RHV, the right lobe allowed to return to anatomical position and a hand-assisted cholecystectomy was performed. The right hepatic artery (RHA) and right portal vein (RPV) were isolated posteriolaterally, using the LigaSure™ with hand-assisted laparoscopy, as they entered the right lobe. At this point, the hand port and all other laparoscopic devices were removed and, using the hand-assist/extraction incision, under direct vision, the cystic duct was cannulated in preparation for cholangiogram. Once cholangiography confirmed the biliary anatomy, the right hepatic duct was isolated, and using fluoroscopic cholangiographic guidance the right hepatic duct was then transected leaving a 4 mm stump with the donor hepatic confluence which was oversewn with 7-0 monofilament, nonabsorbable suture. The RHA and RPV branches were further dissected under direct vision. No inflow occlusion was applied at any point in the case. Central venous pressure was maintained at 2–4 mmHg in preparation for parenchymal transection. Using the hand-assist/extraction incision the liver parenchyma was divided at Cantlie’s line, under direct vision, from an inferior/anterior to superior/posterior direction using the Helix Hydrojet™ (ERBE USA Incorporated Surgical Systems, Marietta, GA, USA) and the TissueLink BPS2.3™ (TissueLink Medical, Dover, NH, USA). The middle hepatic vein tributaries from segments five and eight were ligated. We used the umbilical tape toward the end of the parenchymal transection to bring the transection plane closer to the surface. Once the hemilivers were separate and the recipient operative team notified, the RHA was ligated just lateral to the common bile duct and transected sharply with scissors distally through the hand-assist incision, allowing back bleeding from the graft side. Immediately the RPV was stapled but not divided using the vascular TA device (US Surgical, Norwalk, CT, USA). The right lobe was retracted laterally and, under direct vision, the RHV was stapled and divided at the IVC using an endovascular GIA stapler (US Surgical). The RPV was then transected sharply distally to the staple line using scissors. The right lobe was decompressed by allowing backbleeding through the graft side of the RPV and the right lobe was extracted, using gentle traction, by grabbing it at the gallbladder fossa and removing it through the original hand-assist subxiphoid incision. A completion cholangiogram was performed to confirm the integrity of the left biliary system and to rule out any leaks. A closed suction drain was placed in proximity to the remnant liver cut surface and was exteriorized through the right subcostal port site and secured to the skin with 3-0 nonabsorbable suture. The remaining port sites and the extraction incision were closed in layers. Estimated blood loss was 150 mL, the majority arising from decompression of the right lobe graft prior to extraction.

On the backtable, the vascular staple lines on the RHV and RPV were excised, and the right lobe graft was flushed with Custodiol® HTK Solution (Odyssey Pharmaceuticals, East Hanover, NJ, USA) within 90 s of removal. The graft had the appearance of a uniform flush, no signs of trauma and weighed 825 g. The RHV (4 mm length, 28 mm diameter), RPV (5 mm length), RHA (18 mm length) and single right hepatic duct were inspected. Graft implantation and reperfusion proceeded uneventfully in an adjoining operating room with total warm and cold ischemia times of 22 and 35 min, respectively.

Clinical Course

Donor
The donor was transferred to the surgical intensive care unit for an overnight stay. On postoperative day 1, she was transferred to the surgical floor, with minimal surgical site pain easily controlled by parenteral analgesics, and progressed to oral intake with moderate nausea controlled by medical therapy. She was discharged on postoperative day 3, anicteric, tolerating a general diet, oral analgesics and with minimal serosanguinous nonbilious fluid in the abdominal drain. On follow-up as an outpatient, on postoperative day 7, her hepatic chemistry panel has normalized, including serum bilirubin. The abdominal drain was removed and the patient resumed normal activity (see Table 1).

Recipient
The patient was extubated following the transplant procedure, remained overnight in the surgical intensive care unit, and was transferred to the surgical floor once liver
ultrasound with Doppler was performed. Gastrointestinal function returned and patient was discharged on an oral diet and analgesics with two abdominal drains with normal effluent and dual agent immunotherapy. As an outpatient, over a 2-week period, the hepatic panel has normalized including the total bilirubin.

## Discussion

The limiting step to a wider application of LDLT is donor risk. Therefore any effort to minimize the morbidity associated with LDH is worth considering. Others have previously published their experience with laparoscopic live donor left lateral segmentectomy (13). Similarly, recent reports have outlined the feasibility of hepatic lobectomy, but not in the setting of live donor procedures (11,14,15). To our knowledge, this is the first report of a laparoscopic live donor right hepatic lobectomy.

Minimally invasive surgery has been embraced largely due to reduction in abdominal wall morbidity and enhanced postsurgical recovery. In particular, laparoscopic donor nephrectomy has been found to provide both functional grafts and advances in donor morbidity and recovery (16,17). More recently, LLR has generated considerable enthusiasm in that it, like many minimally invasive procedures, has the potential to reduce abdominal wall operative trauma (12,18,19). Multiple reports have shown the feasibility and efficacy of LLR in the treatment of peripheral, benign hepatic lesions (18), and this has led to small series where major hepatic resection (lobectomy, hemihepatectomy) has been performed successfully using minimally invasive approaches (11,20–23). While experience is increasing, initial reports suggest LLR is safe and effective in a myriad of both benign and malignant hepatic neoplasms and magnitudes of resection (11,18,22,23).

During the advancement of LLR, the topic of LLR for LDH has been raised and studied in animal models. Elegant investigations in both swine and sheep have shown success in left lobe resections (24,25). Furthermore, a report of two successful left lateral segment laparoscopic LDHs gave testament to the potential for this mode of liver donation (13). This initial experience prompted our center to consider the laparoscopic approach in right lobe LDH. Our institution has performed over 70 right lobe adult-to-adult live donor liver transplants. In addition, we had been performing LLR since 2001 and had amassed an experience of 200 laparoscopic resections, including 52 right lobectomies. Our laparoscopic experience has suggested that patients benefit from the minimally invasive approach and created the desire to apply these advantages to liver donors during right lobe LDH.

Prior to embarking on laparoscopic LDH our team had to consider several issues pertinent to donor safety and recipient outcome. First, while open LDH affords the ability to manage vascular and biliary anatomical variations, our laparoscopic experience in lobectomy has reinforced the premise that these variations greatly increase the difficulty of dissection in the hepatic hilum. The need to absolutely maintain the integrity of all structures in LDH demands anatomic simplicity when considering the laparoscopic approach, and consideration of open conversion if structure integrity is in jeopardy. Moreover, careful selection of potential laparoscopic liver donors should include appropriate body habitus, consideration of cosmetic results and a thorough understanding of the technique and potential for open conversion. However, it should be noted that vascular and biliary anatomical variants may not preclude this approach since the hilar dissection can be performed through the hand-assist/extraction incision in a fashion similar to the open technique. Second, it is described that the greatest risk of hemorrhage occurs during laparoscopic hepatic parenchymal transection (25). It should be clear from our description of the procedure that the parenchymal transection was performed under direct vision with the standard instruments used in the usual open lobectomy. Therefore, no incremental risk related to the parenchymal transection was added. Finally, while there has been a suggestion of liver injury during laparoscopic resection in a rodent model (26), the growing reports of clinical experience have not suggested significant liver dysfunction postoperatively, even in those cases of long duration or major resection (14,21). With these factors in mind, our operative strategy was to perform a standard right lobe LDH using the laparoscopic hand-assisted approach principally to avoid the morbid right subcostal incision which is necessary for right lobe and IVC mobilization. In addition, the hand-assist subxiphoid incision and our standard open techniques were used for those parts of the procedure where safety might have been compromised by the laparoscopic approach.

We should mention that although the dissection was between the liver and IVC, the cholecystectomy and partial dissection of the RPV and RHA were performed laparoscopically, these could also be done using open techniques through the hand port incision. We chose to do these laparoscopically because, given our experience, it seemed easier and more efficient. However, once the right lobe is mobilized, the liver can be rotated to the left of the midline and retracted in this position while the retrohepatic IVC dissection is performed under direct visualization using open techniques. Similarly, the cholecystectomy and all hilar

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Table 1: Donor and recipient perioperative profiles

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<tr>
<th></th>
<th>Donor</th>
<th>Recipient</th>
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<tbody>
<tr>
<td>OR time</td>
<td>235 min</td>
<td>340 min</td>
</tr>
<tr>
<td>Length of stay</td>
<td>3 days</td>
<td>6 days</td>
</tr>
<tr>
<td>PT/INR</td>
<td>19.6 s/1.7</td>
<td>23.9 s/2.2</td>
</tr>
<tr>
<td>ASTI</td>
<td>381 mg/dL</td>
<td>360 mg/dL</td>
</tr>
<tr>
<td>ALTI</td>
<td>396 mg/dL</td>
<td>267 mg/dL</td>
</tr>
<tr>
<td>API</td>
<td>170 mg/dL</td>
<td>286 mg/dL</td>
</tr>
<tr>
<td>TB</td>
<td>2.8 mg/dL</td>
<td>10.4 mg/dL</td>
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1Peak values.
dissection can be done through the hand port incision using standard open techniques.

The operation resulted in favorable donor and recipient outcomes. Donor recovery was uneventful, with serum chemistries similar to our open donors (data not shown). We witnessed a subjective benefit in the donor with regards to lessened postoperative pain. This report focuses on the potential morbidity reduction of minimally invasive surgery, specifically that related to potential abdominal wall complications and related morbidity.

In conclusion, we describe the first reported minimally invasive right lobe LDH. The procedure was performed using two laparoscopic port sites and one 5 cm midline incision. This last incision is the absolute minimal incision required to remove the graft even if the procedure were to be performed entirely with laparoscopic techniques. In our opinion, patient safety was not compromised, whereas morbidity related to subcostal incisions was avoided. This first case provides proof of principle that minimal invasive techniques can be applied successfully to LD right hepatic lobectomy. The combination of extensive experience in laparoscopic hepatic lobectomy and live donor liver transplantation, careful donor selection and meticulous intraoperative technique are essential to the successful application of this approach.

Addendum

Since this report was submitted and subsequently accepted for publication in AJT, we have performed three additional cases using the technique exactly as described. Since this is a technical paper, we felt that the manuscript should remain unchanged, but we have included length of stay (LOS) data on these four cases comparing them to a contemporaneous cohort of 20 patients who underwent the standard open technique at our institution (Table 2). Given our extremely short LOS for the open procedure, we discerned no difference in LOS between the two groups.

References


Table 2: Length of stay for open and laparoscopic assisted LD right lobectomies

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<thead>
<tr>
<th></th>
<th>Length of stay (days)</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Range</td>
</tr>
<tr>
<td>Open (n = 20)</td>
<td>3</td>
<td>3</td>
<td>2–7</td>
</tr>
<tr>
<td>Laparoscopic assisted (n = 4)</td>
<td>3</td>
<td>3</td>
<td>2–4</td>
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