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Optimized Surgical Techniques in Laparoscopic Living-Donor Right Hemihepatectomy Using Indocyanine Green Fluorescence Images

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This paper outlines the surgical technique for laparoscopic living-donor right hemihepatectomy (LLDRH), a minimally invasive procedure that increases graft safety and reduces donor morbidity. The technique includes careful patient selection, precise port placement, meticulous liver mobilization, and careful parenchymal dissection, followed by secure graft extraction and effective hemostasis. LLDRH offers several advantages over open living-donor surgery, including lower costs, less postoperative pain, shorter hospital stays, and better cosmetic results. The use of advanced three-dimensional laparoscopic systems and indocyanine green fluorescence imaging has further increased the safety and effectiveness of this procedure. As laparoscopic technology continues to evolve, LLDRH is likely to become more widely adopted, offering a valuable option for liver transplantation programs. A video clip shows a 32-year-old woman with a body mass index of 25.7 kg/m^2 who donated her right liver. Her remnant liver volume was 34%, and the estimated graft-to-recipient weight ratio was 1.2. The operation time was 240 minutes, with an estimated blood loss of 150 mL. She was discharged on the fifth postoperative day without any complications.

Keywords: Laparoscopy; Liver transplantation; Living donors; Hepatectomy; Minimally invasive surgical procedures; Indocyanine green

Introduction

The growing expertise in laparoscopic techniques has made laparoscopic living-donor right hemihepatectomy (LLDRH) a viable option for liver transplantation programs [1-3]. Advancements in laparoscopic equipment, such as the use of three-dimensional laparoscopic systems and laparoscopic energy devices—including ultrasound devices, cavitron ultrasonic surgical aspirator (CUSA), and bipolar devices—have improved the precision and safety of LLDRH. Consequently, LLDRH has emerged as a significant advancement in minimally invasive liver surgery, ensuring both graft safety and viability. Living donors benefit from reduced postoperative pain, shorter hospital stays, and better cosmetic outcomes compared to those undergoing open donor hepatectomy. We outline the basic surgical techniques used in LLDRH [4]. All surgical procedures performed by the operator and first assistant are described in a supplementary document (Supplementary Material 1).

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Case Presentation

A 32-year-old woman donated her right liver to a family member. Her weight was 65.3 kg and her height was 159.3 cm, resulting in a body mass index of 25.7 kg/m^2. Based on computed tomography (CT) volumetry, the future remnant liver volume was estimated as 34%, and the estimated graft-to-recipient-weight ratio was 1.2. CT showed that she had conventional anatomy of the hepatic artery (HA) and the hepatic vein (HV), as well as trifurcation-type portal vein (PV) anatomy. Magnetic resonance imaging revealed a fat fraction of 3.5% and typical bile duct (BD) anatomy. The operation time was 240 minutes, with an estimated blood loss of 150 mL. She was discharged on the fifth postoperative day without any complications. The Institutional Review Board of Seoul National University Hospital approved this study (2406-037-1542).

Patient selection

Careful donor selection is crucial for LLDRH. Suitable donors are healthy adults with typical vascular and BD anatomy. A single right HA, a single right PV, and a single right BD without a significantly sized right inferior HV are preferred because complex vascular and BD variations increase the risk of complications. The right liver graft should be 0.8% to 1.5% of the recipient's body weight, and the remnant liver volume should exceed 30%.

Preparations

The donor was positioned supine with legs split and straightened, in a reverse Trendelenburg position at 15° with a left tilt. To prevent movement as the bed position changed, the patient was secured. An operator stood between the donor's legs, while the first assistant and a scopist were positioned on the patient's left side.

Port placement

A trans-umbilical port was utilized for the camera, while the operator's two working ports were positioned approximately 30° away from the center of the liver. The other two ports were for an assistant.

Liver mobilization

After resecting the falciform ligament up to the inferior vena cava (IVC) and the right coronary ligament, the inferior portion of the right liver was detached from the right hepatorenal ligament. Care was taken to gently separate the right adrenal gland from the liver to minimize the risk of bleeding. A space was created between the liver and the IVC, during which the short HVs and the small right inferior HVs were also excised. The large right inferior HV was resected just prior to the extraction of the liver.

Hilar dissection

The cystic duct was left long and used for traction to expose the right PV and right HA. After temporarily clamping the right HA and the right PV, indocyanine green (ICG) was administered intravenously. The parenchymal resection line was then marked along the boundary indicated by the fluorescence images of the left liver.

Parenchymal dissection

The traction method is not always necessary, but it is helpful for large livers. Both parenchymal sides of the resection line were retracted by pulling a rubber band from outside the abdominal cavity. Liver parenchymal dissection was performed using an ultrasound device, CUSA, and a bipolar device. The segment 5 (V5) branches and the segment 8 branches (V8) branches of the middle HV (MHV) were temporarily ligated with plastic clips. The resection plane was followed along the right side of the MHV. The caudate process and remaining liver parenchyma above the IVC were transected after dividing the right BD under ICG fluorescence imaging. A hanging maneuver using a tube or an instrument was useful for facilitating the parenchymal dissection and reducing bleeding. The hilar plate was transected, leaving only the right PV and right HA in the hilum.

Graft extraction

A vinyl bag containing the right liver graft was removed through the Pfannenstiel incision following a longitudinal incision on the abdominal wall. This procedure was performed after dividing the right HA and applying staples to the right PV and HV. Additionally, the right IVC ligament was resected using a staple.

Hemostasis and fixation

A closed suction drain was positioned near the resection site to monitor bleeding and bile leakage. To prevent vascular torsion and ensure correct positioning, the remaining left liver was secured with sutures anchored to the remnant falciform ligaments.

Discussion

Open hepatectomy has long been the standard approach in living donor surgery, providing direct visualization and facilitating easier manipulation of the liver. However, this method is associated with higher morbidity, including significant postoperative pain, extended hospital stays, and larger scars. Robotic living donor hepatectomy, a newer technique, offers enhanced dexterity, precision, and a three-dimensional view of the operative field. It shares the benefits of minimally invasive surgery with laparoscopic living donor hepatectomy, such as reduced postoperative pain and quicker recovery [5,6]. However, robotic surgery incurs high costs and requires specialized training and equipment, which may limit its accessibility.

LLDRH offers the advantages of minimally invasive surgery, and a postoperative complication rate comparable to that of open donor right hemihepatectomy. These benefits have contributed to its widespread adoption and greater accessibility compared to robotic surgery. The use of flexible high-definition three-dimensional laparoscopic systems and ICG fluorescence imaging has significantly improved the precision and safety of LLDRH [7]. Additionally, these tools assist in the clear identification of vascular and biliary structures, thereby minimizing the risk of intraoperative complications [4].

As laparoscopic techniques continue to advance, the adoption of LLDRH is expected to grow [8,9]. Additionally, ongoing training programs and the accumulation of experience will enable surgeons to overcome the technical challenges associated with LLDRH.

Supplementary Materials

Supplementary Marterial 1. Surgical procedures.

Disclosure

No potential conflict of interest relevant to this article was reported.

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Author contributions

Conceptualization: YRC, KWL, KSS; Data curation: YRC, SKH, NJY; Writing–original draft: YRC; Writing–review & editing: YRC, SKH, NJY, KWL, KSS; Video-review: YRC, SKH, NJY, KWL, KSS.

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