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Review

SAFETY, EFFICACY, AND RESULTS OF FULLY LAPAROSCOPIC RIGHT LOBE LIVING DONOR LIVER DONATION

Flavio Milana[1-3], Hwi-Dong Cho[3], Ki-Hun Kim[3]

[1] Department of Biomedical Sciences, Humanitas University, Pieve Emanuele (MI) Italy; [2] Division of Hepatobiliary and General Surgery, Department of Surgery, IRCCS Humanitas Research Hospital, Rozzano (MI) taly; [3] Division of Hepatobiliary Surgery and Liver Transplantation, Department of Surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Republic of Korea

Summary

Living donor liver transplantation (LDLT) is an essential strategy to address the shortage of organs, particularly in Eastern regions where cadaveric donation is limited. Minimally invasive procurement techniques, specifically pure laparoscopic donor right hepatectomy (PLDRH) for adult LDLT, have gained popularity due to their potential benefits in terms of donor early recovery and improved cosmetic outcomes. However, concerns regarding its safety have hindered the widespread adoption of PLDRH and the lack of consensus on the procedure highlights the need for standardized guidelines. This study aims to comprehensively examine the key aspects of PLDRH, focusing on donor selection and operative procedures, to improve its safety and efficacy. The authors emphasize the importance of donor safety and provide valuable insights into the technical challenges encountered during PLDRH. Donor selection criteria include specific anatomical features, as well as considerations for graft volume. The bile duct division, a technically challenging step, has been made safer by techniques such as Indocyanine-green fluorescence imaging other than intraoperative cholangiogram. Experience in both open and minimally invasive liver resection, as well as open LDLT, is crucial to ensure a smooth learning curve for surgeons performing PLDRH.

Recent evidence, including studies from Korean centers, supports the safety and feasibility of PLDRH. Meta-analyses have shown comparable outcomes between laparoscopic and open approaches in terms of donor and recipient complications. Nevertheless, a minimum number of 60 PLDRH cases has been recommended to achieve standardization and optimize outcomes.

PLDRH represents a safe and effective procedure for LDLT. Donor selection, meticulous operative techniques, and a standardized post-operative plan contribute to enhanced safety and efficacy. PLDRH is a valuable option in the field of LDLT, backed by increasing evidence and advancements in surgical expertise.

Key words: liver transplant, living donor, pure laparoscopic donor, right hepatectomy

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Correspondence
Flavio Milana
E-mail: milana.flavio@gmail.com

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INTRODUCTION

Living donor liver transplantation (LDLT) has become a fundamental resource to overcome the organ shortage, particularly in Eastern regions. The Republic of Korea is a leading country holding more than 900 LDLT per year [1]. Since the donor hepatectomy is addressed to healthy individuals,

both early recovery and cosmetic results have been regarded as crucial. In this scenario, minimally invasive procurement gained popularity.

After the first successful laparoscopic procurement for a pediatric LDLT [2], boundaries of minimally invasive donation have been expanded for adults with end-stage liver disease and more complex procedures have been performed. The laparoscopic procurement of a right hemiliver for an adult recipient was first attempted in a hand-assisted fashion in 2006 [3]. Nevertheless, only in 2013, the pure laparoscopic donor right hepatectomy (PLDRH) took place [4]. Although encouraging results were primarily observed in the Korean series [5,6], the complexity of the procedure and the requirement for a highly specialized surgical team have emerged as significant obstacles to the worldwide reproducibility of PLDRH. Notably, the consensus meetings held in Morioka [7] and Seoul [8] highlighted concerns regarding the safety and general applicability of this technique.

In this scenario, Asan Medical Center (Seoul, Republic of Korea) has represented a pioneering hospital, reporting its first series of PLDRH in 2017 [5]: three cases of PLDRH, all involving young female donors, describing no complications. The series was progressively enlarged up to the recent report of 90 PLDRH with 0 % morbidity and no mortality [9]. Moreover, considering the same series in a case match with open right hemiliver procurement [9], no differences were reported in terms of recipient post-operative complications. Nevertheless, despite this single-center encouraging results, a recent meta-analysis assessed minimally invasive donor morbidity in a range between 2.0 and 21.4 % [10].

The aim of this study is to highlight the key concepts of PLDRH, while elucidating tips and tricks of the technique, to improve its safety by providing guidance to the surgeons through donor selection and addressing potential technical challenges that could be encountered. Indeed, when considering the plan for a PLDRH, it is crucial to prioritize the safety of the donor consistently.

Donor selection and operative procedure

The careful selection of the donor represents a pivotal aspect of any effective LDLT program. This point is even more crucial in planning a minimally invasive procurement. In 2017, the authors first described their own selection criteria for PLDRH, consisting of choosing donors with single and long segments in the right hepatic artery, right portal vein, and right bile duct [5]. Considering the importance of liver outflow, since the routinely performed MHV reconstruction through preservation of segment 5 (V5) and 8 (V8) veins, selecting donors with fewer and larger V5 and V8 is crucial. The presence of inferior-right hepatic veins (IRHV) could be a challenge for liver hepato-caval plane mobilization and outflow reconstruction, hence donors without IRHV are preferable. Another noteworthy consideration is the volume of the graft. Indeed, the laparoscopy handling of a heavy liver poses challenges, thereby leading the authors to initially exclude grafts that exceed 650 g. These few points may guarantee the acquisition of a safe, reproducible, and standardized technique. However, these limits may be pushed forward with the surgeon's experience, as demonstrated by the latest reports describing even more complex cases [9].

Since a step-by-step procedure has already been described elsewhere [5], the authors seek to recapitulate in brief the key steps, emphasizing the main aspect that attempts donor safety: the division of the bile duct. Following the placement of the donor in a supine 30° reverse Trendelenburg position, the surgeon stands between the donor's legs, while the first assistant and the cameraman are positioned on the left side of the patient. Five trocars are inserted (Fig. 1). Monitors are strategically placed on the middle and the right side of the donor. Parenchymal transection is conducted without the Pringle maneuver. Temporary clamping of the right portal and hepatic artery is executed using laparoscopic bulldog clamps to delineate the division line. Intraoperative ultrasonography is employed to guide the resection plane and identify the MHV and its tributaries. The transection progresses from the liver's anterior

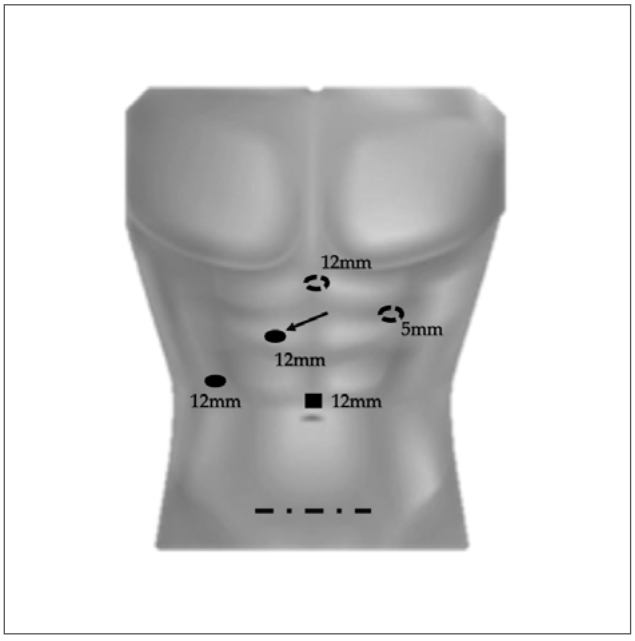

Figure 1. Trocar positioning. The peri-umbilical trocar (solid black rectangle) serves as the entry point for the cameraman. The two 12 mm trocars on the right (solid circles) represent the access points for the surgeon, with the main working port during transection indicated by the arrow. The midline and left paramedian trocars (empty circles with dashed outlines) correspond to the access points for the first assistant. A dotted straight line indicates the graft retrieval site.

surface to the right hepatic hilum along the MHV, extending down to the anterior surface of the inferior vena cava (IVC). When the liver division reaches the V5 or V8 of the MHV, a sizeable branch (> 5 mm in diameter) is preserved by the isolation and division using Hem-o-lock clips facilitating its retrieval and reconstruction on the back table. The smaller branches are isolated and divided among metallic clips.

However, the hilar plate control and bile duct section represent the most technically demanding aspects of laparoscopic liver procurement, particularly in the case of the right lobe since the main risk of donor common bile duct strictures. Indocyanine-green (ICG) is a fluorescent dye initially used in laparoscopic liver resection, whose effectiveness has been translated into minimally invasive liver donation to help in bile duct identification and preservation. Nevertheless, it is important to consider that the ICG has a deep penetration capacity, in the range of 0.5-0.8 cm, that in some "fatty" hepatic hilum cannot be totally reliable. For this reason, the authors firmly believe that the use of intra-operative cholangiogram (IOC) remains essential. A radiopaque rubber band placed on the target site on the bile duct to be sectioned represents a perfect marker during IOC (Fig. 2). Moreover, in the process of bile duct isolation, energy devices may injure the biliary tree and their use in hilar dissection should be minimized. Whilst many surgeons may prefer suturing the bile duct stump, even in laparoscopic procedures, the authors reported favorable outcomes with the use of Hem-O-Lok. This approach has been employed since 2008 when the first pure laparoscopic left-lateral sectionectomy was performed. Notably, no complications associated with the use of these clips have been reported, even in the context of PLDRH.

In addition to careful donor selection and intraoperative cautiousness, the improvement of a standardized post-operative plan is of crucial importance. Oral intake and early mobilization are strongly encouraged starting from the postoperative day (POD) 1. Furthermore, in Asan Medical Center, all the donors undergo a CT-scan examination on POD 5, in order to exclude the presence of any intra-abdominal collection and asses the remnant liver perfusion, with discharge planned soon after.

Multicentric results and learning curve

In literature, PLRDH advantages have been largely reported, comprehending donor faster recovery and cosmetic results. The leadership role of Asan Medical Center in LDLT and in particular in minimally invasive procurement relies on the experience of the surgeon (K-H.K.), previously trained in minimally-invasive surgery and open LDTL, along with the experience of the entire

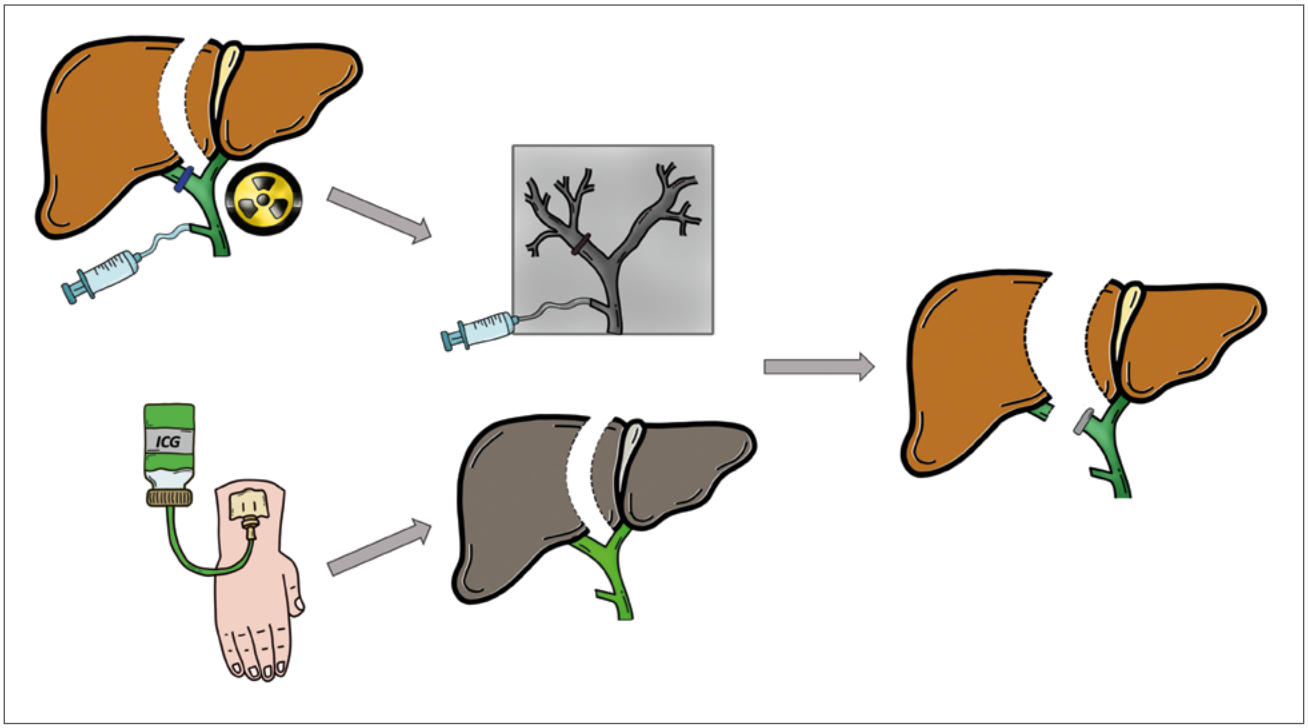

Figure 2. Safe section of the right bile duct. The combination of intraoperative cholangiogram (IOC – at the top of the figure) with the intravenous injection of indocyanine green (ICG – at the bottom of the figure) leads to correct visualization of the biliary tree and safe section of the right bile duct, thus reducing the risk of leak or stenosis of the common bile duct.

surgical team. Over the past decade, Korean LDLT centers have been making a substantial contribution to reported evidence concerning living donation and minimally invasive procurement, with the aim to fill the gap of evidence that emerged in the Morioka and Seoul meetings. This has been exemplified by the recently published Korean multicentric experience about the outcome of over 500 pure laparoscopic donor hepatectomies, in which 481 cases were PLDRH6. In this series, with a primary focus on PLDRH, no mortality cases were reported, with a rate of open conversion of 1.9 %, and the mean duration of hospitalization was observed to be 9.4 (± 3.6) days. Anyway, a 4.9 % Clavien-Dindo grade >= 3 post-operative morbidity was presented, essentially related to biliary complications (strictures or leaks) requiring endoscopic stenting or percutaneous drainage. Moreover, in the reported series, 2 cases of biliary leakage required re-operation with no irreversible disabilities reported and a 0 % mortality. In another report [12], a learning curve effect was clearly assessed with a minimum number of 60 PLDRH required to standardize the technique. These results effectively demonstrate the feasibility and reproducibility of PLDRH, when performed by experienced surgeons. The recently published meta-analysis by Zhang et al. [13] has contributed to an enhanced level of evidence by analyzing the outcomes from 14 studies, including 8 studies published by Korean centers. Their findings pointed out no significant differences in severe complication rates between laparoscopic and open approaches for both donors and recipients, providing substantial support to PLDRH feasibility.

Conclusions

In conclusion, the PLDRH represents a safe and effective procedure that offers several advantages over open surgery in terms of patient recovery and cosmetic results. The safety of the donor is comparable to open surgery, with no different outcomes for the recipients. The technical challenges of hilar plate control and bile duct section can be overcome with the use of IOC and ICG fluorescence imaging. These techniques have been shown to be effective in preventing bile duct complications and improving safety and efficacy in a series of 90 consecutive PLDRH. A minimum number of 60 PLDRH has been identified to standardize the technique. Overall, laparoscopic right lobe liver donation represents a valuable option for living donor liver transplantation.

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Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions

FM: conceptualisation; FM, H-DC: writing-original draft preparation; FM, H-DC, K-HK: writing-review and editing; K-HK: supervision. All authors have read and agreed to the published version of the manuscript.

Ethical consideration

Not applicable.

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