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Hand-Assisted Laparoscopic Living Donor Hepatectomy

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Abstract

This paper discusses hand-assisted laparoscopic living donor hepatectomy as a technique currently used to make the operation more appealing to prospective live liver donors and to retain, at the same time, safety. It is in fact, the argument goes, a safer technique than the pure laparoscopic approach and retains a certain amount of control for the operating surgeon.

Keywords: living donor liver transplantation, hand-assisted, laparoscopic techniques

Introduction

Liver transplantation is the most effective treatment for end-stage liver disease. Over the past few decades, liver transplantation has evolved with significant advancements in surgical techniques, postoperative care, immunosuppressive drugs, and organ preservation. Among the surgical techniques, living donor liver transplantation (LDLT) was developed as an alternative to deceased donor liver transplantation.[1] Living donor liver transplantation can address the critical shortfall in liver organ supply in the United States and around the world.[2-4] Furthermore, live donor hepatectomy has also proven to provide superior recipient outcomes when compared to deceased donor liver transplant.[4,5] Nonetheless, this operation is not widely accepted in the United States, despite there being a large gap between the supply and demand of liver organs, and a waiting list mortality rate between 10-20%.[6,7]

Background

The reluctance of living donor liver transplantation in the United States is in direct contrast to the Asian experience, wherein it is much more widely accepted. Historically, liver transplantation in Asia did not become well-accepted until the 1990s.[1] There were multiple contributing factors, and none of these related to a lack of surgical skills or resources, but rather to a lack of acceptance by the public.[8] Religious opposition related to the definition of brain death, and ethical issues associated with procurement of transplant organs from donors who had not suffered cardiac death, were among the main reasons behind the slow expansion of deceased-donor transplantation.[8] Changing the public perception back then proved to be a very difficult obstacle to over-

come. Thus, liver transplantation from living donors became the most viable option. The first successful LDLT in Asia was performed in 1989.[9,10] After that first successful case, LDLT increased exponentially, and, to date, it has remained the main option for liver transplant organs. In the present era of transplantation, the Asian liver transplant centers are considered pioneers and innovators in LDLT.[1,8] More than three decades of experience have led to advancement and refinement of their techniques. Living donation was initially devised for pediatric liver transplant, but, over time, it became routine in adults.

Initially, left lobes were used. However, right lobe grafts became more commonplace in adults. Ultimately, with the advent of laparoscopic surgery, many centers have focused their efforts on performing laparoscopic living donor surgery with great success and outcomes.[11] Since the first laparoscopic living donor hepatectomy was performed in 2012 (Cherqui), many centers in Asia, mainly in Korea and Japan, have become the epicenter of minimally invasive LDLT, and, currently, have the largest series of successful laparoscopic and robotic living donor hepatectomies in the World.[12-16]

In the United States and the Western world, concern for donor safety and morbidity of the operation has historically been a major impediment for living donor liver transplant. Concern for donor safety and postoperative complications, pain, and long recovery time, are some of the major limitations for widespread adoption. Thus, deceased donor liver transplants have remained as the mainstay of liver transplantation in the US. However, in the past decade, advances in laparoscopic liver resection have generated interest in the application of laparoscopic techniques for living donor liver hepatectomy.[17-20] The concerns regarding donor safety during the laparoscopic liver hepatectomy have been allayed somewhat by the high volume, skilled centers from Korea.[21-25] The experience generated from these centers has proven that laparoscopic living donor hepatectomy has safe outcomes, a shorter duration of surgery, and less blood loss with improved cosmesis and functional status of the donor.[24,26] Thus, many transplant centers in the US are developing an interest in performing more LDLT.

Current Status

In 2019, 529 LDLTs were performed in the United States, a 30% increase from 2018, and the highest number since 2001, according to the Organ Procurement and Transplantation Network.[27] Still, this is substantially lower compared to countries in Asia. In the last two decades, the number of LDLT has had an approximate 10-fold increase in the number per year.[11,28] India, Turkey, and South Korea are the major participants, with high-volume centers performing over 200 LDLT per year[11] Figure 1. shows the top 5 countries with the largest volumes of LDLT (transplant observatory and unos.org).[27,29]

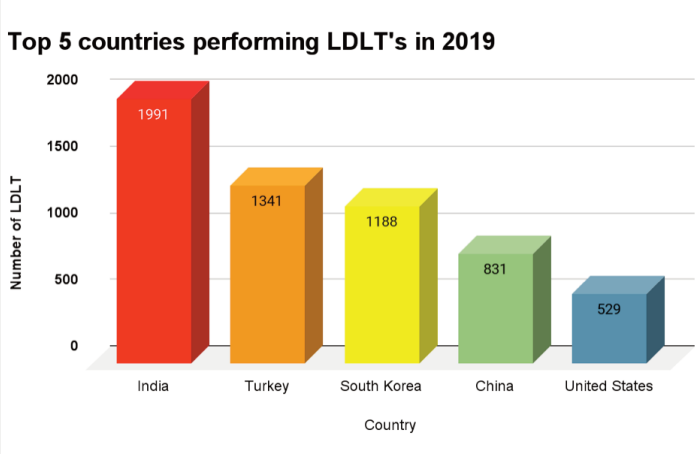

Figure 1. *Top 5 countries in the world that performed LDLT's in 2019*.
Source: *Transplant Observatory, UNOS*.

When comparing LDLT vs. deceased donor liver transplant in the last two decades, multiple single center and multicenter studies have demonstrated superior outcomes with LDLT. In the United States, a multicenter analysis performed by the Adult to Adult Liver Transplantation (A2ALL) research group reviewed data from over 16 years and demonstrated a higher survival probability at 10 years with LDLT at 70% vs DDLT at 64%, as well as fewer post-transplant ICU days.[30] Recipient outcomes in reports from Asia have shown similar results.[31-33] In terms of donor outcomes, the A2ALL group retrospective studies, and then prospective cohort, showed that approximately 40% of donors experience some sort of complication after donation. Most of these complications are minor, and 95% resolve within the first year. However, there were also significant events and donor deaths reported in the A2ALL centers.[30] In contrast, in Asia, the donor complication rate is lower. Reports from countries like South Korea have reported extremely low rates of complications (1-15%), with less than 2% major complications.[34] This may be a function of volume and consolidation of expertise in a few centers.

When comparing laparoscopic vs open surgery for LDLT, data from different centers from around the world have shown favorable outcomes for the recipients when compared to the benchmark series of open standard donor hepatectomy.[35] A recent study published by Soubrane et al, comprising data for multiple centers (a total of 412 LDLT donors) from the Western and Eastern hemispheres, has confirmed good outcomes. Rates of complications were 25-26% overall, with the majority being minor complications. Only 9% were severe.[35]

Laparoscopic Techniques

The technical steps of living-donor hepatectomy can be divided into five components: (1) Mobilization of the right lobe; (2) hilar dissection of the hepatic artery, portal vein, and duct; (3) parenchymal transection; (4) division of the vessels and bile duct, and hepatic vein; and (5) extraction of the liver graft from the abdomen.[36] The type of laparoscopic assistance required can be defined in terms of which of the five steps are performed either open or laparoscopically (36). As defined by the international panel of laparoscopic liver surgery in Louisville, Kentucky, in 2008, the following terms for different techniques were established[37]:

- Pure laparoscopy: The resection of the liver is performed in its entirety through laparoscopic ports. A small incision is performed at the end of the procedure to extract the liver lobe. Usually, this incision is suprapubic in the form of Pfannenstiel incision.

- Hand-assisted laparoscopy: Defined by the early placement of a hand port to facilitate the laparoscopic procedure, and requires an incision large enough for the surgeon's hand to be inside the abdominal space. The graft is removed through this incision.

- Hybrid technique: The procedure is started as pure or hand-assisted; afterwards, the resection is performed through a minimal laparotomy incision.

Single Center Experience

We developed a laparoscopic approach utilizing hand-assist techniques in our center so as to enhance the outcomes and make the operation more acceptable to potential donors.

In 1998, we developed a hand-assist device at the University of Massachusetts, which was commercialized by Smith & Nephew (HandPort™). This device was subsequently superseded by GelPort™ (Applied Medical), which we currently use for hand-assisted surgery. However, we gained our experience in the late 1990's with hand-assisted laparoscopic surgery (HALS) and, at that time, we developed hand-assist approaches to live donor nephrectomy, colectomy, the aorta, as well as other complex laparoscopic operations.[40-44] When we determined that we would develop a laparoscopic living donor hepatectomy program, we thought that it would be most suitable to use a hand-assist technique. The decision to adopt a hand-assist technique was utilized for two reasons: (1) an incision is required to extract the liver in every case; (2) having our hand in the abdomen lends an element of safety that cannot be accomplished with pure laparoscopic instrumentation. In addition to those two main reasons, other advantages include tactile feedback, less potential for vascular injury, and better and timelier access to control any major vascular injury.

The surgical technique performed in our center is performed in the following fashion[20]:

1. Trocar and GelPort placement: A 12-mm Hassan trocar is placed through an infra-umbilical cutdown. The peritoneum is insufflated, and, then, a right subcostal 8 cm HandPort incision is made from the tip of the 12th rib, extending medially towards the right lateral border of the right abdominal rectus muscle. Insufflation before performing the GelPort™ incision is essential in order to optimize the positioning for maximal access to retrohepatic space and hepatoduodenal ligament. Then, a GelPort device (Applied Medical) is inserted. Following, two additional 12 mm trocars are placed. One 1 cm below the xiphoid and another one halfway between the xiphoid and umbilicus. In addition, a 5 mm trocar is inserted 4 fingerbreadths below the left costal margin in the midclavicular line to assist with retraction and manipulation as needed. (Figure 2)
2. Mobilization of the Right lobe: We divide the peritoneal reflection, right triangular and coronary ligaments.
3. Division of short hepatic veins and hepatocaval ligament: Short hepatic veins are taken down with Ligasure device. Then, the hepatocaval ligament is divided between Hem-o-lok clips. This allows full mobilization of the right lobe and full visualization of the retro-hepatic vena cava up to the base of the right hepatic vein.
4. Dissection of hepatic veins and establishment of a plane between right and middle hepatic vein
5. Retrograde cholecystectomy
6. Dissection of hepatoduodenal ligament
7. Inflow occlusion in order to determine the cleavage plane between right and left hepatic lobes. Currently, we utilize immunofluorescence imaging with Indocyanine Green (ICG). (Figure 4)

8. Parenchymal transection with SonaStart (Misonix Inc., Farmingdale, NY, USA. (Figure 3)

9. C-Arm cholangiogram, or ICG imaging, to determine the confluence of right and left hepatic ducts. (Figure 5)

10. Division of right pedicle in the following order: 1. bile duct; 2. hepatic artery; 3. portal vein.

11. Transection of right hepatic vein

Retrieval of the right lobe through the subcostal incision (Figure 6)

Our results have been outstanding. We perform all of our living donor cases as laparoscopic hand- assisted surgery[20]. An advantage noted in a recent analysis of our cases of laparoscopic hand-assist LDLT performed in our center were a decreased operative time (laparoscopic cases 1 hour shorter) with no differences in blood loss, and a low conversion rate to open. The most significant postoperative complication observed was a bile leak in our donors. This was attributed to dislodgment of clips from the left hepatic remnant, or from the sharp transection of the hilar plate. As a result, after division of the bile duct, so as to decrease the risk of missing caudate lobe branches, our team has implemented stapling of the hilar plate. An important advantage of our technique is that the HandPort incision provides direct access to the hilar structures and the cut edge of the liver remnant, which allows for easy inspection for any leak through the incision. In the most recent cases, no bile leaks have been identified[20].

Discussion

Minimally invasive living donor liver surgery has been developed in the last two decades to enhance donor safety and improve graft survival. Growing debate in the literature now exists regarding the advisability of laparoscopic approaches given the wide acceptance in Asia. Laparoscopic approaches have advantages such as magnification during the laparoscopic view during hilar dissection of the artery, portal vein and bile duct, and parenchymal dissection. The main disadvantage is related to safety concerns. In particular, it is related to unexpected bleeding, which can be torrential or organ injury[36]. Although pure laparoscopic operations might have the advantage of a Pfannenstiel incision for organ extraction, which may have less pain, disability and better cosmesis, a similar sized right upper quadrant lateral incision, when performing hand-assisted laparoscopic surgery, will certainly allow for much better control of bleeding and also provide enhanced retraction and control.

Postoperative outcomes of laparoscopic approaches, especially, pain, incisional disability and complications, and cosmesis are excellent. Unfortunately, the learning curve for pure laparoscopic surgery is steep suggesting that these cases should only be performed in highly experienced centers[36].

Hand-assisted laparoscopic liver hepatectomy offers all of the advantages of pure laparoscopic approaches including less postoperative pain and less blood loss, faster recovery, and better cosmesis as compared to open surgery. Having hand access to the vascular structures and the tactile feedback provides an advantage to the surgeon as compared to traditional laparoscopic surgery.[20,36] When discussing which is the best approach, it is important to understand that the pure laparoscopic approach has a very steep learning curve and the level of expertise, that is required, is extensive. There are only a few centers in the world capable of performing them. The hand-assisted technique can be adopted in centers with appropriate laparoscopic and open transplantation experience and skills and, thus, may be the best approaches for those centers.

Conclusions

We believe that the hand-assisted technique currently used in our center will continue to make the operation more appealing to prospective donors, on the one hand, and retain safety, on the other. This approach utilizing hand-assist techniques should be easier to adopt for transplant surgeons across the globe, since this technique is easier than the pure laparoscopic approach, and retains a certain amount of control and safety for the operating surgeon without compromising safety.

Conflict of Interest Disclosure Statement

The authors have no conflicts of interest to disclose.

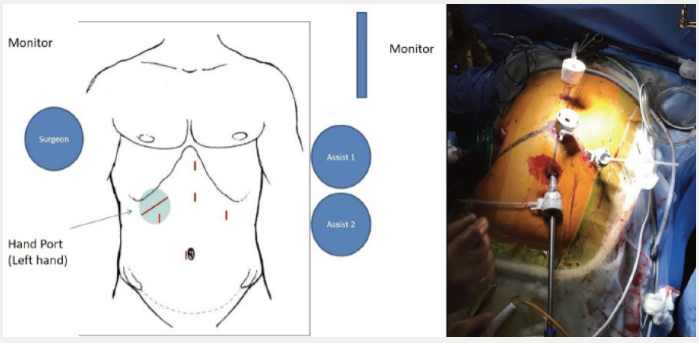

Figure 2. *Handport on the right subcostal incision and three laparoscopic ports.*

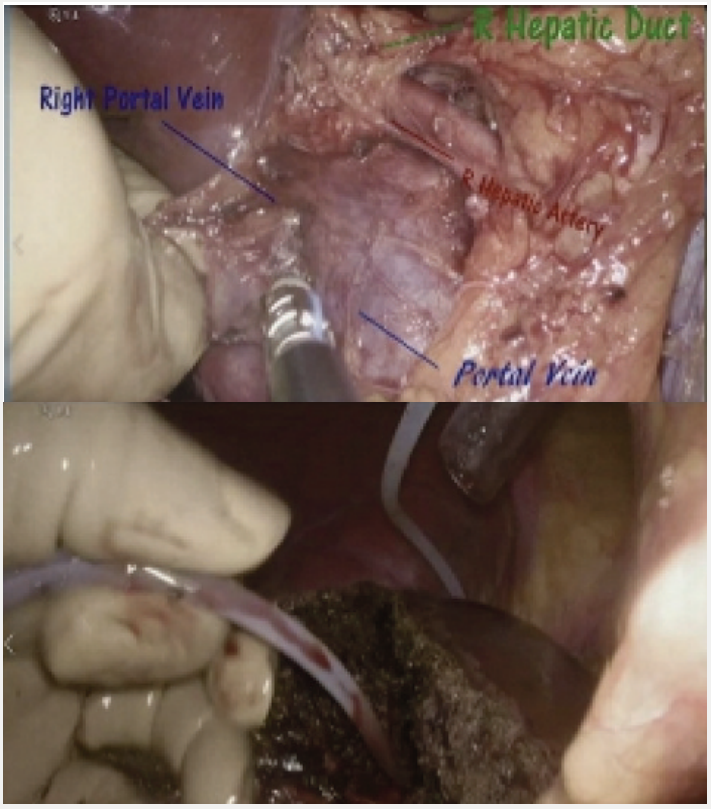

Figure 3. *Hilar dissection. The hand helps with retraction, dissection, and palpation to identify structures. On the right, the hanging maneuver is demonstrated during parenchymal transection.*

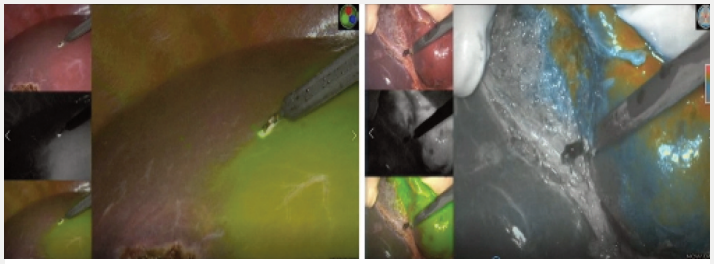

Figure 4. *The right portal vein and the right hepatic artery are tagged with vessel loops before clamping with bulldogs to demarcate the resection line. In addition, ICG immunofluorescence is used to better identify the line of inflow occlusion.*

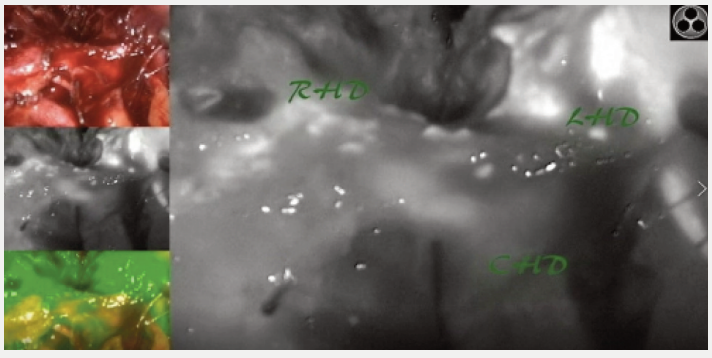

Figure 5. *Real time near infra-red ICG cholangiography performed to identify the bifurcation and to cut the right hepatic duct.*

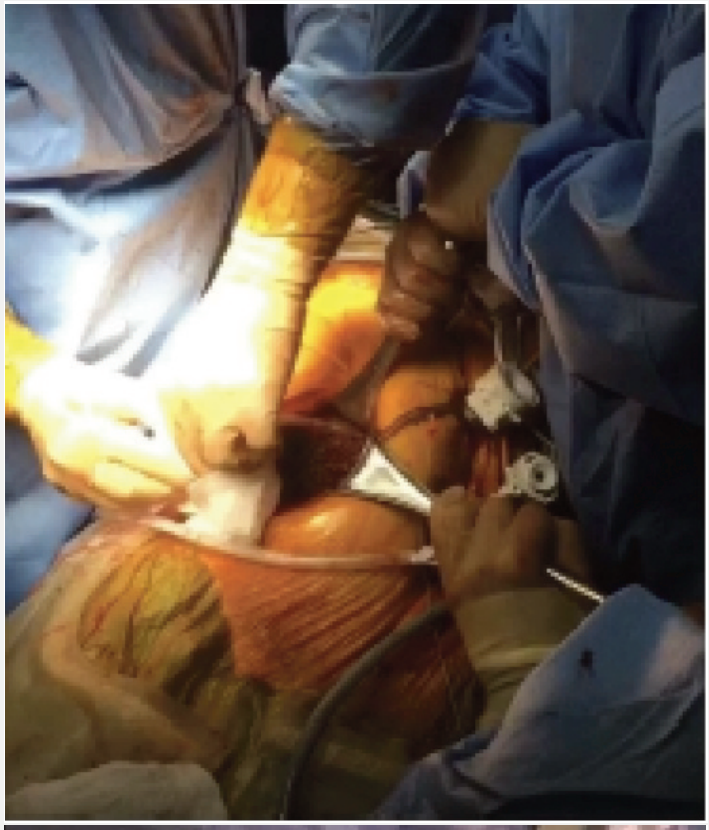

Figure 6. *Graft removal through the 8 cm hand port subcostal incision.*

Figure 7. ***a)*** *Right lobe of the liver.*
b) *Incision a month after the procedure*

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