

A Minimal Invasive Approach in Living Donor Liver Transplantation: A Systematic Review

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Abstract:

Living donor liver transplantation (LDLT) is probably the most high-profile of all surgical enterprises. At the same time, it is an amazing act of altruism. As the demand for LT continues to increase, LDLT provides life-saving therapy for many patients who would otherwise die awaiting a cadaveric organ. As long as the donor shortage continues to increase, LDLT will play an important role in the future of LT. Today, liver transplantation (LT) represents the treatment of choice for end-stage liver disease and represents the culmination of a long history of innovations made by liver surgeons based on hemorrhage control, appreciating the occurrence of regeneration and understanding the liver anatomy. In the past few years, a number of centers with significant laparoscopic and living donor experience have reported fully minimally invasive approach to hemi-hepatectomies. It has invaluable potential to alleviate the vast gap between supply and demand of hepatic allografts, even though its advantages such as shorter hospital stay and faster return to normal life could attract additional living donors, safety for donors is still being questioned and investigated due to its relatively recent development.

Keywords: Living donor liver transplantation (LDLT), cadaveric organ, Minimal invasive approach.

Introduction:

The introduction of living donor liver transplantation (LDLT) has been one of the most remarkable steps in the field of liver transplantation (LT). It requires hard work of dedicated multidisciplinary medical teams coupled with the courage of the patients and their families. The concept of LDLT is based on the following two factors: (1) the remarkable regenerative capacity of the liver, and (2) the shortage of cadaveric organs.¹ LDLT has become an acceptable alternative for patients in need of liver transplantation (LT) who are not likely to receive a deceased donor liver transplant (DDLT) in a timely fashion.² The first successful living donor liver transplantation (LDLT) was performed in 1989 and was followed by successful adult LDLT in 1994. Since then, it has become a widely accepted treatment option for patients with end stage liver disease (ESLD) with restricted deceased donor availability.³ The scarcity of donor organs has been a limiting factor in liver transplantation. As an example, in 2018 in the United States, there were over 14,000 individuals on the waiting list for liver transplantation. Approximately 7000 liver transplantation candidates will wait for >1 year for a transplant, and many patients will die waiting for an organ. Living donor liver transplantation (LDLT) is one approach that has been used to expand organ availability. Adult-to-adult LDLT has been performed in the United States for over twenty years, and over 4500 patients have received a living donor liver transplant.⁴

Anatomy:

Historically, it has been shown that partial liver allografts have higher associated risk of technical complications (e.g., vascular thrombosis and biliary leak, structure) compared with whole liver allografts. The presumed association is due, in part, to more delicate nature of smaller segmental components used for anastomosis with recipient structures. For partial grafts with conventional vascular and biliary anatomy, this may be less of a concern. However, liver allografts with unconventional anatomy, such as multiple accessory vessels or ducts, present unique challenges for reconstruction. It is at the discretion of the donor and recipient transplant surgeons to determine whether potential graft anatomy is acceptable and amenable to reconstruction.

Assessment of a potential donor for living liver donation requires consideration of liver volumetry relative to recipient size and severity of illness (GRWR)

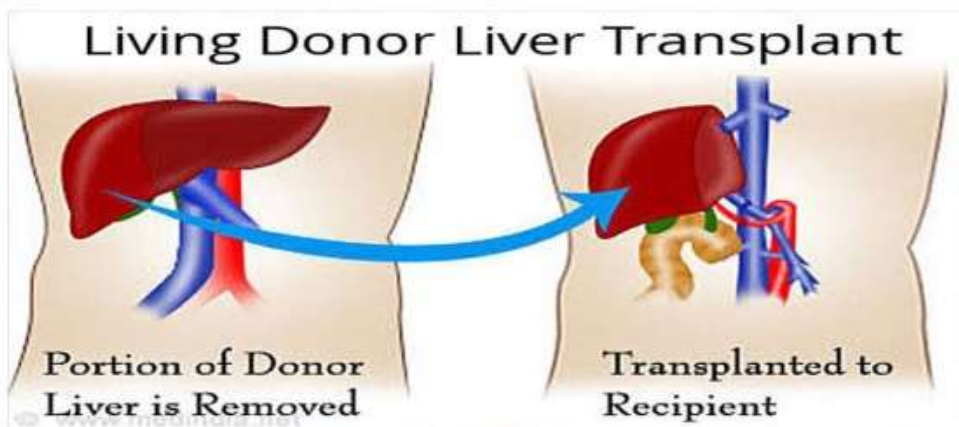


Figure 1: Part of liver transferring from donor to recipient

Volume:

Liver allograft options include:

- Left lateral section (segments 2 and 3) – 15-25% total liver volume
- Left lobe (segments 2-4 with or without caudate) – 30-40% total liver volume
- Right lobe (segments 5-8) – 60-70% total liver volume, may or may not include the middle hepatic vein (MHV).⁵

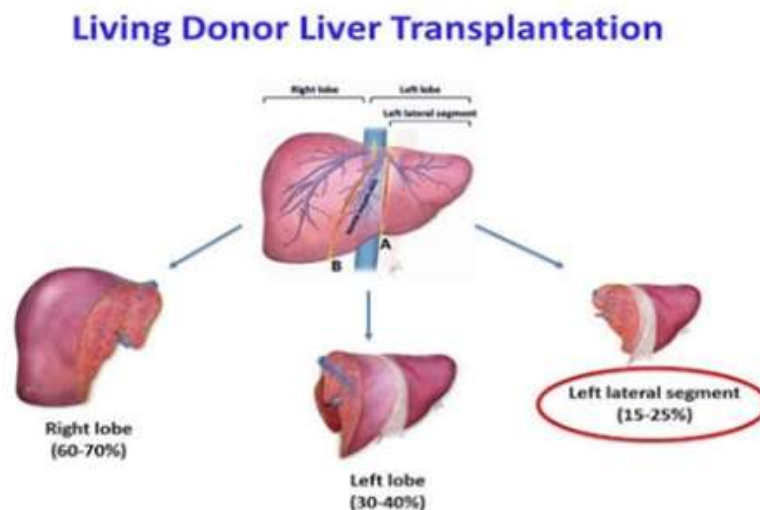


Figure 2: Liver lobes

Typically, a left lateral section graft is donated from an adult to small child. Adult-to-adult living donor liver transplant (LDLT) commonly utilizes right lobe grafts, or left lobe grafts for smaller or less sick adult recipients. Inclusion of the caudate with left lobe grafts to increase functional graft mass has not been well studied. Right posterior sector allografts have been transplanted infrequently and are associated with high biliary complication rates. The anatomic work up of a potential living donor is dependent on center access to and expertise in high quality imaging techniques. Pre-donation imaging typically includes contrast-enhanced CT or MRI (arterial, portal venous, and delayed venous phases), MRCP, and 3D reconstruction. This imaging is recommended to perform accurate volumetric analysis and assess the presence of anatomic variants. Importantly, the principal objective is always to minimize the risk of harm to a potential donor while trying to provide adequate liver function to the intended recipient. For liver donors, the degree of perioperative risk appears to be associated with the volume of liver resected.⁶⁻⁷ Donation of left lateral section and left lobe grafts appears to be associated with lower peri-operative risk than donor right hepatectomy.⁸ Donor right hepatectomy is associated with morbidity rates of 24-40% (Clavien grade 1-4) in large cohorts reported from the U.S. and Canada.⁹⁻¹⁰ The donor's future liver remnant (FLR) ideally should be > 30-35% of the total liver volume to minimize risk of post-operative hepatic insufficiency, remnant liver failure, and death.¹¹⁻¹⁴

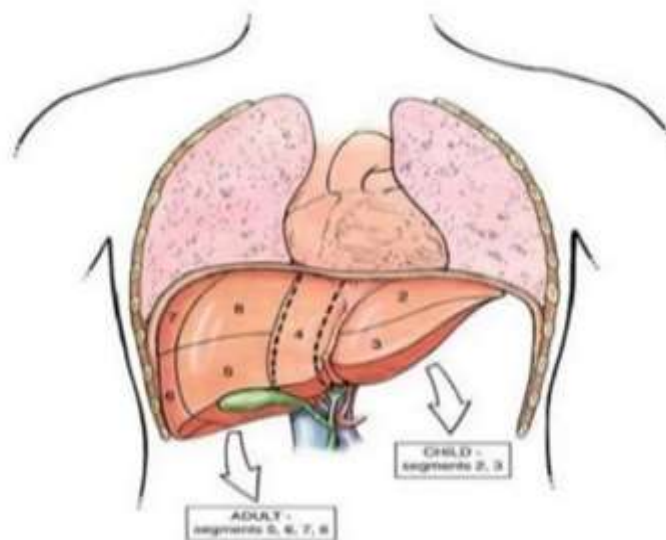


Figure 3: Different part of liver transfer to adults and childrens

Minimally invasive approaches, including laparoscopic procedures, have increasingly been applied in surgery due to their advantages such as reduced surgical trauma, a better quality of life, shorter hospital stay, and less postoperative morbidity compared with open surgeries.¹⁵

Laparoscopic techniques and instruments for living donor hepatectomy, which has become increasingly accepted in the minimally invasive surgery era,¹⁶⁻¹⁷ have a number of differences compared with standard open approach. The major advantage of laparoscopic surgery is that the incision is small and midline, in the supra-umbilical area, which helps prevent scar discomfort.¹⁸ There were remarkably less blood loss and postoperative complications under laparoscopy than open surgery, these results are mainly due to the smaller incision on the abdominal wall and less invasive procedures with clear dissection of blood vessels during laparoscopic operation.¹⁹

Minimal Invasive Liver Surgery (MILS):

An expansive accumulation of global experience in LDLT has fostered technical development and innovation, but concerns regarding donor safety and quality of life remain which have hindered the universal progression and spread of LDLT. Many Studies suggest that donor hepatectomy introduces a 0.2%–0.6% mortality rate and a 20%–40% incidence of overall morbidity.²⁰⁻²² Most of the morbidity associated with open living donor hepatectomy is associated with the operative approach manifesting with incisional pain, surgical site infection, disfiguring scar, hernia, and adhesive intestinal obstruction.²³⁻²⁵ With the revolutionary development of minimal invasive liver surgery (MILS), an international expert panel in Louisville in 2008 promoted the attributes of laparoscopic liver resection for minor and some major liver resections in selected patients at experienced centers.²⁶ Multiple meta-analyses have demonstrated that laparoscopic liver resection not only outperforms open liver resection in terms of blood loss, but may also convey a survival benefit in favor of laparoscopic liver resection, with lower overall and major morbidities in the laparoscopic group.²⁷⁻²⁹

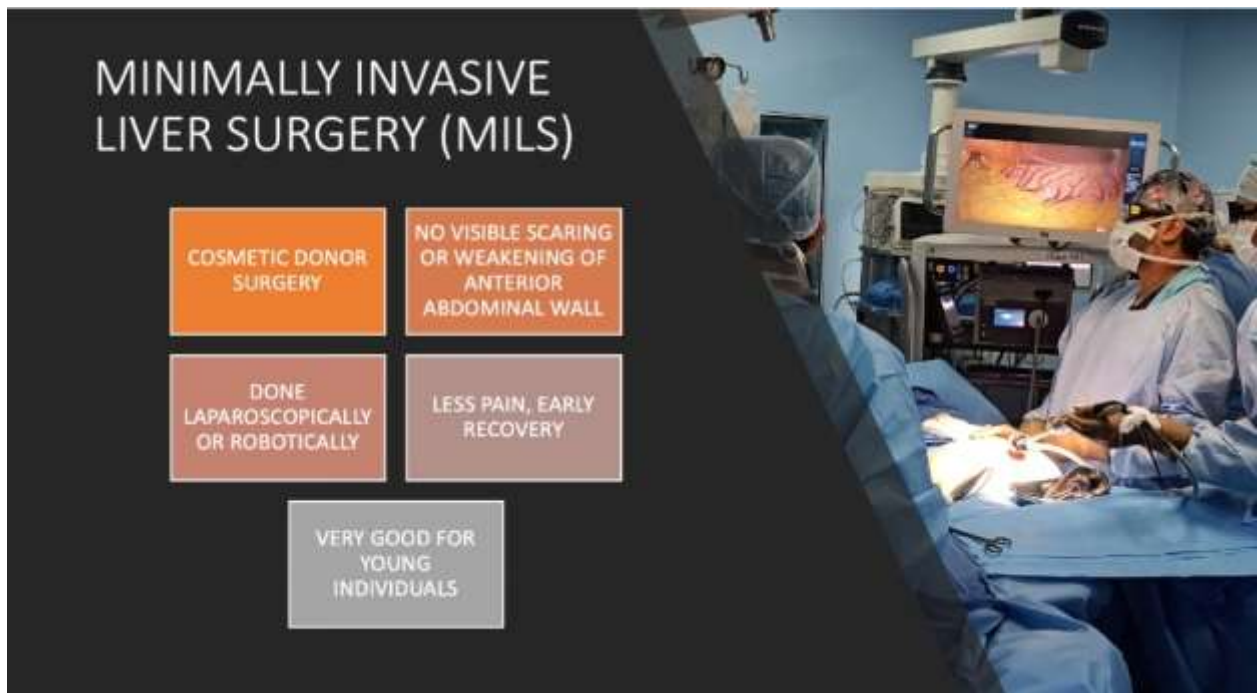


Figure 4: Merits of minimally invasive liver surgery

The first application of MILS in the field of living liver donation occurred in Paris in 2002 by Cherqui and Soubrane resulting in a sentinel proof-of-concept series in donor left lateral sectionectomy (LLS).³⁰

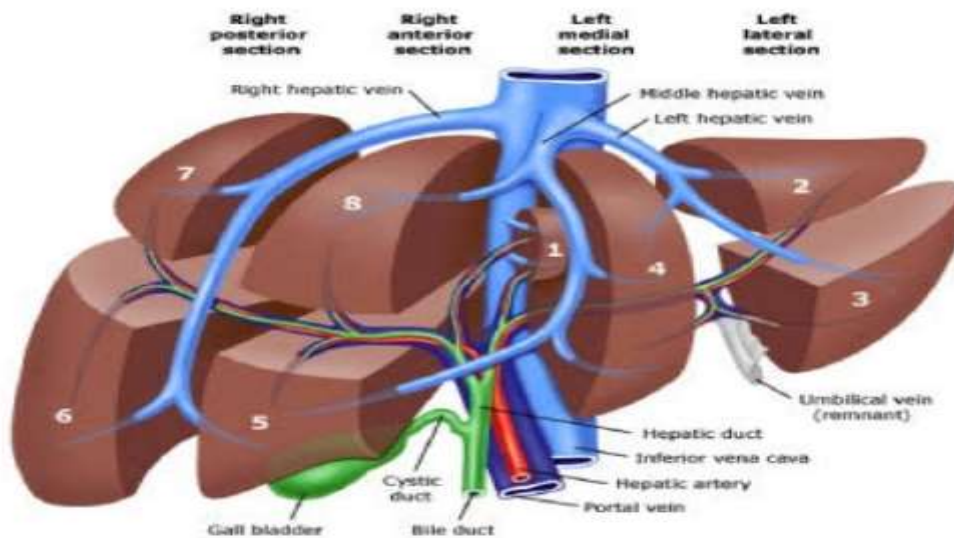


Figure 5: Liver sectionectomy

Several years later in Chicago, Koffron and colleagues utilized hand-assistance to initiate MILS applicability in hemi-liver donation.³¹ Technical advancements continued and pure laparoscopic donor hepatectomy (PLDH) techniques were developed by Han in Korea (right side PLDH, 2010) and Troisi in Ghent (left side PLDH, 2013), which formed the origins of minimally invasive donor hepatectomy (MIDH).³²⁻³³

Advantages of MIDH:

Most of the post-operative morbidities associated with open donor hepatectomy (ODH) deriving from the abdominal wall trauma itself, with short- and long-term disabilities like keloid scar, hernias, pain, and discomfort, and delay in return to normal activities. Eliminating the large, upper abdominal incision and its sequelae would be a major advantage for the donor.³⁴⁻³⁶

In the last two decades, minimally invasive liver surgery has evolved into a well-established clinical effort with the clear intent of avoiding the short- and long-term complications that plague living liver donors undergoing conventional ODH.³⁷⁻⁴¹

Minimally Invasive Techniques:

Some of the numerous innovations to use minimally invasive techniques to improve upon open donor hepatectomies include the following:

- Laparoscopic left lateral segmentectomy⁴²⁻⁴³
- Laparoscopic hand-assisted right hepatectomy.⁴⁴⁻⁴⁵
- Laparoscopic hand-assisted right hepatectomy using midline incision “Hybrid Method”⁴⁶⁻⁴⁸
- Laparoscopic hand-assisted right hepatectomy using a transverse or subcostal incision⁴⁹
- Single port laparoscopic-assisted right hepatectomy using a right subcostal incision⁴⁹
- Right hepatectomy through upper midline laparotomy.^{50,51}
- Right hepatectomy through an upper midline minilaparotomy with or without laparoscopic assistance.⁵²
- Totally laparoscopic full left hepatectomy.⁵³

- Pure laparoscopic right hepatectomy⁵⁴
- Robot-assisted right hepatectomy.⁵⁵

Discussion:

LDLT will continue to play an important role for many patients who have no chance of receiving an organ from a deceased donor in timely fashion. This procedure demands technical expertise in both hepatobiliary surgery and whole-liver transplantation and hard work of multidisciplinary medical team. Every step requires attention and should be planned and performed meticulously. Minimally invasive procedures using laparoscopic techniques for liver graft procurement have the potential to improve donor safety and increase the number of willing living donors and decrease waiting list mortality. laparoscopic approach for living donors could further minimize its invasiveness and benefit donors' postoperative recovery. In order to promote living donation, absolute transparency about the risks and benefits of this procedure is mandatory.

Three decades of work and progress in MILS, DH technique, and LDLT have now merged in such a way that a paradigm shift in living donor surgery is materializing in the form of minimally-invasive donor hepatectomy (MIDH). The impact of MIDH surgery is not limited to simply completing the operation with smaller, better-positioned, or more aesthetically pleasing incisions. Instead, the journey's end for MIDH will only reach its true potential when both the innovations and innovators synergistically join to in making living donation truly safer.

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Declaration of competing interest:

There are is no conflict of interest.

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