



Pure laparoscopic living donor hepatectomy using the Glissonean pedicle approach (with video)

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Abstract

Background The use of pure laparoscopic donor hepatectomy has been increasing, with various advantages reported. However, the Glissonean approach has not been adopted despite its usefulness. The aim of this study was to introduce the Glissonean pedicle approach for laparoscopic living donor hepatectomy.

Methods We retrospectively reviewed data from 11 patients who underwent pure laparoscopic donor hepatectomy for adult living donor liver transplantation. In this novel operative procedure, after mobilization of the liver, the right or left Glissonean pedicle was encircled, and then the liver parenchymal transection was completed. Next, the right or left hepatic artery, portal vein, and hepatic duct were dissected out. The right or left hepatic duct was divided under intraoperative cholangiography guidance using indocyanine green fluorescence, and the hepatic artery and the portal vein were cut. Finally, the hepatic vein was divided using the laparoscopic stapler, and the graft liver was procured via a suprapubic incision.

Results The overall median surgical time was 387 min (range 280–563 min), and the volume of blood loss was 75 mL (21–1228 mL). The warm ischemic time was 5 min (2–10 min). A conversion to open procedure was occurred in 1 patient. A complication, a grade IIIa bile leakage according to the Clavien–Dindo classification, was noted in 1 patient.

Conclusion This is the first report of the Glissonean pedicle approach for pure laparoscopic donor hepatectomy; our results demonstrate the safety and feasibility of this technique.

Keywords Donor · Glissonean · Glissonian · Laparoscopy · Liver transplantation

Laparoscopic liver resection (LLR) has been established as a safe and feasible treatment option for liver tumors, and has become increasingly common owing to its clinical benefits [1–6]. Moreover, the indications for a greater extent of resection have been expanding, with pure laparoscopic major hepatectomy becoming the standard procedure at specialized institutions [7–11]. One method used for this procedure is the so-called Glissonean pedicle approach, an extrafascial approach to the portal pedicle that was introduced by Takasaki and Couinaud [12, 13]. This method constitutes an approach to the pedicles at the hepatic hilus without liver

dissection. As various types of anatomical hepatectomies can be carried out using this approach, it is considered one of the most important procedures in liver surgery [14, 15].

However, despite the importance of the Glissonean approach in liver surgery, it has not yet been reported for pure laparoscopic donor hepatectomy (PLDH). Indeed, expert panel statements regarding laparoscopic living donor hepatectomy in general have been cautious, with more evidence needed to demonstrate its safety and feasibility. This is because the development of donor selection guidelines and technical standardization are still in their early stages, and outcomes of the procedure remain unknown [2, 16–18].

To address these issues, this study aimed to introduce the novel application of the Glissonean approach to laparoscopic living donor hepatectomy, and to provide a preliminary assessment of its outcomes, safety, and feasibility.

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Patients and methods

Ethical statement

This study was approved by our institutional review board. All patients provided informed consent for the procedure.

Patient recruitment

At our institution, laparoscopic donor hepatectomy using a laparoscopy-assisted technique was launched in July 2007. PLDH was later adopted in December 2012, with the Glissonean pedicle approach for PLDH being introduced in November 2017.

For this study, we retrospectively reviewed the prospective database of patients treated with adult-to-adult living donor liver transplantation (LDLT) at our institution. All potential donors underwent dynamic contrast-enhanced computed tomography (CT) and a drip infusion CT cholangiogram to provide liver volumetry and 3-dimensional vessel/biliary anatomy. Our criteria for graft selection were as follows: if the left liver was estimated to have a graft-recipient weight ratio (GRWR) $> 0.7\%$, the left liver with the middle hepatic vein was selected; if the left liver was estimated to have a GRWR $\leq 0.7\%$ and an estimated remnant liver volume of $> 35\%$ of the donor's whole liver volume, the right liver without the middle hepatic vein was selected.

Surgical procedure

Our surgical procedure is demonstrated in the video clips provided with our study's electronic data (Video 1, pure laparoscopic donor right hepatectomy; Video 2, pure laparoscopic donor left hepatectomy). All patients were placed in the reverse Trendelenburg position, and were additionally placed in either the semi-left lateral decubitus position for right liver grafts or the supine position for left liver grafts. The surgeon stood on the right side of the patient, while the assistant and scopist stood at the patient's left side. Five to six ports were placed, and a carbon dioxide pneumoperitoneum was maintained at 10 mmHg.

After the liver biopsy, the gallbladder was removed and the right or left liver was mobilized. For left liver donor hepatectomy, the Arantius duct was divided. The right or left Glissonean pedicle was then encircled and controlled. To overcome the restriction of movement during this step, Nitta forceps was used. This instrument was originally developed for the Glissonean pedicle approach and the hanging maneuver in mini-laparotomy procedures [19]. For right liver grafts, the Nitta forceps was inserted from the left edge

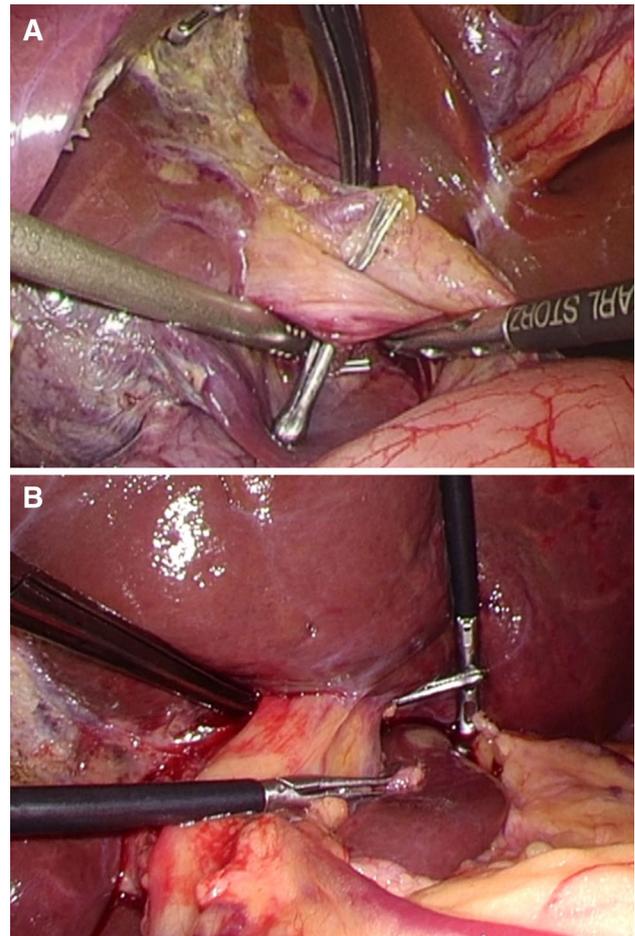


Fig. 1 Encircling of the right Glissonean pedicle (A) and the left Glissonean pedicle (B)

of the anterior Glissonean pedicle and emerged from the dorsal side of the right Glissonean pedicle (Fig. 1A). For left liver grafts, the Nitta forceps was instead inserted from the right edge of the root of the umbilical portion and emerged from the cranial side of the divided Arantius duct (Fig. 1A).

The Glissonean pedicle was then clamped temporarily, and the demarcation line was revealed and marked. The middle hepatic vein was observed using ultrasonography. Next, the liver parenchyma was transected, during which the controlled Glissonean pedicle served as an important landmark. For right liver grafts, the parenchyma was transected between the demarcation line, the middle hepatic vein, the Glissonean pedicle, and the inferior vena cava. For left liver grafts, the parenchyma was transected between the demarcation line, the middle hepatic vein, the Glissonean pedicle, and the Arantius plate. Use of these landmarks avoided disorientation, which is one of the disadvantages of laparoscopic surgery. After the liver parenchymal transection

was completed, the hepatic vein was encircled. To control bleeding from the liver parenchyma, the intermittent Pringle maneuver was routinely used. Additionally, low central venous pressure, low airway pressure, and low tidal volume contributed to the control of bleeding from the hepatic vein.

The hepatoduodenal ligament was dissected, and only the corresponding hepatic artery and portal vein were dissected out and freed from the Glissonean pedicle. Then, the hepatic duct was encircled by subtracting the hepatic artery and portal vein from the Glissonean pedicle (Fig. 2A, B). Before transection of the hepatic duct, intraoperative cholangiography using indocyanine green fluorescence with near infrared light was performed to confirm the precise cutting line. After heparinization, the right or left hepatic artery was clipped. Subsequently, the right or left hepatic duct was clamped with a Hem-O-Lok clip (Weck Closure System; Research Triangle Park, NC, USA) and cut. The hepatic artery was cut, and the portal vein was clipped and cut. The

hepatic vein was divided with a laparoscopic stapler (Eshelon 7; Ethicon Endosurgery, OH, USA). Finally, the liver graft was put in a plastic bag and procured via a suprapubic incision (9-cm incision for right liver grafts and 7-cm incision for left liver grafts).

Results

The clinical records of 11 patients who underwent PLDH using the Glissonean pedicle approach were reviewed and analyzed. Donor characteristics and operative outcomes are summarized in Table 1. In all patients, hilar dissection could be performed using the Glissonean pedicle approach. A conversion to open laparotomy was required due to bleeding from the right hepatic vein secondary to misfire of the laparoscopic stapler. The complication that occurred in 1 patient was a grade IIIa bile leakage according to the Clavien–Dindo classification.

Regarding recipient outcomes, 3 biliary complications occurred, including 2 bile leakages, and 1 stenosis of the duct-to-duct anastomosis. No vascular reconstruction complications, including hepatic artery thrombosis, portal vein stenosis, and outflow block of the hepatic vein, occurred.

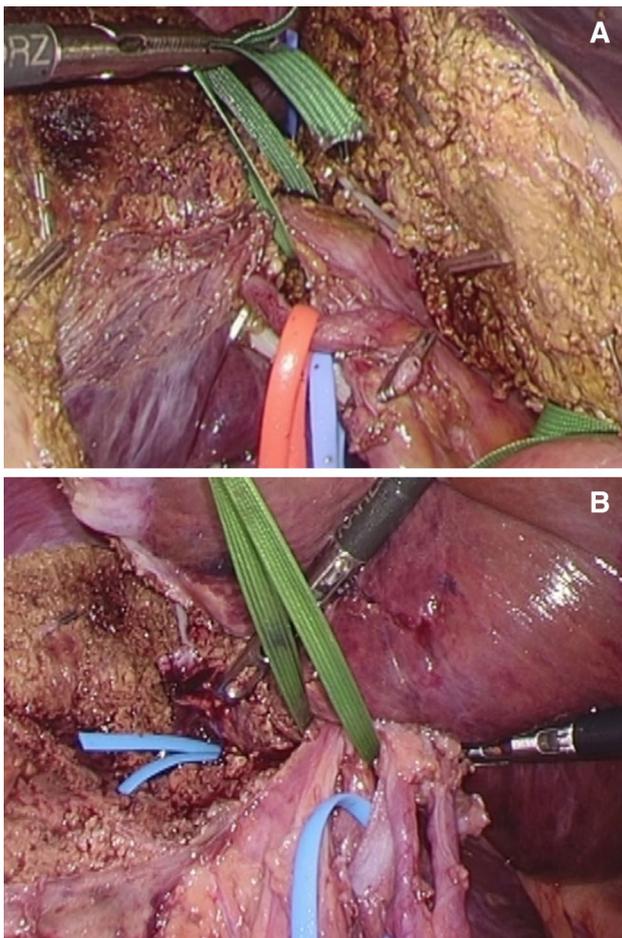


Fig. 2 The right hepatic duct (A) or the left hepatic duct (B) was encircled by subtracting the hepatic artery and portal vein from the Glissonean pedicle

Table 1 Characteristics and operative outcomes of donors

Donor characteristics	
Number of patients	11
Age (years)	42 (18–53)
Sex	
Male	5
Female	6
Graft type	
Right without middle hepatic vein	8
Left with middle hepatic vein	3
Estimated graft volume (mL)	717 (326–1083)
Estimated future remnant liver (%)	38.3 (30.2–69.3)
Actual graft weight (g)	659 (272–898)
Donor operative outcomes	
Operative time (min)	387 (280–563)
Blood loss (mL)	75 (21–1228)
Blood transfusions	0
Conversions to open laparotomy	1
Duration of Pringle maneuver (min)	53 (32–68)
Warm ischemic time (min)	5 (2–10)
Complications	1
Length of hospital stay (days)	11 (8–96)

Data are presented as number or median (range)

Discussion

LDLT has become a widely accepted therapeutic modality due to the limited availability of cadaveric donors, especially in East Asia. The most important principle of LDLT is to ensure minimal risk to the healthy donor, as well as to ensure that surgical invasiveness is minimized as much as possible. These principles can be achieved with PLDH, which contributes to rapid recovery and the lessening of physical and mental burdens on patients who undergo the procedure. Recently, reports of PLDH have been increasing, with a meta-analysis demonstrating that laparoscopic donors have less operative blood loss and shorter hospital stays than those who undergo open laparotomy, with no significant differences in postoperative complications [20–30]. Furthermore, Rotellar et al. reported that long-term abdominal wall complications are decreased in donors who have undergone PLDH [31].

Despite these advantages, PLDH has not been well-received by the surgical community due to concerns about both donor safety and technical difficulty. To address these issues at our institution, the indications for LLR were extended in a stepwise manner, and the approaches for donor hepatectomy were changed in a step-by-step fashion to ensure patient safety [29, 32, 33]. We also reiterate the points raised in recent expert panel consensus reports: that laparoscopic donor hepatectomy should be performed only by highly proficient surgeons with extensive experience in both LDLT and LLR, and that the widespread diffusion of this technique cannot be currently recommended [2, 18].

Nevertheless, we believe that our technique has several advantages, which result from 2 distinctive features: the Glissonean approach and the dissection of the portal pedicle after the liver parenchymal transection. Regarding the first feature, few institutions apply the Glissonean pedicle approach for open donor hepatectomy [34, 35], and it has not been adopted at all for laparoscopic donor hepatectomy. Although the Glissonean pedicle approach in LLR is still challenging due to the restriction of movement associated with laparoscopic surgery, it has several merits. First, the controlled Glissonean pedicle becomes a landmark for liver parenchymal transection. This is useful as one of the disadvantages of laparoscopic surgery is disorientation. With our technique, the Glissonean pedicle, demarcation line, and middle hepatic vein serve as good landmarks for guidance during parenchymal transection. Second, because Glisson's capsule is stronger and thicker than bile ducts, the Glissonean approach may avoid injuring small bile ducts running from the caudate lobe. Third, minimal dissection around the hepatic duct is possible using the subtraction method, helping in avoiding damage to the peribiliary arterial plexus.

Regarding the second distinctive feature of our technique, the dissection of the portal pedicle after parenchymal transection provides a good surgical view at the hilus during exposure of the hepatic artery and portal vein. This can be achieved because this step separates the right and left liver, thus expanding the surgical space. Moreover, views from several angles can be obtained during dissection of the hepatic duct, enabling the cutting line of the hepatic duct to be exposed. As the portal pedicle dissection procedure in laparoscopy is still challenging, our strategy of carrying this out after parenchymal transection may help overcome some of the disadvantages of laparoscopic surgery.

Concerning operative outcomes, only 1 case developed a complication. This patient experienced bile leakage at postoperative day 9 and required percutaneous transhepatic biliary drainage. Although the cause of bile leakage was not obvious, we can conclude that due to the late development of this complication, arterial plexus blood flow around the bile duct might have been reduced. This may have been associated with a minor abnormality of the patient's liver anatomy, whereby bifurcation of the hepatic duct was embedded in the remnant left liver, and the right hepatic artery ran near the stump of the hepatic duct. To avoid similar complications in such cases in the future, less dissection between the hepatic artery and hepatic duct should be performed. Moreover, 1 case was converted to open laparotomy due to bleeding secondary to misfire of a laparoscopic stapler. This was caused by a metal clip used for division of a short hepatic vein. Attention should be paid to avoid this occurrence. However, rapid conversion and hemostatic suturing were performed, preventing a disastrous situation nor need for blood transfusions.

Complications in recipients were also scarce, and included two cases of bile leakage and 1 case of stenosis of the duct-to-duct anastomosis. Vascular complications, including hepatic artery thrombosis, portal vein stenosis, and outflow block of the hepatic vein, did not occur. The types of vascular cutting devices are limited in laparoscopic surgery compared to open laparotomy. Nevertheless, the operative outcomes of our patients demonstrate that laparoscopic staplers and clips should be made available during donor hepatectomy.

Despite the insights provided by this study, there are some limitations to consider. First, the number of cases was limited. Second, we could not compare outcomes of the Glissonean approach versus the individual dissection approach, which are decided based on the surgeon's preference.

In conclusion, we found that the Glissonean approach for PLDH could be successfully performed with good operative outcomes. Thus, we believe that this novel technique is safe and feasible for laparoscopic living donor hepatectomy, and could be recommended for suitable cases in the future.

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Compliance with ethical standards

Disclosures Drs. Yasushi Hasegawa, Hiroyuki Nitta, Takeshi Takahara, Hirokatsu Katagiri, Shoji Kanno, and Akira Sasaki have no conflicts of interest or financial ties to disclose.

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