



Various techniques for bile duct division in pure laparoscopic donor hepatectomy

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Background: Pure laparoscopic donor hepatectomy has advantages than conventional donor hepatectomy or laparoscopy-assisted hepatectomy. But bile duct division is the most difficult things during operation. The initial period, there was many trials to make safe and feasible technique. We describe different methods and chronical change of bile duct division methods in pure laparoscopic donor hepatectomy.

Methods: Between January 2016 and December 2018, we performed 92 cases of pure laparoscopic donor hepatectomy. We usually use ICG cholangiography intraoperatively for bile duct division. We divided 3 period as the methods for of bile duct division. (I) Suture, (II) metal clip, (III) Hem-o Lok were used for each period.

Results: There was no bile duct complication after changing our method for bile duct division. Suture method is the same procedure with that of open donor hepatectomy. But it is time consuming procedure than other method and sometimes it caused remnant bile duct stenosis. Metal clip is easy to apply but it can be spillages when the bile duct is thick. Hem-o-Lok can be solution of these problem. We need to dissect more around bile duct for applying that. But there were no spillages during operation. And there was no bile leak at the remnant stump.

Conclusions: Various bile duct division technique had several merits and drawbacks. We should choose appropriate method for safe pure laparoscopic donor hepatectomy.

Keywords: Laparoscopy; liver; donor; bile duct division

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Introduction

Laparoscopic liver surgery (LLS) has been accepted as a tool of the management of several kind of liver diseases in the world. It has advantage of short hospital stay, early recovery and wound cosmetic aspect. The initial period, there was many trial to make safe and feasible technique (1,2). Even the expert panel found that laparoscopic adult living donor hepatectomy is in the development phase with unclear benefit-risk ratio and long-term outcomes

of donors and recipients (3). However, the indications for LLS has expanded recently from minor liver resect to major liver resections for various liver tumors with feasible short- and long-term outcomes (4-6). And indication of LLS now expanded to living donor hepatectomy. Many centers have reported their feasible and excellent outcome of pure laparoscopic donor hepatectomy (7-11). However, biliary complications after liver transplantation are a concern for both donors and recipients. Appropriate bile duct division using laparoscopic instruments should be

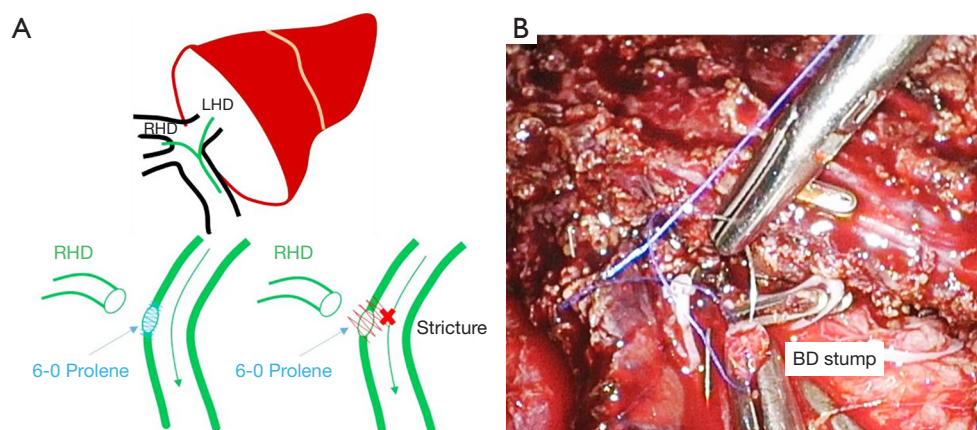


Figure 1 Description of suture method for bile duct division. Suture closure method is exactly same with open surgery. But sometimes suture material make left hepatic duct narrow partially. And suture method also relatively difficult than other methods. RAHD, right anterior hepatic duct, RPHD; right posterior hepatic duct; LHD, left hepatic duct.

emphasized in this aspect. There were many efforts to ensure accurate bile duct division. For example, Primovist MRI can be used to confirm the bile duct anatomy before surgery, or intraoperative cholangiography can be used to accurately perform bile duct division (12,13). Recently, ICG cholangiography has been reported to help safely perform bile duct division during surgery (14). However, there are still some differences in how to handle bile duct stumps. We describe different methods and chronological changes of bile duct division methods in pure laparoscopic donor hepatectomy. This report aims to describe our procedure for safe pure laparoscopic adult living donor hepatectomy with several techniques of bile duct division.

Methods

Between January 2016 and December 2018, we reviewed the 92 cases of adult living-donors who underwent pure laparoscopic donor hepatectomy by a single surgeon (Lee K.W.) at Seoul National University Hospital, Seoul National University, Korea. We described the technique of bile duct division in three different ways. This study was approved by the Institutional Review Board (IRB) at Seoul National University Hospital (SNUH) number “1812-062-993” which waived the need for informed consent.

Surgical technique

The surgical technique had been described before (Hong *et al.*, 2018) (15). Here, we describe a single surgeon (Lee

K.W.) technique, in short, emphasizing important technical tips for pure laparoscopic adult living donor hepatectomy for donors focused on bile duct division (*Figure 1*).

Donor position and Port placement

The donor was placed in lithotomy and reverse Trendelenburg position with right side upward tilt. The surgeon stands between the donor's legs, assistant and scopist stand on the donor's left side. CO2 pneumoperitoneum was maintained at 12 mmHg, and five port system was used.

Liver parenchymal transection

The superficial layer of the liver parenchyma is divided using energy device (THUNDERBEAT®; Olympus Medical Systems Corp., Tokyo, Japan). The deep portion of the parenchyma is transected by cavitron ultrasonic suction aspirator (CUSA®; Valleylab, Inc., Boulder, CO, USA). Hepatic veins draining segments V and VIII were clamped by Hem-O-Lok and divided to be reconstructed on bench surgery. After transecting the main part of the parenchyma, the hilar plate is approached. Real-time ICG near-infrared fluorescence cholangiography is used to identify bifurcation of the right and left hepatic ducts

Identification of Bile duct with ICG cholangiography

All donors were assessed preoperatively for a history of

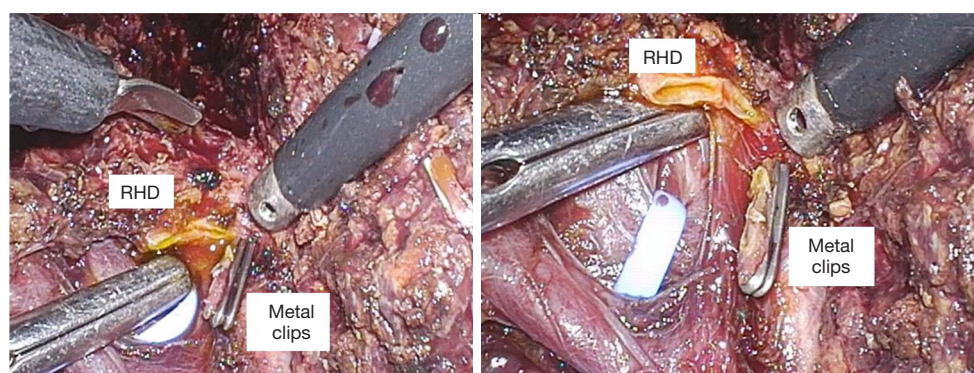


Figure 2 Description of metal clips application for bile duct division. Metal clip is easily applicable and quick. Two-10 mm metal clips usually be applied to bile duct stump. But, if there are thick tissue around bile duct or huge bile duct, it has high chance of slippage.

iodine allergy and anaphylactic reactions to any other drugs. ICG (0.05 mg/kg) was injected intravenously 60 minutes before the dissection of the hilar plate. After comparing real-time ICG fluorescence cholangiography and preoperative delayed phase of Primovist MRI image, the bifurcation of the right and left hepatic ducts were carefully dissected. When the right or left hepatic duct was well visualized, the appropriate resection point of the bile ducts was determined. After rechecking the patency of the remnant side of the bile ducts and the common bile duct (CBD), we resected the bile duct along the marked line.

Bile duct division

Suture

This method is mainly used in open donor hepatectomy. After identifying the right hepatic duct, applying the tagging suture between right and left bifurcation site with 6-0 Prolene. Pull downward the tagging suture by assistant then we resected right bile duct. After resection, the stump was closed with continuous suture using 6-0 Prolene. At this time, lifting the initial point of the suture by using the grasp of the assistant. This can prevent the bile duct stricture of the remnant left hepatic duct (*Figure 1*).

Metal clip

After checking the position of the right bile duct, tunnel through the Y-shape using the dissector. At this time, lower the power of the electrocautery to prevent damage to the biliary tract that may occur elsewhere. After tunneling, isolate the right bile duct with a dissector and ligation one 10mm metal clip. Then we rechecked the ICG

cholangiography to determine if the distance to CBD is appropriate. Then we also applied the 10mm clip in the same way, and resect the right bile duct. If we performed bile duct division to the case of multiple bile duct opening, this method can be applied repeatedly. It is easy and quick to apply and has a merit that it is easy to apply and can be applied to the case of a short length of right CBD because the shape is thin. (*Figure 2*)

Hem-O-Lok

As we mentioned the way to use the metal clip described above, the right bile duct is separated and then Hem-o-Lok can be applied. If there is not enough space for two Hem-O-Loks, you can apply another 10 mm metal clip on the top. It is better to apply to a thick or wide bile duct than the metal clip because the metal clip sometimes slipped from remnant thick bile duct stump. And it prevents the massive dissection around bile duct that could because of bile duct ischemia (*Figure 3*).

Remnant Glisson tissue ligation

Remnant Glisson tissue should be ligated for preventing bile leakage from small branch of caudate duct. It can be performed by Hem-O-Lok or Endostapler. Hem-O-Lok is suitable usual case, Endostapler is suitable for wide Glisson tissue division. When we used the stapler for this procedure, we need more space between portal vein and bile ducts. Especially, if the right posterior duct cross over the portal vein, this procedure would be dangerous. Therefore, we should be careful for preventing injury to right post duct during stapling (*Figure 4*).

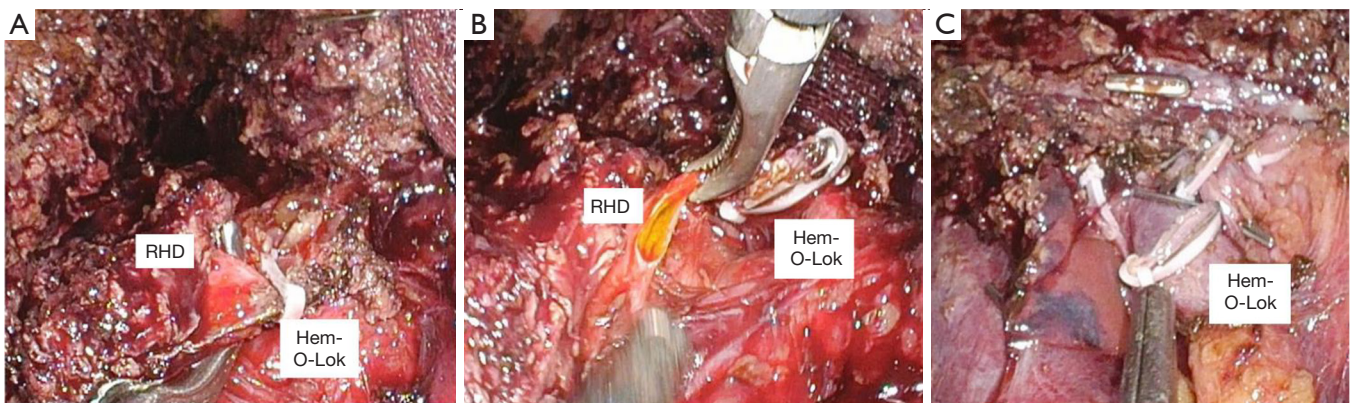


Figure 3 Description of Hem-O-Lok application for bile duct division. Hem-O-Lok clip is also easily applicable and quick. Small size of Hem-O-Lok usually be applied to bile duct stump. If there are thick tissue around bile duct or huge bile duct, it is better than metal clips because it has little chance of slippage. But Hem-O-Lok needs wider space than metal clip for applying to bile duct.

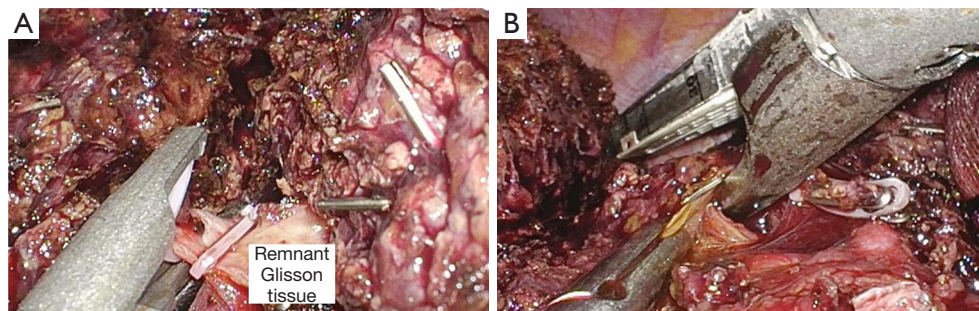


Figure 4 Remnant Glisson tissue ligation (Hem-O-Lok *vs.* Endostapler). Remnant Glisson tissue should be ligated for preventing bile leakage from small branch of caudate duct. It can be performed by Hem-O-Lok or Endostapler.

Results

In this study, we present a single surgeon's tip of various bile duct division in pure laparoscopic adult living-donor hepatectomy. We used intraoperative ICG cholangiography for checking bile duct anatomy in every case. The biliary stricture occurred only 1 case of the suture method group. There was no stricture or leakage in metal clips and Hem-o-Lok clip groups. We described the merit and drawbacks of each method in *Table 1*.

Operative outcomes

No open conversions occurred in this series. The mean operative time of donors was 227.6 ± 68.46 minutes and the mean estimated blood loss was 241.8 ± 177.3 cc. None of the donors in this series received intra- or postoperative blood transfusion. All donors started ambulation on the

1 day after the operation. Sips of water was started on the first post-operative day. Most donors had no biliary complication. Only one donor (1.1%) had a biliary stricture in the case of the suture closure method. This donor developed prolonged cholestasis requiring re-operation (grade III morbidity, according to Clavien-Dindo classification) (16). It was related to suture material for remnant bile duct stump closure. After re-operation, it is not necessary to do additional treatment for this donor. We changed our policy of the bile duct division method after this event. There was no re-hospitalization due to biliary complications that were required intervention during the follow-up period of the donors in this series. In the recipients, there were 7 cases (7.6%) of biliary complication that was required intervention. There was no mortality related to bile duct complications in these recipients.

Table 1 Merits and drawbacks of three different methods for bile duct division in pure laparoscopic donor hepatectomy

	Suture	Metal Clips	Hem-O-Lok Clips
Merits	<ul style="list-style-type: none"> • Safe • Similar to open approach • No concerns about slippage of closing material 	<ul style="list-style-type: none"> • Good control of small sized bile duct (separated 2BD) • Safe and precise • Requires narrow space • Easy to apply additional clips 	<ul style="list-style-type: none"> • Removable and re-adjustable • Easily applied in limited space between RPV branches
Drawbacks	<ul style="list-style-type: none"> • Time consuming • Requires meticulous suturing skills • Possible slippage and subsequent bleeding during suturing 	<ul style="list-style-type: none"> • High chance of slippage 	<ul style="list-style-type: none"> • Possible slippage and subsequent bleeding • Requires more wider space than metal clips • Huge remnant material

Discussions

Bile duct division is the most important step for reducing biliary complications after liver transplantation in both donors and recipients. Therefore, it is important to know the exact structure of the biliary tract before and during surgery. Some centers do not offer laparoscopic donor surgery in consideration of donor safety in the donor with bile duct anatomic variations (7,17). An intraoperative cholangiogram also has been used to identify the anatomy of the biliary tract during surgery for safe bile duct division. Recently, preoperative Primovist MRI has been used to identify the anatomy of the biliary tract in a non-invasive manner. Despite these efforts, bile duct division is still an important challenge to overcome in pure laparoscopic donor surgery. In the case of laparoscopic donor hepatectomy, it is not easy to confirm the bile duct during surgery as compared to open donor hepatectomy, and if it is not safely ligated, the donor may have problems such as leakage of the bile and biliary stricture. Therefore, learning the methods for safe bile duct division in pure laparoscopic donor hepatectomy is a key factor for donor safety and good surgical outcomes in the center that want to set up pure laparoscopic donor hepatectomy.

SNUH's initial principle of laparoscopic donor hepatectomy is the same way with open donor surgery should be applied in laparoscopic donor surgery. Initially, the suture method was used like an open donor surgery. There was no big problem in initial cases, but the laparoscopy suture method is relatively difficult compared

to the open surgery and it is relatively unfavorable for implantation of graft bile duct because it must contain enough stump. The most significant disadvantage was that stenosis of the left bile duct could be occurred in some case and that might be related to difficulty of laparoscopic suture to small bile ducts in the case of multiple bile duct donors. Recently, we changed the primary method with a metal clip or hem-O-Lok. But, if there were bile spillage from bile duct stump in several cases or if it is difficult to apply a large material such as a metal clip or hem-O-Lok due to narrow space, the suture can also be a good alternative.

Since ICG cholangiography has been used, accurate anatomy of the biliary tract can be identified, making it easier to use metal clips or hem-O-Lok (17,18). It is easy to encircle the bile duct, and depending on the size, the biliary duct can be sufficiently ligated with only a metal clip. Even in the case with bile duct variation, we can perform safely based on ICG image (*Figure 5*) (19).

However, similar with case of cholecystectomy, the metal clip sometimes slippages when ligation of thick ducts. In these cases, hem-O-Lok could be a good alternative. However, because hem-O-Lok is relatively thick and large, it is important to make an appropriate selection according to the size and thickness of the bile ducts. *Table 1* describes the advantages and disadvantages of each method. The limitation of this study is not a comparative study of each method because we chose each method by considering operative field, bile duct thickness, and number of duct opening. Therefore, each group has different

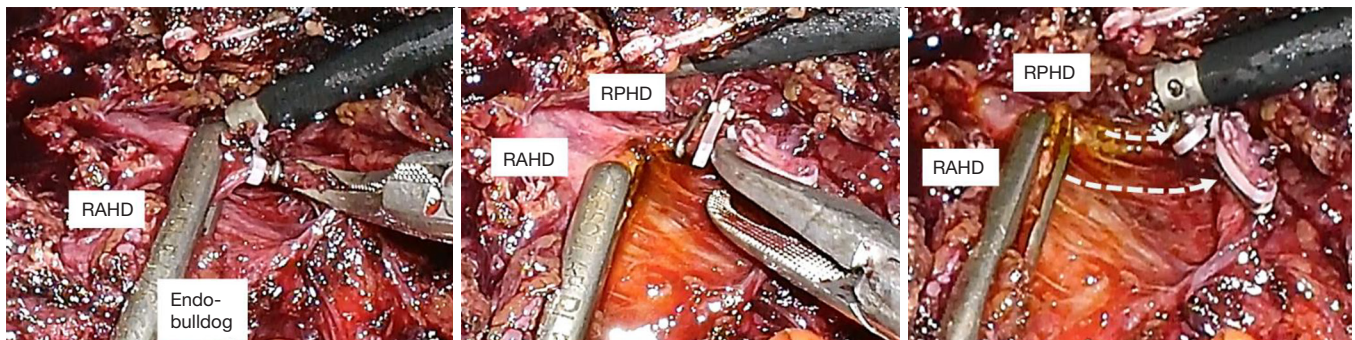


Figure 5 Bile duct division under ICG cholangiography (2 bile duct). ICG cholangiography is useful modality to identify separated RABD and RPBD. Temporary clamping of RABD stump (donor side) before division of RABD is helpful tip for preventing bile leakage from stump. After that, we can use ICG cholangiography for RPBD division.

demographics and not homogenous. Currently, the method will be updated chronically using mainly hem-O-Lok. Therefore, comparing the results of these three methods is not appropriate considering factors such as the learning curve. As mentioned above, the main purpose of this study is to show that each method can be applied in various cases depending on the advantages and disadvantages of each method and the overall results of applying the three methods are feasible. We wanted to focus on the technical issues about method of bile duct division and each merit and drawbacks. There have been recent reports of laparoscopic donor studies and they are known to be feasible for their stability and complications. However, few studies described detail about the bile duct division methods. Because almost studies focused primarily on outcomes rather than detailed descriptions of surgical methods, there is a lack of adequate guidance and useful information for the surgeon in centers that are preparing for laparoscopic donor surgery. SNUH currently achieved more than 350 cases of pure laparoscopic donor hepatectomy. Based on these experiences, merit and drawbacks about various methods of bile duct division are described in this article. It will be a good guide to future laparoscopic donor surgeons.

In conclusion, laparoscopic adult living donor hepatectomy is a technically challenging procedure requiring many advanced laparoscopic techniques. Various bile duct division technique had several merits and drawbacks. We should choose the appropriate method for safe pure laparoscopic donor hepatectomy. The current series will be a step towards further expansion of the laparoscopic adult living donor hepatectomy in the world by giving them information about the detailed surgical procedure of bile duct division.

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Footnote

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