



Pure laparoscopic donor right hepatectomy: perspectives in manipulating a flexible scope

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Received: 11 July 2018 / Accepted: 13 November 2018 / Published online: 21 November 2018
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Abstract

Background Interest in pure laparoscopic donor hepatectomy (PLDH) is increasing worldwide with the donor's cosmetic demands and improvements in surgical techniques. Efficient manipulation of flexible scope is mandatory for successful PLDH, especially in right hepatectomy which requires more mobilization. This study provides guidelines on how to manipulate optimally a flexible scope.

Methods Data from 158 donors who underwent pure laparoscopic donor right hepatectomy (PLDRH) between November 2015 and December 2017 were retrospectively reviewed.

Results None of the donors required transfusion, conversion to open hepatectomy, or experienced any irreversible disabilities or mortalities. Three types of laparoscopic view provided by the flexible scope, which are bird's eye view, low angle view, and lateral view, were applied to each step of the procedure.

Conclusions PLDRH can be successfully performed with maximizing visibility given by the tips and pitfalls in manipulating the flexible scope.

Keywords Living donor liver transplantation · Donor hepatectomy · Laparoscopy · Right hepatectomy · Flexible scope

Abbreviations

PLDRH Pure laparoscopic donor right hepatectomy
IVC Inferior vena cava
CUSA Cavitron ultrasonic aspirator

Although pure laparoscopic donor right hepatectomy (PLDRH) was shown to be feasible and safe [1–11], these

Suk Kyun Hong and Eunhye Shin contributed equally to this work as co-first authors.

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s00464-018-6594-1>) contains supplementary material, which is available to authorized users.

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studies focused on the operator, not on the assistant who manipulates the scope. The latter presents the laparoscopic view to the operator and may influence the performance of the surgeon. Manipulation of the scope is especially important in laparoscopic liver surgery because of the relatively small space available to manipulate instruments [11]. Moreover, even small mistakes cannot be tolerated during donor surgery. Successful manipulation of a flexible scope is therefore important for successful laparoscopic donor hepatectomy.

PLDRH was first performed in our center in November 2015, with about 90% of live donors undergoing this procedure without any selection criteria. We previously reported the details and outcomes of our surgical technique for PLDRH, showing that this procedure was both feasible and safe [6–9]. This study reports technical tips and pitfalls in manipulating the flexible scope during PLDRH.

Materials and methods

Patients and data

The institutional review board of Seoul National University Hospital approved this study (IRB no. 1805-090-946). Of the 166 living donors who underwent pure laparoscopic hepatectomy between November 2015 and December 2017, eight underwent other than right or extended right hepatectomy and were excluded. PLDRH was performed in selected donors with no anomalies of the bile duct or portal vein until February 2016. Since March 2016, PLDRH has been performed in all donors without any selection criteria, unless the 3D flexible scope system was not available on the day of surgery or the donor refused to undergo laparoscopic surgery. The medical records of the 158 included donors were retrospectively reviewed.

Surgical technique

The technique used for PLDRH has been described in detail [6–9]. An Endoeye Flex 3D laparoscope (Olympus, Tokyo, Japan) was used in all donors. This flexible scope provided three types of laparoscopic view. The first, a bird's eye view, as in open surgery, was used throughout each operation (Fig. 1A). The second, a low angle view, obtained by lifting up the scope handle and bending the end upward, was used when there was not enough space on the top, making the bird's eye view difficult to access (Fig. 1B). The third, a lateral view, obtained by fully moving the scope handle to the lateral side while bending the end medially, was used when approaching from the side (Fig. 1C).

During mobilization of the falciform ligament and moving to the upper part of the inferior vena cava (IVC), the low angle view was changed to the bird's eye view (Fig. 2A). The scope was gradually inserted into the abdomen while pushing down the handle and bending the end down. The bird's eye view was also used during mobilization of the coronary and triangular ligaments (Fig. 2B). The handle of

Fig. 1 The three types of laparoscopic view provided by the flexible 3D scope. **A** bird's eye view. **B** Low angle view. **C** lateral view. **D** Manipulation of the extra-abdominal space for the bird's eye view. **E** Position of the scopist. **F** Proper position of the patient's legs

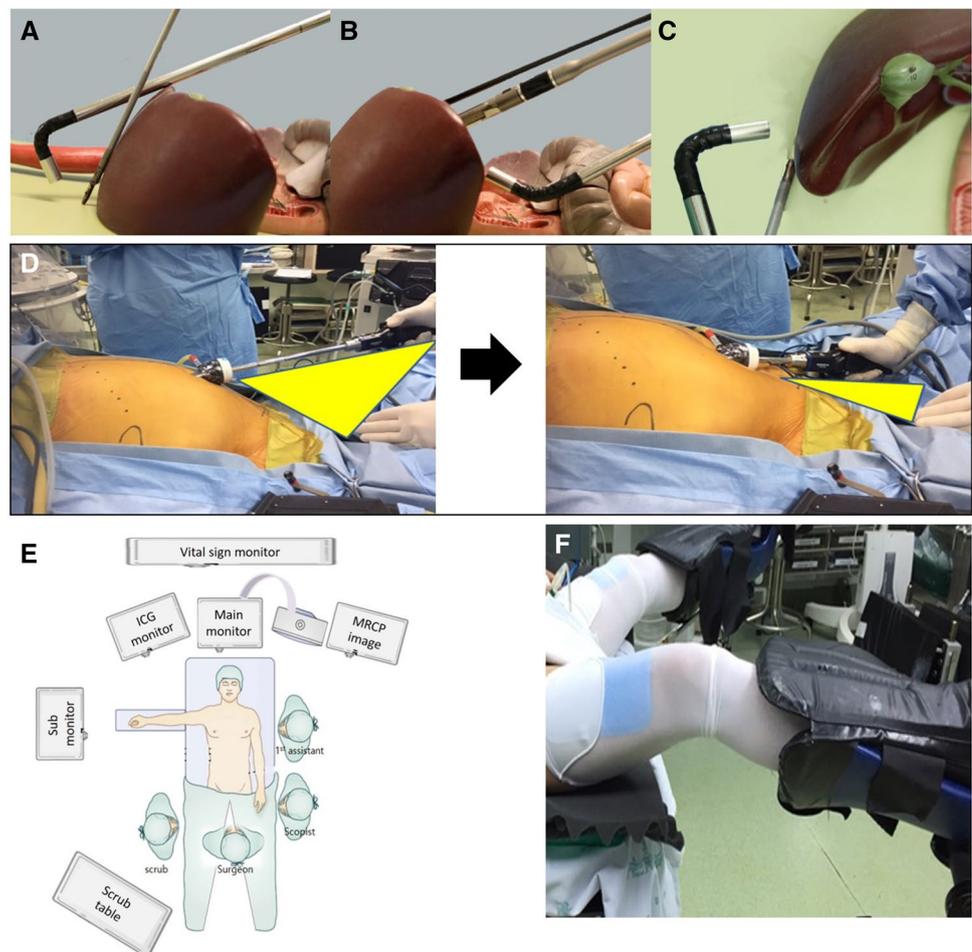
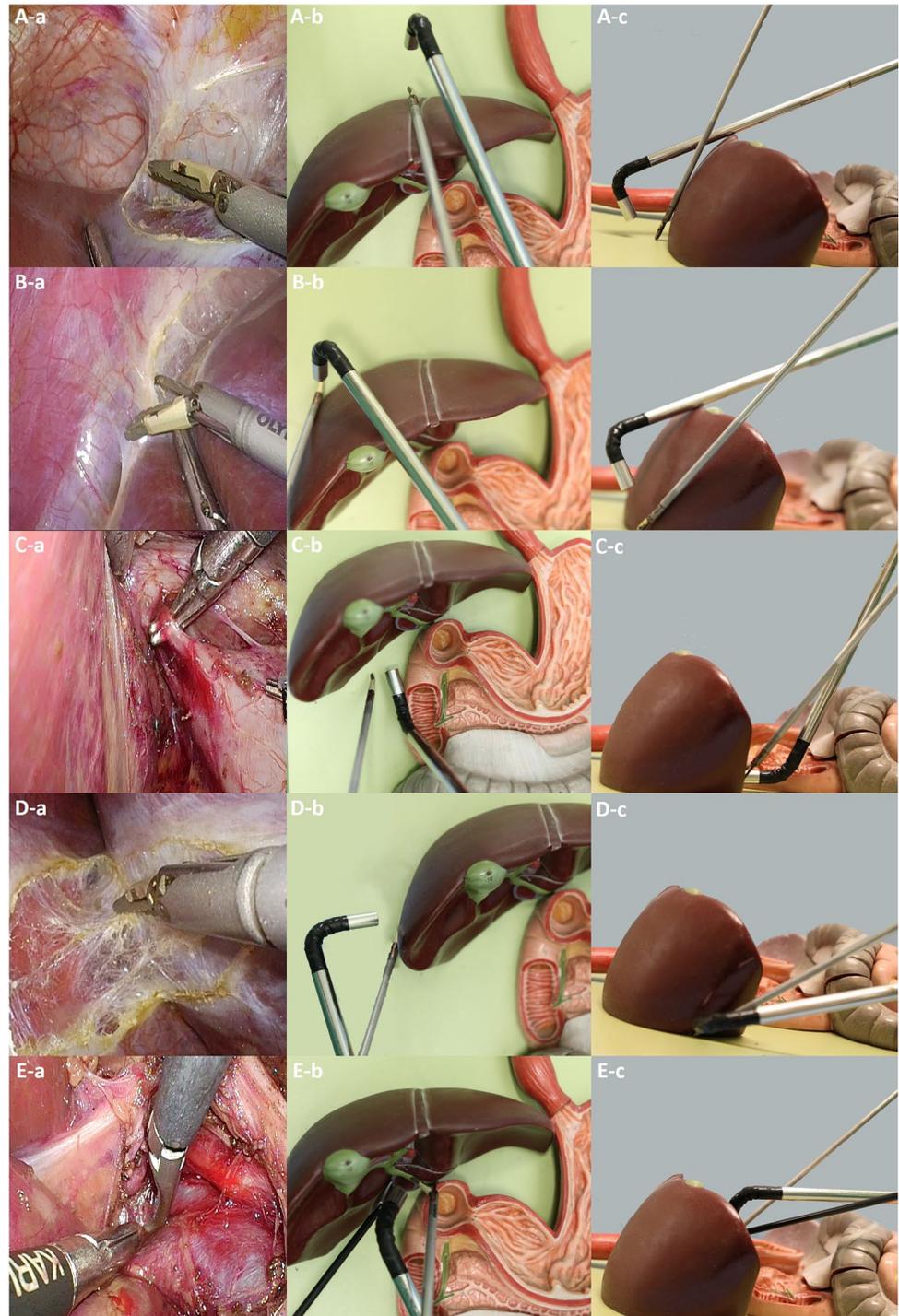


Fig. 2 Position of the scope and other instruments during each surgical stage. **A** Falciform mobilization. **B** Mobilization of the coronary and triangular ligaments. **C** Inferior liver mobilization. **D** Mobilization of the lateral portion of the liver. **E** Hilar dissection. a, Actual laparoscopic view. b, Front view. c, Side view



the scope was pushed down to the patient's side as far as possible, and the end was bent to a maximum of at least 90° while moving only to the right and left. The low angle view was generally used for inferior liver mobilization and dissection of the liver from the IVC, because of the limited access provided by the bird's eye view (Fig. 2C). During mobilization of the lateral portion of the liver, most of the liver was lifted and turned by holding the remnant end of the

right triangular ligament (Fig. 2D). For hilar dissection, the scope was moved close to the gallbladder bed with its end bent medially (Fig. 2E). The position of the scope during parenchymal transection was dependent on the direction of the caviron ultrasonic aspirator (CUSA), as determined by the selection of the working port. For example, if the working port was located medially and the CUSA was inserted in a lateral direction from the medial, the scope was inserted

in a lateral to medial direction while using the bird's eye view (Fig. 3A). Conversely, if the working port was located laterally and the CUSA was inserted in a lateral to medial direction, the scope was inserted in a medial to lateral direction while using the bird's eye view (Fig. 3B). The scope was also inserted in a lateral to medial direction when transecting segment 8, which is located in the cranial portion (Fig. 3C). The low angle view was used when transecting the caudate lobe (Fig. 3D), and the bird's eye view was used when dissecting and dividing the bile duct (Fig. 3E). The view from the medial to lateral direction was used to clarify the optimal point for cutting the right hepatic artery, recognizing the location of clips at the remnant side of the artery (Fig. 3F). Alternating the bird's eye view and the low angle view is used to dissect the right hepatic artery and to divide the right portal vein (Fig. 3F, G).

Statistical analysis

Statistical analyses were performed using SPSS software (version 22; SPSS Inc., Chicago, IL, USA). Continuous parameters are reported as mean \pm standard deviation, and categorical parameters as *n* (%).

Results

Donor characteristics and postoperative outcomes are presented in Table 1. Mean donor age was 33.4 years, and mean body mass index was 23.6 kg/m². Grafts from eight donors included the middle hepatic vein. Mean operation time was 310.3 min, and mean hospital stay was 7.6 days. None of the donors required transfusion or experienced any irreversible disabilities or mortalities.

Discussion

Previous reports of PLDRH have been limited to studies of one or a few patients [1–5, 10, 11]. In many of these studies, a 2D non-flexible scope was used, in contrast to the 3D flexible scope that was used in the present study [3–5, 10]. To perform minimally invasive right donor hepatectomy, our center has adopted hand-assisted laparoscopic surgery (HALS) [12] or a laparoscopy-assisted technique, coupled with an upper midline incision. HALS and the laparoscopy-assisted technique may compensate for the limitations and maintain the advantages of both laparoscopic and open approaches [13–16]. However, these methods may cause fatigue to the surgeon's hand, which is used for the hand port but still required for the upper abdominal wound. After performing HALS on two patients and laparoscopy-assisted donor hepatectomy on 60, and after introduction of the 3D

flexible scope, our center began its PLDRH program in November 2015. By June 2018, our center had performed PLDRH using a 3D flexible scope on more than 200 donors.

The 3D image system allows depth perception, which is not achieved with a conventional 2D image system. Moreover, flexible scopes are advantageous for operating in a limited space, making them especially useful during liver mobilization and parenchymal transection [6, 7]. These scopes provide three types of laparoscopic view. A bird's eye view, in which the end is bent with the handle of the scope down and the end up, is useful when there is sufficient space at the top (Fig. 1A). This view is generally used for coronary ligament mobilization, hilar dissection, and parenchymal transection. The low angle view is useful for dissecting the anterior aspect of the IVC, transecting segment 1, and looking up and down alternately when dissecting vessels. It is important not to bend the end too much, because the view is limited if the bottom surface occupies more than one-third of the screen. The lateral view is generally used for liver mobilization, dissection of the triangular ligament, and hilar dissection (Fig. 1C).

Donor position and preparation

The flexible scope has the advantage of being able to approach the end in any direction, but it requires two spaces to bend the end. First, an extra-abdominal space should be secured. A bird's eye view is obtained by attaching the handle of the scope to the patient's lower abdomen and lifting the end of the scope (Fig. 1D). The scopist usually stands adjacent to the left thigh of the patient (Fig. 1E). If the patient's legs are overly bent, the scope handle cannot be lowered, making the bird's eye view insufficient (Fig. 1F). To maximize the bird's eye view, the patient's knees should be prevented from bending too much and the abdomen should be checked to ensure that it is not hypoinflated. The patient should be placed in a position resembling the reverse Trendelenburg position, and the scope handle should be moved in a medial direction from the left thigh. An intra-abdominal space should also be secured. It is important to ensure that the abdominal pressure drops below 10 mmHg due to the CUSA or patient withdrawal from anesthesia. In addition, the intra-abdominal port length should be checked periodically and always kept as short as possible to prevent any interference with the scope.

Liver mobilization

During mobilization of the falciform ligament and moving to the upper part of the IVC, the low angle view changes to the bird's eye view (Fig. 2A). The scope is gradually inserted into the abdomen while pushing down the handle and bending down the end. Injuries to the right

Fig. 3 Position of the scope and other instruments during each surgical stage. **A, B** Parenchymal transection. **C** Segment 8 transection. **D** Caudate lobe transection. **E** Bile duct division. **F, G** Hepatic artery and portal vein division. a, Actual laparoscopic view. b, Front view. c, Side view

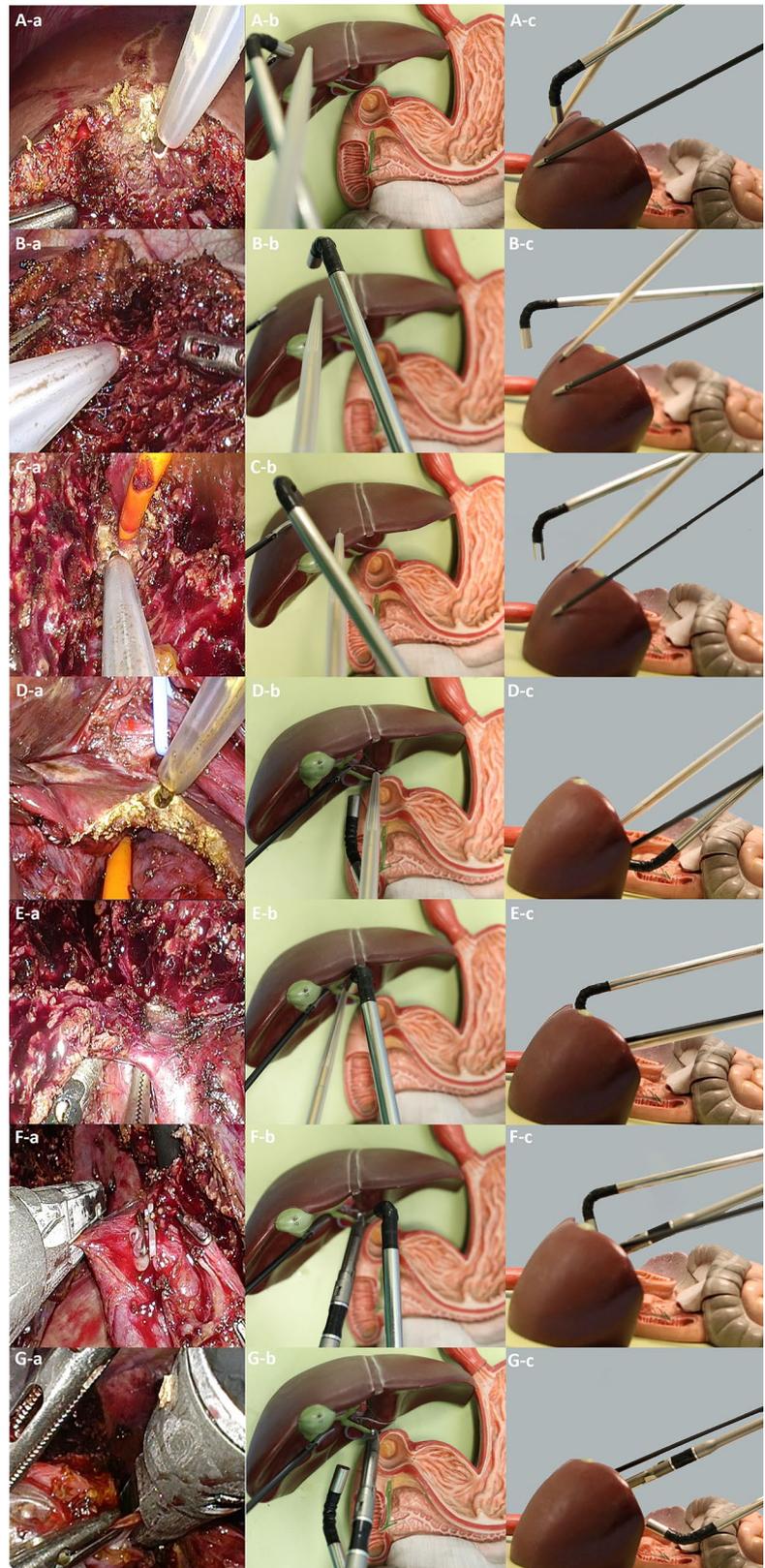


Table 1 Demographic characteristics and postoperative outcomes of donors undergoing pure laparoscopic right hepatectomy

Variables	N=158
Sex, male:female	90:68
Age, mean \pm SD (years)	33.4 \pm 11.6
Body mass index, mean \pm SD (kg/m ²)	23.6 \pm 3.3
Graft including middle hepatic vein, n (%)	8 (5.1)
Operative time, mean \pm SD (min)	310.3 \pm 56.3
Intraoperative transfusion, n (%)	0
Hospital stay, mean \pm SD (days)	7.6 \pm 1.7

hepatic vein and/or small venous branches may occur during further mobilization in the direction of the right hepatic vein if the end of the scope is inserted in a lateral to medial direction, because the dorsal part may not be visualized. Thus, the end of the scope should be inserted in a medial to lateral direction to ensure that both ventral and dorsal structures are secured. The bird's eye view is also used for mobilizing the coronary and triangular ligaments (Fig. 2B). The handle of the scope is pushed down to the patient's side as far as possible, and the end is bent to a maximum of at least 90 degrees while moving only to the right and left. Because the bird's eye view has limited access, the low angle view is generally used for inferior liver mobilization and dissection of the liver from the IVC (Fig. 2C). Too low an angle, however, may provide a limited view, as the floor may look like a hill. Due to the narrow space, the scope may come in contact with the operator's instruments when dissecting the inferior portion of the liver. This interference can be reduced if the scope is located around the instrument held in the operator's left hand, because most operators use their left hand to hold the liver, thereby moving their left hand less than their right, or working, hand. Collisions between the scope and other instruments can be minimized by inserting the scope just below the grasper held by the operator's left hand or positioning the scope across the grasper and bending the end of the scope medially while viewing at a minimally low angle. This technique can ensure the safe dissection of both short and inferior hepatic veins, without injuring any structures at the back. During mobilization of its lateral portion, most of the liver is lifted and turned while holding the remnant end of the right triangular ligament (Fig. 2D). At this point, the dissection plane may not be visualized well if the scope is placed between the operator's instruments or if it is inserted from the cranial direction. This plane can, however, be well visualized if the scope is inserted inferiorly and more lateral to the instruments with its end bent medially.

Hilar dissection

For hilar dissection, the scope is inserted close to the gallbladder bed with its end bent medially (Fig. 2E). While encircling, the right hepatic artery and the right portal vein should be placed at the center of the screen. Encircling can be performed safely by repeatedly checking the upper side of the vessel using the bird's eye view and the lower side of the vessel using the low angle view.

Parenchymal transection

The position of the scope during parenchymal transection is dependent on the direction of the CUSA, which is determined by the selection of the working port. The transection plane and the end of the scope cannot be well visualized if the directions of the CUSA and scope are parallel. Thus, it is important to place the scope at an angle 20°–30° to the CUSA. For example, if the working port is located in a medial direction and the CUSA is located lateral to the medial direction, the scope should be inserted in a lateral to medial direction while using a bird's eye view (Fig. 3A). Conversely, if the working port is located in a lateral direction and the CUSA is inserted in a lateral to medial direction, the scope should be inserted in a medial to lateral direction while using a bird's eye view (Fig. 3B). The midplane of the liver is in a lateral to medial direction at the cranial portion. Thus, while transecting segment 8, which is located in the cranial portion, the scope should be inserted in a lateral to medial direction (Fig. 3C). Visual confusion may occur if the scope shows a medial to lateral direction at this point, with the transection plane accidentally entering into the right lobe and denuding the right hepatic vein. The scope should be placed above the CUSA and the end in a lateral to medial direction using a bird's eye view, thereby minimizing interference between the scope and other instruments as well as visualizing the transection plane. When transecting the caudate lobe, the low angle view is useful (Fig. 3D). It is important to place the end in a lateral to medial direction and visualize the IVC, right portal vein, and right hepatic artery on one screen, so that they are not injured by the CUSA.

Bile duct division

The bird's eye view is advantageous for dissecting and dividing the bile duct (Fig. 3E). Although it may vary, bending the end of the scope from the medial to the lateral direction generally shows a better view. This view is helpful in visualizing the bifurcation of the bile duct as well as the posterior part of the hilar plate, thus preventing strictures in the remnant bile duct while dividing the bile duct.

Division of hepatic artery, portal vein, and hepatic vein

Alternating the bird's eye view and low angle view is helpful for dissecting the right hepatic artery (Fig. 3F, G). The view from the medial to the lateral direction can clarify the optimal cutting point of the right hepatic artery, recognizing the location of clips on the remnant side of the artery. This view is also useful when dividing the right portal vein, as it allows the operator to determine whether the remnant left portal vein is at any risk of stricture or twisting. Before firing the endo stapler, the low angle view at the right side of the stapler can determine whether the artery and bile duct of the graft are at any risk of injury. At this point, the bird's eye view is generally inadequate because the operator usually lifts the endo stapler slightly, blocking the view over the stapler. The low angle view is better, as it provides more space and may better visualize the graft artery. The bird's eye view is used during vision of the right hepatic vein. Because this vein may be difficult to visualize when the right liver is large, it may be better visualized in the medial to lateral direction.

The present study had several limitations, especially in regard to its retrospective design. Also, this study was based on the experience of a single center. Each operator's visual preference may differ, as may the details of surgical techniques and instruments. Moreover, a 3D flexible scope may not be available in some centers. Therefore, our suggestions may not be generalizable to all centers and surgeons. To date, however, no larger cohorts of donors have undergone PLDRH, and the tips gained from our cohort may help other centers starting this procedure.

In conclusion, skillful manipulation of a flexible scope and agreement between the surgeon and the laparoscopist are important for successful PLDRH.

Author contributions SKH and K-WL: participated in study design. SKH, ES, K-WL, KCY, J-ML, J-HC, N-JY, and K-SS: performed the research. SKH, ES, and W-WL: analyzed the data and wrote the manuscript.

Compliance with ethical standards

Disclosures Suk Kyun Hong, Eunhye Shin, Kwang-Woong Lee, Kyung Chul Yoon, Jeong-Moo Lee, Jae-Hyung Cho, Nam-Joon Yi, and Kyung-Suk Suh have no conflicts of interest.

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