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Title page

Minimally Invasive Living Donor Liver Transplantation: Pure Laparoscopic Explant Hepatectomy and Graft Implantation Using Upper Midline Incision

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Footnote page

Abbreviations: AFP (alpha-fetoprotein), BMI (body mass index), DDLT (deceased donor liver transplantation), HCC (hepatocellular carcinoma), INR (international normalized ratio), IVC (inferior vena cava), LDLT (living donor liver transplantation), LT (liver transplantation), MELD (Model for End-Stage Liver Disease), NASH (nonalcoholic steatohepatitis), PIVKA-II (protein induced by vitamin K antagonist-II), POD (postoperative day), PT (prothrombin time)

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Introduction

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.[1] Minimally invasive approaches in liver transplantation (LT) may have similar advantages for the recipients, including less pain and a shorter hospital stay, which could facilitate rehabilitation. However, there is only one reported case of a laparoscopic explant hepatectomy during deceased donor LT (DDLT), which indeed requires left lateral sectionectomy for completion of the procedure.[2]

Based on the experience of the surgeon and the transplant team, we initiated a minimally invasive LDLT program. Here, we present our initial experience of pure laparoscopic explant hepatectomy without liver fragmentation, followed by graft implantation using an upper midline incision. To the best of our knowledge, no previous study has reported successful experience of minimally invasive LDLT, including pure laparoscopic explant hepatectomies.

Patients and Methods

Patients and data

From March 2020 to June 2020, five patients were enrolled in the study. The study was performed in accordance with the Helsinki Declaration, as revised in 2013. The institutional review board of Seoul National University Hospital approved this study (IRB no. 2003-019-1106).

Surgical technique

The patient was placed supine, with legs apart, in the reversed Trendelenburg position. Pneumoperitoneum was maintained at 12 mmHg, and five trocars were used (Figure 1A). Thunderbeat (Olympus, Tokyo, Japan) was used as an energy-based device under the view of the Endoeye Flex 3D laparoscope (Olympus, Tokyo, Japan). Figure 2 summarizes the characteristics of surgical procedures. A venovenous bypass was not performed.

Results

Five patients were enrolled in the study (Table 1); among whom, pure laparoscopic explant hepatectomy was successfully completed in the last three patients. The excised liver was removed and the right liver graft from the donor was successfully implanted using an upper midline incision in these three patients. Open conversion was performed in the first two patients. In patient 1, the operative field of view was occluded due to congestion after dividing the left portal vein. In the last step of the procedure, division of the trunk of the middle and left hepatic veins was maintained. However, bleeding occurred during dissection and encircling of the trunk of the middle and left hepatic vein due to a bad view, which required open conversion. In patient 2, the right portal vein was divided, and right liver mobilization was performed. While dissecting and encircling the right hepatic vein, injury at the IVC occurred, which required open conversion. However, in both patients, bleeding was controlled and LDLT was successfully completed under conventional open procedure without further problems.

Minimally invasive LDLT was successfully completed in patients 3–5 (Table 2). Portal vein clamping lasted for 161, 188, and 160 min, respectively. The time required to remove the liver was 285, 180, and 166 min, respectively, and the total operative time was 640, 575, and 499 min, respectively. The duration of hospital stay was 30, 26, and 15 days, respectively. Patient 3 showed prolonged elevation in liver function tests, which spontaneously improved. Patient 4 experienced endoscopic retrograde biliary drainage due to bile leakage on postoperative day (POD) 8. No complications occurred in patient 5 during the follow-up period of 92 days.

Discussion

To our knowledge, there has been only one reported case of minimally invasive LT involving a pure laparoscopic total hepatectomy followed by midline implantation of a liver graft.[2] However, this report was confined to a single, deceased donor LT case and was based on left lateral sectionectomy as an intermediate process of explant hepatectomy. Considering that more than half of the LDLT patients in Korea have HCC[3] and there is always a possibility of occult HCC in a cirrhotic liver, exclusion of partial liver resection during explant hepatectomy, particularly in LDLT patients, is necessary. The left portal flow-preserving hilar dissection method was therefore used instead to dissect between the IVC and the liver, and to approach the level of the right hepatic vein and the common trunk of the left and middle hepatic veins.[4]

We selected patients with a less cirrhotic liver, without definite atrophy or shrinkage, and with a relatively good coagulation status. However, according to our initial experience of five cases, patients with small livers with definite varices would be better candidates for this procedure. The small liver provides adequate space and thus allows easier manipulation of instruments and cameras. Varices prevent bowel congestion during portal vein clamping, which warrants the time needed for laparoscopic dissection and explanting the liver as well as keeping pace with donor surgery.

The patients only had an upper midline wound and several port site wounds (approximately 1 cm in size) (Figure 1B), which were barely visible. Although further experience and studies are needed to draw a well-grounded conclusion, the possible benefits of this minimal incision would be avoiding transverse incision with muscular division, which may result in postoperative lung complication, wound hematoma, infection, or sometimes, hernia.

In conclusion, minimally invasive LDLT can be performed by a highly experienced surgeon and transplantation team on select patients. However, preliminary, further experiences and comparative studies are needed to determine the feasibility and establish the safety of the procedure.

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Figure Legends

Figure 1. (A) Position of ports. (B) Abdominal wound on postoperative day 43 in patient 5.

Figure 2. Procedural steps of purely laparoscopic explant hepatectomy. (A) Initial laparoscopic view showing the cirrhotic liver. (B) The right liver was mobilized while gently holding the remnant end of the right triangular ligament. (C) The right liver was mobilized as near as possible to the inferior vena cava (IVC). (D) The right hepatic artery was divided at the level near to the liver between a laparoscopic bulldog clip at the remnant side and a Hem-O-Lok clip (Weck Closure System, Research Triangle Park, NC) at the liver side. (E) The right portal vein was identified and divided between Hem-O-Lok clips for further right liver mobilization. (F) The lesser sac was divided. (G) The left side of the hilum was dissected and the middle and left hepatic artery was also divided. (H) The right and left bile ducts were divided at a high hilar level for later bile duct reconstruction. (I) Small venous branches were divided using clips or intracorporeal ties. (J) The left portal vein was remained intact as long as possible to prevent bowel congestion up to this point. (K) The left anterior aspect of the IVC was dissected after dividing the left portal vein. (L) The IVC ligament was divided using a Hemo-O-Lok clip or endostapler. (M) The right hepatic vein was encircled and divided using an endostapler. (N) The trunk of the middle and left hepatic vein was divided using an endostapler. (O) Final view after explant hepatectomy.

Table 1. Demographic characteristics.

	Recipient 1	Recipient 2	Recipient 3	Recipient 4	Recipient 5
Age, yr	48	69	58	52	75
Sex	Male	Male	Female	Male	Male
Height, cm	160·0	173·0	152·0	160·6	166·0
Weight, kg	62·7	79·0	56·5	65·5	75·4
BMI, kg/m^2	24·5	26·4	24·5	25·4	27·4
Underlying liver disease	HBV	Alcoholic	NASH	Alcoholic	HBV
Hepatocellular carcinoma	Not viable	Not viable	Yes	Not viable	Not viable
Size, cm	-	-	< 1	-	-
Number	-	-	Multiple	-	-
Pre-LT procedure	TACE	TACE	-	TACE, EVL	TACE
Laboratory findings					
Platelet, $\times 10^3/\mu L$	106	84	67	43	47
Bilirubin, mg/dL	0·4	3·2	0·7	2·6	0·5
Albumin, g/dL	4·9	2·2	3·9	3·4	2·3
PT INR	0·97	1·52	1·24	1·48	1·10
AFP, ng/mL	3·4	3·3	9·7	2·2	1·9
PIVKA-II, mAU/mL	25	19	15	17	24
Image findings					
PVT	No	No	No	No	Bland thrombus
Varix	Not definite	None	Esophageal varix	Minimal esophageal	Paraesophageal, perigastric, splenic varices with splenorenal shunt
Child–Pugh score	A5	C11	A5	B9	B9
Ascites	1	3	1	3	3
Bilirubin	1	3	1	2	1
Albumin	1	3	1	2	3
PT INR	1	1	1	1	1
Encephalopathy	1	1	1	1	1
MELD score	6·4	17·5	8·8	15·5	10·4
Estimated GRWR	0·99	1·11	1·19	1·15	1·13

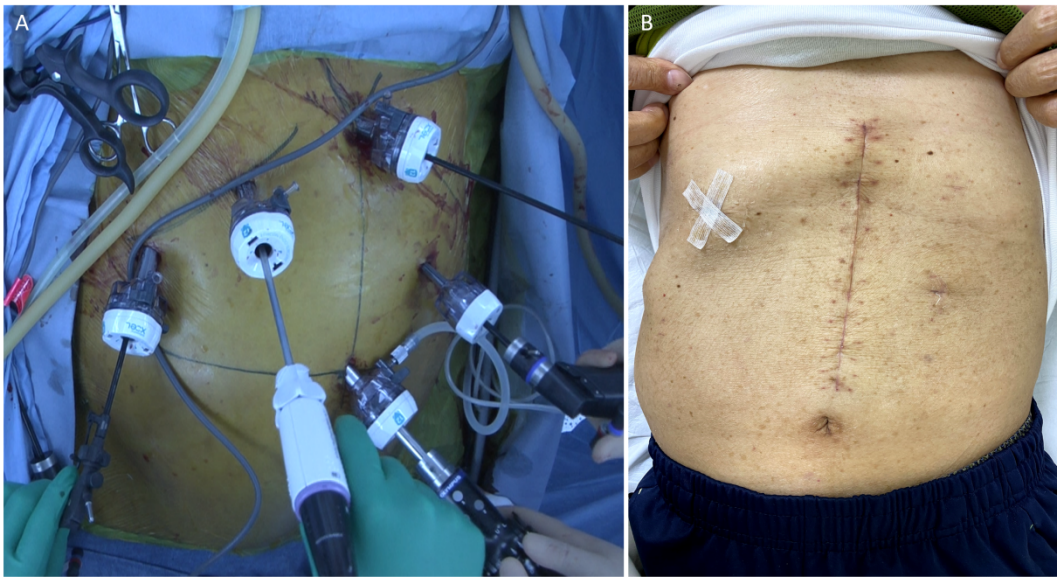
BMI, body mass index; LT, liver transplantation; TACE, transarterial chemoembolization Endoscopic variceal ligation; PT, prothrombin time; AFP, alpha-fetoprotein; PIVKA-II, protein induced by vitamin K antagonist-II; PVT, portal vein thrombosis; MELD, Model for End-Stage Liver Disease; GRWR, graft-to-recipient weight ratio

Table 2. Operative outcomes

	Recipient 1	Recipient 2	Recipient 3	Recipient 4	Recipient 5
Open conversion	Yes	Yes	No	No	No
Explant liver weight, g	1539	672	1224.5	752	863
Right liver graft weight, g	614	813	580	752	773
Duration of procedure, min					
Portal vein clamping	74, Portocaval shunt	59, Portocaval shunt	161	188	160
Anhepatic phase	68	201	25	126	135
Cold ischemic time	141	72	132	109	50
Warm ischemic time	47	56	31	27	37
Time to remove liver, min	253	173	285	180	166
Total operative time, min	558	570	640	575	499
Estimated blood loss, mL	3400	7800	1750	5250	4350
Transfusion, pack					
RBC	4	22	2	13	10
FFP		18	1	6	6
PC		6		2	1
Hospital stay, days	25	16	30	26	15
Postoperative complications*					
Grade I, II	-	Diuretics Wound seroma (POD 7)	Prolonged LFT elevation	-	-
Grade III, IV	PCD due to bile leakage (POD 12) ERBD (POD 56)	-	-	ERBD due to bile leakage (POD 8, 21)	-
Follow-up period, days	155	155	106	99	92

RBC, red blood cell; FFP, fresh frozen plasma; PC, platelet concentrates; POD, postoperative day; LFT, liver function test; PCD, percutaneous drainage; ERBD, endoscopic retrograde biliary drainage

*Complications were graded according to the Clavien–Dindo classification.



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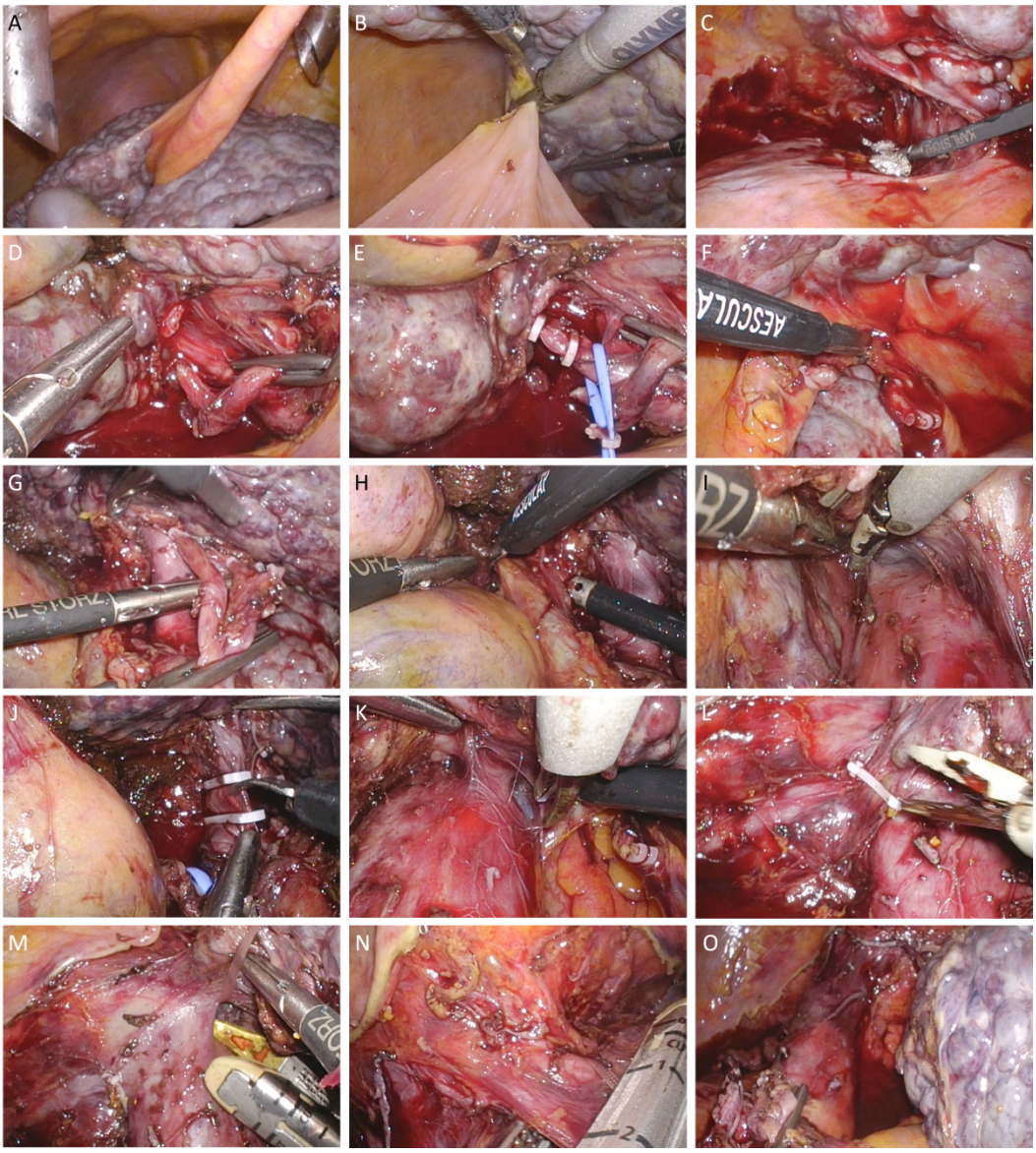

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