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Original Article

Technical Evolution of Laparoscopic Hepatic Resection: A Single Institutional Experience

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Abstract

Purpose : Laparoscopic hepatic resection (LHR) is still a challenging and developing surgical modality because of technical difficulty and a lack of training opportunities and experience. In this study, we present the results of our initial experiences of LHR, focusing on technical evolution in the management of LHR.

Methods : Between April 2011 and March 2012, a total of 12 LHRs were performed. The first 5 of these LHRs were performed under laparoscopic assistance (hybrid-LHR), while the last 7 LHRs were performed totally laparoscopically (pure-LHR). Indications for LHR were hepatocellular carcinoma (n = 9) and metastatic liver cancer (n = 3). LHR procedures consisted of partial resection (n = 2), left lateral segmentectomy (n = 2), and left lobectomy (n = 1) in the hybrid-LHR group, and partial resection (n = 4), left lateral segmentectomy (n = 2), and right lobectomy (n = 1) in the pure-LHR group. Operative outcomes were compared between the groups and technical modifications were evaluated.

Results : The mean operative time, blood loss, and length of hospital stay in the hybrid- and pure-LHR groups were 3.8 and 6.1 hours, 220 and 611 ml, and 9.4 and 7.4 days, respectively. There were no postoperative complications in both groups. Tumor margins were negative in all cases.

Conclusions : LHR is a feasible and effective procedure for patients with various types of liver tumors, although technical challenges still need to be overcome.

Key words : Laparoscopic hepatic resection, Hepatocellular carcinoma, Liver tumor

Introduction

Application of laparoscopic hepatic resection (LHR) has been delayed compared with other types of endoscopic surgery because of presumed technical difficulties and concerns of uncontrollable bleeding and gas embolism during parenchymal transection. However, courageous efforts of pioneers[1)~3)] and recent advances in laparoscopic devices[4)~6)] have made this formidable procedure feasible. LHR is now rapidly expanding throughout the world, and is becoming one of the standard procedures in selected centers[7)~10)]. Several studies[11)12)] have demonstrated significant advantages of LHR over conventional open hepatic resection (OHR) in terms of improved cosmetics, less pain and less use of analgesic drugs, and less blood loss and transfusion requirements, all leading to shorter hospital stay and reduced medical costs. However, LHR is still a challenging procedure and is exclusively performed in highly selected institutions because it requires highly advanced laparoscopic techniques, as well as expertise in hepatobiliary surgery.

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More importantly, LHR (partial resection and left lateral resection) has been covered by national insurance in Japan from April 2010. Therefore, LHR is expected to expand more rapidly in the coming years.

The most difficult and challenging part of LHR is how to manage bleeding during parenchymal transection. However, appropriate exposure of the operative field and transection plane, as well as effective control of bleeding, is technically limited in LHR compared with OHR. Nonetheless, various techniques have been reported, but there are still no established techniques.

We present and compare our initial experiences of laparoscopy-assisted (hybrid-LHR) and pure LHR (pure-LHR), focusing on the technical evolution, especially in pure laparoscopic parenchymal transection.

Material & Methods

Between April 2011 and March 2012, 12 patients underwent LHR in the Department of Surgery, Saiseikai Fukuoka General Hospital. Before surgery, all patients were informed of the risks and benefits of LHR, and informed consent was obtained. The first 5 LHRs were hybrid-LHR. The last 7 cases were all pure-LHR, for which all procedures were performed under laparoscopy. The mean age of the patients was 67 years old. There were 6 males and 6 females. Nine patients had hepatocellular carcinomas and 3 had colorectal metastatic liver cancers. All tumors were single and the mean tumor size was 2.7 cm (1.0-6.5 cm). Tumor locations were in S2 (n = 3), S3 (n = 5), S4 (n = 1), and S6 (n = 3). Liver function of all patients was Child-Pugh Class A. However, 5 patients had liver cirrhosis. The types of hepatectomy were partial resection (n = 2), left lateral segmentectomy (n = 2), and left lobectomy (n = 1) in the hybrid-LHR group, and partial resection (n = 4), left lateral segmentectomy (n = 2), and right lobectomy (n = 1) in the pure-LHR group. These demographics are summarized in Table 1.

Patients were usually placed in the supine position, except for cases 9 and 12 in whom the left hemi-decubitus position was used. In pure-LHR, 4 or 5 ports (usually 2 12-mm and 2 5-mm ports) are necessary, including a 12-mm port for a camera port in the umbilicus. Pneumoperitoneum was established by maintaining an intraperitoneal pressure of 8 mmHg. An intraoperative ultrasound scan was performed to confirm and mark the line of transection. Table 2 summarizes the techniques that were used in the pure-LHR group. As shown in Fig. 1A, liver parenchymal transection was performed mainly with an endoscopic ultrasonic surgical aspirator

Table 1 Demographics of patients

Case #	Age	Sex	Indication	Tumor location	Size (cm)	Procedure	Methods of LHR
1	70	F	HCC	S3	3.0	LL	Hybrid
2	80	M	MLC	S6	1.0	Partial	Hybrid
3	69	M	MLC	S6	1.0	Partial	Hybrid
4	47	M	HCC	S2	1.7	LLS	Hybrid
5	83	F	HCC	S2	6.5	LLS	Hybrid
6	53	F	HCC	S3	1.3	LLS	Pure
7	77	M	HCC	S3	3.0	LLS	Pure
8	79	M	HCC	S3	3.0	Partial	Pure
9	45	F	MLC	S6	3.0	Partial	Pure
10	78	M	HCC	S4	4.0	Partial	Pure
11	63	F	HCC	S3	1.0	Partial	Pure
12	75	M	HCC	S5	2.0	RL	Pure

LHR, laparoscopic hepatic resection ; HCC, hepatocellular carcinoma ; MLC, metastatic liver cancer ; LL, left lobectomy ; LLS, left lateral segmentectomy ; RL, right lobectomy.

Table 2 Surgical devices and procedures for pure laparoscopic hepatic resection

Case #	Methods of LHR	CUSA	Soft coagulation	BiClamp	Pringle's maneuver	IHGA	Precoagulation	Stay sutures
6	LLS	YES	YES	NO	NO	NO	NO	YES
7	LLS	YES	YES	NO	NO	NO	NO	YES
8	Partial	YES	YES	NO	NO	NO	YES	NO
9	Partial	YES	YES	NO	YES	NO	NO	YES
10	Partial	YES	YES	YES	NO	NO	NO	YES
11	Partial	YES	YES	YES	YES	NO	NO	YES
12	RL	YES	YES	YES	YES	YES	NO	YES

LHR, laparoscopic hepatic resection ; LL, left lobectomy ; LLS, left lateral segmentectomy ; RL, right lobectomy ; CUSA, cavitron ultrasonic aspirator ; IHGA, intrahepatic Glissonian approach.

(SonoSurg, Olympus., Tokyo, Japan) and a round-tip, monopolar, soft-coagulation device equipped with a channel for water-dripping (The VIO system, ERBE Elektromedizin GmbH, Germany). In case 10, a bipolar coagulation forceps (BiClamp® lap forceps, Maryland, ERBE Elektromedizin GmbH, Germany) was introduced for parenchymal transection (Fig. 1B). In 3 cases (9, 11 and 12), Pringle's maneuver was prepared with a cotton tape and a rubber stopper. This was performed by passing a cotton tape trough the foramen of Winslow using a curved retractor (Endo-Retract Maxi®, United Surgical, a division of Tyco Healthcare Group LP, Norwalk, CT) inserted through one of the right lateral ports (Fig. 2A). In case 3, pre-coagulation along with the transection line was performed using a radio-frequency ablation device. Stay sutures (3-0 Vicryl®, Ethicon Inc., Tokyo, Japan) for traction of the liver were placed on both sides of the transection line, except for case 3 (Fig. 3). During parenchymal transection, small vessels were coagulated and cut, while large vessels were closed with multifire titanium clips (Ligamax®, Ethicon Endo-Surgery, Cincinnati, OH, USA) or Hem-O-Lock clips (Weck Closure System, Research Triangle Park, NC) and cut.

In case 12, with the patient in the left hemi-decubitus position, 5 trocars (12 mm, × 3, and 5 mm, × 2) were inserted from the right subcostal to the midline region (Fig. 4A). After cholecystectomy, the right lobe of the liver was mobilized. As shown in Fig. 2B, the right Glissonian pedicle was controlled with a cotton tape by the intrahepatic Glissonian approach using an Endo-Retract Maxi® retractor. Parenchymal transection was performed on the demarcation line under clamping of the right Glissonian pedicle without the hanging maneuver. After completing parenchymal transection, the right Glissonian pedicle was divided with a vascular stapler (Echelon, Ethicon Endo-Surgery) as distally as possible, by retracting a cotton tape to the left side. The right hepatic vein was then divided with a stapler and the specimen was retrieved in a plastic bag from a suprapubic Pfannenstiel incision (Fig. 4B).

Results

All procedures were performed without complications (Table 3). The mean operative time, blood loss, and length of hospital stay in the hybrid- and pure-LHR groups were 3.8 and 6.1 hours, 220 and 611 ml, and 9.4 and 7.4 days, respectively. No patient was converted to OHR in the pure-LHR group. Tumor margins were negative in all cases. In case 10, 4 units of red blood cells were transfused. At the mean follow-up of 300 days, no patient had recurrent disease.

Discussion

Over the last 2 decades, laparoscopic surgery has evolved to become the approach of choice for many abdominal procedures. LHR was first reported in 1992[1]. However, extensive introduction of LHR was delayed because of technical complexity and difficulty. Because of advance-

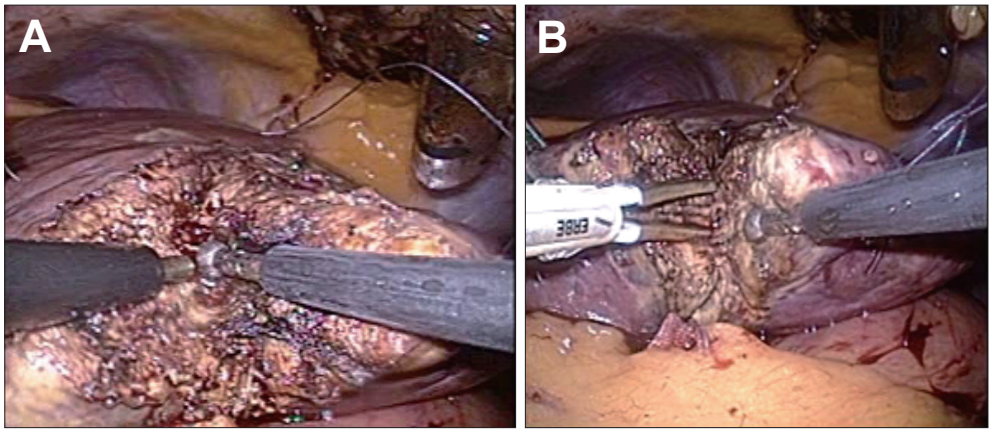

Fig. 1 Devices for parenchymal dissection. A, An ultrasonic dissector and aspirator (left), and a monopolar soft-coagulation device equipped with a channel for water-dripping (right). B, A Biclamp forceps (left).

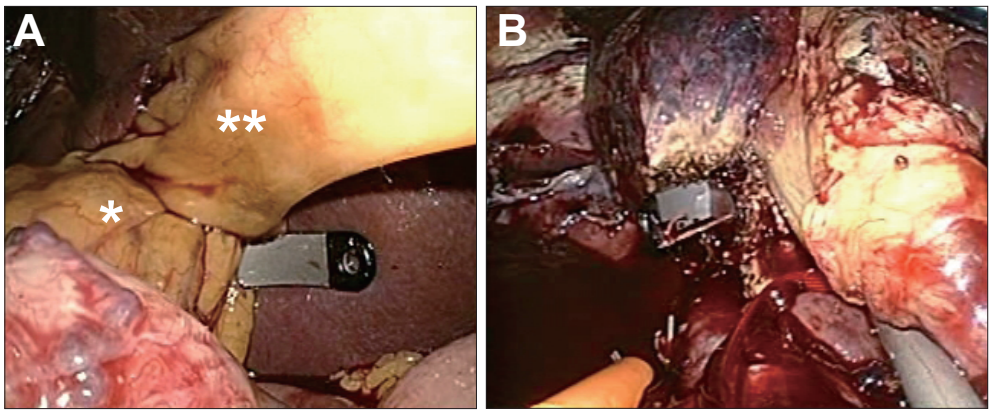

Fig. 2 A, Control of the hepatoduodenal ligament using EndoRetract Maxi® for Pringle's maneuver. *Hepatoduodenal ligament; **round ligament. B, Intrahepatic Glissonian approach of the right Glissonian pedicle using Endoretract Maxi®.

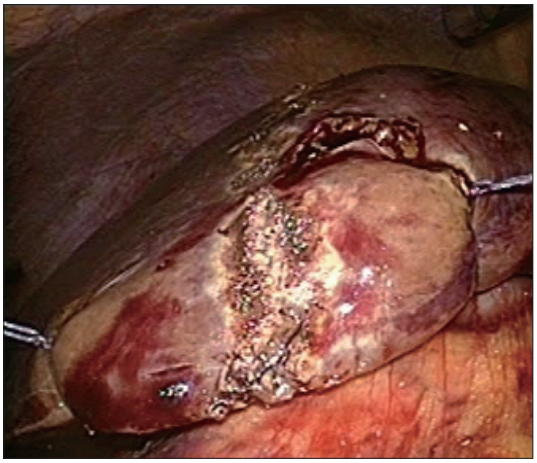

Fig. 3 Two stay sutures for retracting the transection line.

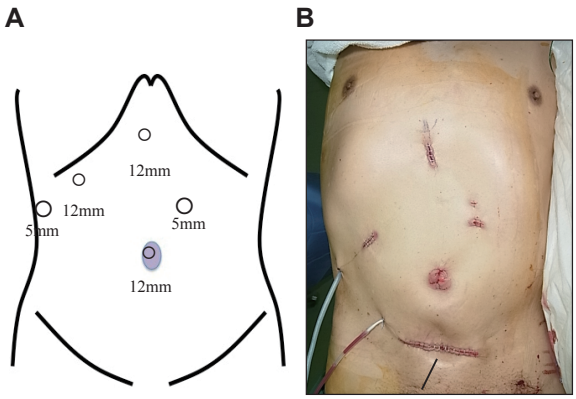

Fig. 4 A, Trocar position for a case of laparoscopic right lobectomy (case 12). The patient was in the left hemi-decubitus position. B, Postoperative view of the abdomen. The specimen was taken from a suprapubic Pfannenstiel incision.

Table 3 Operative and postoperative outcomes

Case #	Procedure	Operative time (h)	Blood loss (ml)	Transfusion (U)	Complication	Hospital stay (days)	Resection margin
1	LL	3.9	350	0	None	9	Negative
2	Partial	2.7	100	0	None	8	Negative
3	Partial	7.7	400	0	None	13	Negative
4	LLS	2	140	0	None	6	Negative
5	LLS	2.6	110	0	None	11	Negative
6	LLS	6.8	288	0	None	6	Negative
7	LLS	5.3	480	0	None	7	Negative
8	Partial	3.1	0	0	None	12	Negative
9	Partial	7.6	592	0	None	6	Negative
10	Partial	8.2	1590	4	None	10	Negative
11	Partial	3.5	200	0	None	5	Negative
12	RL	8.5	1130	0	None	6	Negative

LL, left lobectomy ; LLS, left lateral segmentectomy ; RL, right lobectomy.

ment of endoscopic devices, LHR is now becoming more popular, especially at specialized liver surgery centers throughout the world[7)~10)]. However, LHR is still a challenging and formidable procedure because it requires surgeons to have a high level of expertise in the field of both laparoscopic and hepatobiliary surgery. Nonetheless, major LHR, such as right lobectomy or left lobectomy, is still on the early part of the adoption curve[13)~15)].

One of the limiting factors, which hinder liberal expansion of LHR, is a lack of standardized techniques of parenchymal transection. Appropriate exposure of the transection line, secure control of bleeding, and appropriate angles of transection devices are severely limited and difficult under laparoscopic situations compared with OHR. In the current study, we attempted to perform parenchymal transection the same as that of OHR. For devices of parenchymal transection, we used an ultrasonic dissector and a reusable, round-tip, monopolar, soft-coagulation device equipped with a channel for water-dripping, which most hepatobiliary surgeons are familiar with. In case 9, we used BiClamp® LAP forceps for the coagulation of small vessels up to 5 mm, which was a powerful and effective method to control bleeding. Various energy-based devices, such as LigaSure™ (Valleylab Inc., Covidien, Boulder, CO)[4)] or ENSEAL® (Ethicon Endo-Surgery)[5)] have been used for LHR, but their effectiveness is largely undetermined. At this time, we prefer a combination of an ultrasonic surgical aspirator and BiClamp for parenchymal resection. Nonetheless, the optimal device for these purposes has yet to be established.

The angle of these devices should be in line with the transection plane, but this is often difficult, especially for partial resection having various angles of the transection plane. This may be overcome to a certain level by properly retracting the liver. For this purpose, we always place 2 stay sutures on both sides of the liver. The round ligament is retracted using a loop retractor.

With regard to Pringle's maneuver, some institutions, including ours, believe that it is necessary for preparing for bleeding during parenchymal transection. Various methods[16)17)] have been reported, but we believe that our method is simple and easy. Liberal use of this maneuver may further contribute to reduced blood loss during transection.

In conclusion, LHR is a feasible and effective procedure for patients with various types of liver tumors, although technical challenges still need to be overcome. We believe that LHR will become the standard of hepatic resection in the near future.

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（和文抄録）

腹腔鏡下肝切除における手術手技の工夫と変遷

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【目的】腹腔鏡下肝切除は，未だ発展途上の術式である．今回，当施設における腹腔鏡下肝切除の術式工夫の変遷とその成績を検討した．
【方法】2010年4月～2012年3月までに12例の腹腔鏡下肝切除：腹腔鏡補助下（Hybirid-LHR）5例，完全腹腔鏡下（Pure-LHR）7例を行った．手術適応はHCC 9例，転移性肝癌3例であった．術式は外側区域切除（n=4：Hybrid-LHR n=2，Pure-LHR n=2），部分切除（n=5：それぞれ n=2，n=4），左葉切除（n=1：Hybrid-LHR n=1），右葉切除（n=1：Pure-LHR n=1）であった．Hybrid-LHR 5例は腹腔鏡補助下で肝脱転後，小開腹をおきCUSA，ソフト凝固で直視下に通常の肝切離を行った．Pure-LHR 7例では完全腹腔鏡にCUSA，腹腔鏡用ソフト凝固，バイクランプを基本デバイスとして用い通常の開腹肝切離と同様に肝切離を行った．
【結果】前半5例と後半7例の平均手術時間3.8時間 vs. 6.1時間，出血量220ml vs. 611ml，術後入院日数9.4日 vs. 7.4日であった．後半の1例に4単位の輸血を要した．肝切離面の癌浸潤は全例陰性であった．術後合併症は1例も認めなかった．
【結論】腹腔鏡下肝切除はあらゆる腫瘍占拠部位に対して可能であり，有効な手術手技である．