



# Laparoscopic Liver Resection: Experience of 436 Cases in One Center

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## Abstract

**Background** To report experience of laparoscopic liver resection (LLR) in one center.

**Methods** We retrospectively reviewed 436 consecutive LLRs in 411 patients between December 2010 and December 2016. On the basis of the 2008 Louisville Statement, we divided the 436 cases into two groups: Simple Group ( $n = 203$ ) and Difficult Group ( $n = 233$ ).

**Results** The indications were HCC ( $n = 194$ ), colorectal cancer liver metastasis ( $n = 156$ ), benign tumors ( $n = 62$ ), hepatolithiasis ( $n = 2$ ), and other malignant lesions ( $n = 22$ ). The median tumor size was 24 mm (range 3 to 130). Procedures of LLR included wedge resection ( $n = 230$ ), one segmentectomy ( $n = 8$ ), two segmentectomies ( $n = 12$ ), left lateral sectionectomy ( $n = 75$ ), right hepatectomy ( $n = 52$ ), left hepatectomy ( $n = 31$ ), extended right hepatectomy ( $n = 2$ ), extended left hepatectomy ( $n = 5$ ), central bisectionectomy ( $n = 3$ ), right posterior sectionectomy ( $n = 12$ ), and right anterior sectionectomy ( $n = 6$ ). The median operative time was 228 min (range 9–843) and median blood loss was 150 ml (range 2–3500). Twenty-five cases required blood transfusion (5.7%). Conversion to open surgery was required in six cases (1.4%). The mean length of stay was  $6.4 \pm 2.9$  days. Overall complication rate was 9.4% and major complication rate was 5%. One patient died of liver failure on the thirtieth postoperative day after a right hepatectomy. We had higher median blood loss (200 vs. 100 ml;  $p < 0.001$ ), higher transfusion rate (8.2 vs. 2.9%;  $p = 0.020$ ), longer median operative time (297 vs. 164 min;  $p < 0.001$ ), higher conversion rate (2.6 vs. 0%;  $p = 0.021$ ), higher complication rate (14.2 vs. 3.9%;  $p < 0.001$ ), and longer mean postoperative hospital stay ( $6.8 \pm 2.9$  vs.  $5.9 \pm 3.0$  days;  $p < 0.001$ ) in the Difficult Group.

**Conclusions** Laparoscopic liver resection is safe for selected patients in the Difficult Group. On the basis of the 2008 Louisville Statement, selection criteria of LLR are helpful to predict the difficulty of the operation and the postoperative outcomes of LLR.

**Keywords** Laparoscopic · Liver resection · Hepatectomy · Consensus · Outcomes

## Introduction

Cherqui et al. reported a prospective cohort of 30 patients of laparoscopic hepatic surgery.<sup>1</sup> Laparoscopic liver operations

vary in complexity and difficulty but can be broken down into three categories: (I) biopsies and small wedge resections, (II) resections of the left lateral section or anterior hepatic segments (4b, 5, 6), and (III) hemihepatectomies,

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trisectionectomies, and resections of the difficult posterior segments (4a, 7, 8). The last category of procedures was referred to as major liver resections.<sup>2</sup>

By 2008, the first two types of resections were introduced into clinical practice and many publications have demonstrated the feasibility and safety of LLR. However, laparoscopic major liver resections are still on the early part of the adoption curve. The first International Consensus Conference on laparoscopic liver surgery was held in Louisville. It was concluded that laparoscopic left lateral sectionectomy should be considered as a standard practice. Patients with tumors which are either large (> 5 cm), central, multiple, bilateral, or with connections to the liver hilum, major hepatic veins, or the IVC are not at the moment candidates for a laparoscopic approach in most centers. Laparoscopic major hepatectomy should be reserved to experienced surgeons already facile with more limited laparoscopic resections.<sup>2</sup> In experienced hands, laparoscopic liver resections are safe with acceptable morbidity and mortality for both minor and major hepatic resections.<sup>3</sup>

Before the first international consensus conference on laparoscopic liver surgery, the reported learning period of laparoscopic hepatectomy was approximately 60 cases.<sup>4</sup> After the 2008 Louisville Statement, the learning curve of laparoscopic minor hepatectomy was more efficient and smooth.<sup>5</sup> Laparoscopic major hepatectomy was safe and effective when performed in specialized centers and the case number increased with improved short-term outcome and lower conversion rate in the last decade.<sup>6–11</sup> The learning period of laparoscopic major hepatectomy was 45 to 60 patients.<sup>11</sup> *LLR performed in selected patients and by trained surgeons may offer improved patient short-term outcomes compared with OLR.*<sup>12</sup> The aim of this study is to analyze a single institutional experience of 436 consecutive LLRs.

## Patients and Methods

Laparoscopic liver resection was first adopted in China Medical University Hospital, Taichung, Taiwan, in December 2010. The indication and extent of LLR did not vary from traditional open liver resection. Patients with American Society of Anesthesiologists score (ASA) exceeding 3, a decompensated cirrhosis (Child B or C), and a platelet count < 80 × 10<sup>9</sup>/l were unfavorable for LLR. Informed consent of the procedure was obtained prior to operation.

## Surgical Procedures

Patients were placed in a reverse Trendelenburg position with the legs apart. The operating surgeon stood between the patient's legs, and assistants stood on two sides.

Low central venous pressure (< 5 mmHg) was used during LLR, as in open surgery. The CO<sub>2</sub> pneumoperitoneum was generally established at 12 to 18 mmHg with Hasson method. The placement of trocars was based on tumor location. Three trocars were usually used: one 12-mm trocar around the umbilicus for the optic laparoscope, another 12-mm trocar for the application of ultrasound probe, ultrasonic aspirator (Cavitron ultrasonic surgical aspirator), surgical clip, and linear stapler, and one 5-mm trocar for grasper, suction-irrigation, or energy device. One to two additional 5-mm trocars will be placed depending on the surgical need. Intraoperative flexible laparoscopic ultrasound was routinely used to identify the tumor and its associations to the blood vessels.

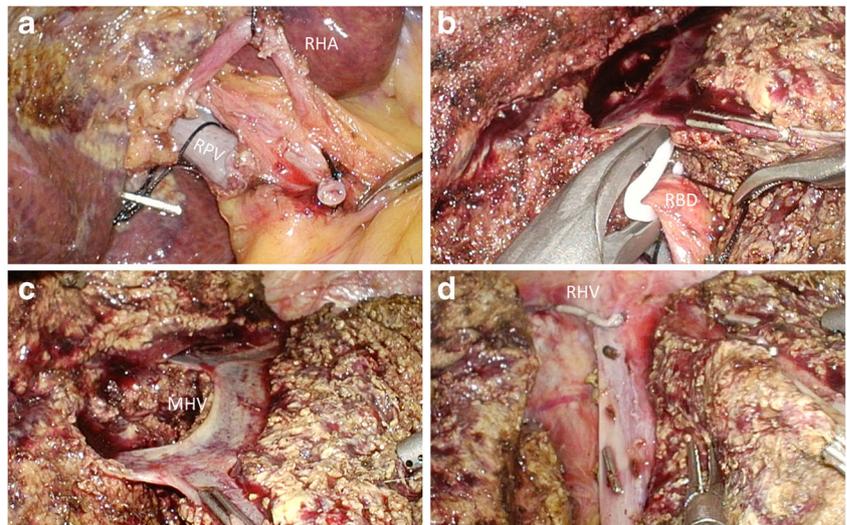
In the case of right or left hepatectomy, hilar dissection with individual vessel preparation was a standard practice in the early phase of our series. Glissonian approach with stapler was performed in the later phase. Transection of the superficial layer of the liver parenchyma was performed using an energy device. Deeper transection was first performed by exposing intraparenchymal structures with a CUSA in the early phase of our series, and subsequently change to clamp-crushing technique. We penetrated the parenchyma and slowly crushed with the use of energy. Vessel control was usually achieved with vessel sealing device for vessels 3 mm or less, and with clips for vessels 3 to 7 mm in diameter. Locked clips or staplers were used for vessels of more than 7 mm. Hemostasis was usually achieved with selective unipolar coagulation or suture at the bleeding point.

In cases of severe bleeding, we increased the pneumoperitoneum pressure to 18 mmHg to decrease back-bleeding. In case of uncontrolled bleeding after increasing pneumoperitoneal pressure, we performed Pringle's maneuver by using a Satinsky clamp to occlude the portal triad for 15 min with an interval of 5-min release. The hepatoduodenal ligament was not routinely identified and encircled.

After resection was completed, gauze was placed on the cutting surface and the intraperitoneal pressure was reduced to 0 mmHg for 5 min to check for bleeding or bile leakage. One Jackson–Pratt drain was routinely placed near the cutting surface. The specimen was placed in a plastic tissue bag and removed via an extended umbilical incision or Pfannenstiel incision without fragmentation. Figure 1 illustrates standard steps in our technique for laparoscopic right hepatectomy.

Resection of tumor with connection to hilum, major vessels, and IVC is challenging. If the patient had a tumor invaded to a major hepatic vein, extended sectionectomy which include invaded major hepatic vein was performed for adequate resection margin. If tumor is close to hilum, exposure of Glissonian sheath with CUSA or energy device was performed. Figure 2 showed the steps of left hepatectomy which included middle hepatic vein for a tumor overriding the confluence of middle hepatic vein and left hepatic vein.

**Fig. 1** Laparoscopic right hepatectomy. **a** Right branch of portal vein (RPV) and right hepatic arterial (RHA) were isolated before division. **b** Closure of right bile duct (RBD). **c** Parenchyma transection with exposure of middle hepatic vein (MHV). **d** Division of the right hepatic vein (RHV) using the vascular linear stapler after liver transection



**Study Population and Patient Categorization**

Between December 2010 to December 2016, 1022 consecutive procedures of traditional open liver resection and 436 consecutive procedures of laparoscopic liver resection were performed at our hospital. The clinical data for 436 laparoscopic liver resections were analyzed retrospectively for this study.

On the basis of the 2008 Louisville Statement, we divided the 436 cases into two groups: Simple Group and Difficult Group. Patients with tumors which are large (> 5 cm), located in difficult posterosuperior segments (1,4a, 7, 8), with connection to the liver hilum, major hepatic veins, or the IVC, in need of multiple liver resection, a resection more than two segments, posterior sectionectomy, anterior sectionectomy, or central bisectionectomy were categorized into Difficult Group. Patient characteristics and postoperative results in each group were compared. The surgical complications were documented according to the Clavien–Dindo classification.<sup>13</sup>

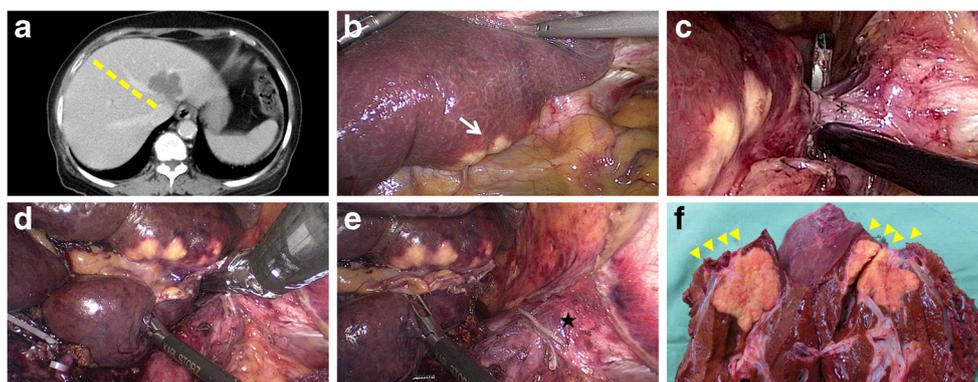
Complications greater than grade III were recorded as “major complications.”

**Statistical Analysis**

All statistical analyses were performed using PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc. Continuous variables were compared between groups by Mann–Whitney *U* test, and categorical variables were compared by the chi-square test. A *p* value of <0.05 was considered statistically significant. Patient characteristics are expressed as the mean ± SD or median (range).

**Results**

The demographic and clinical details of the study patients are shown in Table 1. The indications of laparoscopic liver resection were hepatocellular carcinoma (*n* = 194), colorectal



**Fig. 2** Resection of tumor with connection to major hepatic vein. **a** A tumor overrode the confluence of middle hepatic vein (MHV) and left hepatic vein (LHV). Transection line (yellow-dotted line) was along the right border of MHV. **b** Tumor (arrow) was in S2 and S4 with liver

capsule invasion. **c** Encircle the confluence (⊛). **d** Application of a stapler. **e** Stump of the confluence (★). **f** Resection margin (yellow arrow head) was free of malignancy

**Table 1** Clinical characteristics of laparoscopic liver resection in 436 cases

Variable	Data
Age, y, median (range)	59 (21–88)
Gender, male/female	261/175
BMI, kg/m <sup>2</sup> , median (range)	23.8 (13.7–39.7)
ASA score, n (%)	
I	30 (6.9)
II	260 (59.6)
III	146 (33.5)
Liver cirrhosis, n (%)	32 (7.3)
Indications, n (%)	
HCC	194 (44.5)
CRLM	156 (35.8)
CCC	10 (2.3)
Other malignancy	12 (2.8)
Benign lesion	64 (14.6)
Median tumor size, mm (range)	24 (3–130)
Tumor size > 5 cm, n (%)	68 (15.6)
Tumor location, n (%)	
Anterolateral segments (2,3,4b,5,6)	285 (65.4)
Posterosuperior segments (1,4a,7,8)	151 (34.6)
Tumor connect to hilum or major vessel, n (%)	47 (10.8)
Multiple liver resection	
No	397(91.1)
Yes	39 (8.9)
Extent of liver resection, n (%)	
Partial/one segmentectomy of anterolateral	156 (35.8)
Partial/one segmentectomy of posterosuperior	82 (18.8)
Two segmentectomies	12 (2.8)
Left lateral sectionectomy	75 (17.2)
Left hepatectomy	31(7.1)
Right hepatectomy	52(11.9)
Central bisectionectomy	3 (0.7)
Anterior sectionectomy	6 (1.4)
Posterior sectionectomy	12 (2.8)
Extended left hepatectomy	5 (1.2)
Extended right hepatectomy	2 (0.5)
Difficulty classification base on Louisville Statement	
Simple Group	203(46.6)
Difficult Group	233(53.4)

*BMI* body mass index (calculated as weight in kilograms divided by height in meters squared), *ASA* American Society of Anesthesiologists, *HCC* hepatocellular carcinoma, *CRLM* colorectal liver metastases, *CCC* cholangiocarcinoma

Liver cirrhosis: pathology proved as Metavir F4. Tumor location was recorded according to Couinaud segments

cancer liver metastasis ( $n = 156$ ), benign tumors ( $n = 62$ ), IHD stones ( $n = 2$ ), and other malignant lesions ( $n = 22$ ). The median tumor size was 24 mm (range 3 to 130). The median

operative time was 228 min (range 9–843) and median blood loss was 150 ml (range 2–3500). Twenty-five cases required blood transfusion (5.7%). Conversion to open surgery was required in six cases (1.4%). The reasons for conversion were instrument failure in one patient and uncontrolled bleeding in five patients. The mean length of hospital stay was  $6.4 \pm 2.9$  days. Overall complication rate was 9.4% and major complication rate was 5%. One patient died of liver failure on the 30th postoperative day after a right hepatectomy.

Sixty-eight patients (15.6%) had larger tumor (size > 5 cm). One hundred fifty-one patients (34.6%) had tumor located in the posterosuperior segments. Forty-seven patients (10.8%) had tumor with connection to the hilum, major hepatic veins, or IVC. Thirty-nine patients (8.9%) received more than one liver resection. Procedures of LLRs were wedge resection ( $n = 230$ ), one segmentectomy ( $n = 8$ ), two segmentectomies ( $n = 12$ ), left lateral sectionectomy ( $n = 75$ ), right hepatectomy ( $n = 52$ ), left hepatectomy ( $n = 31$ ), extended right hepatectomy ( $n = 2$ ), extended left hepatectomy ( $n = 5$ ), central bisectionectomy ( $n = 3$ ), right posterior sectionectomy ( $n = 12$ ), and right anterior sectionectomy ( $n = 6$ ). On the basis of 2008 Louisville Statement, 233 cases were categorized into Difficult Group and 203 cases were categorized into Simple Group. The comparison of perioperative details of patients between the two groups are shown in Table 2.

There was no significant difference in the age, gender, BMI, and ASA of patients between the two groups. We had higher median blood loss (200 vs. 100 ml;  $p < 0.001$ ), higher transfusion rate (8.2 vs. 2.9%;  $p = 0.020$ ), longer median operative time (297 vs. 164 min;  $p < 0.001$ ), higher conversion rate (2.6 vs. 0%;  $p = 0.021$ ), higher complication rate (14.2 vs. 3.9%;  $p < 0.001$ ), and longer mean postoperative hospital stay ( $6.8 \pm 2.9$  vs.  $5.9 \pm 3.0$  days;  $p < 0.001$ ) in the Difficult Group.

Annual number of laparoscopic liver resection increased from 3 in 2010 to 120 in 2016 (Fig. 3a). The proportion of LLR of the total annual liver resection increased over time (Fig. 3b). The proportion of patients in Difficult Group in the LLR population increased every year (Fig. 3c).

## Discussion

The 2008 Louisville Statement suggested that the best indication for LLR was a solitary lesion < 5 m, located in peripheral liver segments 2 to 6.<sup>2</sup> Laparoscopic major hepatectomy was more technically demanding, and it was recommended that laparoscopic major hepatectomy should be reserved for experienced surgeons. These recommendations were introduced for patient selection of LLR in our center. Patients with tumors which are large (> 5 cm), located in difficult posterosuperior segments (1,4a, 7, 8), with connection to the liver hilum, major hepatic veins, or the IVC, in need of multiple liver resection, resection of more than two segments, posterior

**Table 2** Perioperative data of the cases in two groups

Variable	Total	Simple ( <i>n</i> = 203)	Difficult ( <i>n</i> = 233)	<i>p</i> value
Age	59 (21–88)	58 (21–84)	59 (22–88)	0.753
Gender (male/female)	261/175	126/77	135/98	0.381
BMI, kg/m <sup>2</sup> , median (range)	23.8 (13.7–39.7)	23.8 (15.4–39.7)	23.8 (13.7–35.9)	0.703
ASA score, <i>n</i> (%)	2 (1–3)	2 (1–3)	2 (1–3)	–
HCC, <i>n</i> (%)	194 (44.5)	100 (49.3)	94 (40.3)	–
CRLM, <i>n</i> (%)	156 (35.8)	64 (31.5)	92 (39.5)	–
Operative time, min, median (range)	228 (9–843)	164 (9–611)	297 (26–843)	<0.001
Operative time > 300 min, <i>n</i> (%)	140 (32.1)	27 (13.3)	113 (48.5)	<0.001
Estimated blood loss, ml, median (range)	150 (2–3500)	100 (5–2300)	200 (2–3500)	<0.001
Estimated blood loss > 500 ml, <i>n</i> (%)	77 (17.7)	25 (12.3)	52 (22.3)	0.006
Intraoperative transfusion, <i>n</i> (%)	25 (5.7)	6 (2.9)	19 (8.2)	0.020
Inflow occlusion, <i>n</i> (%)	50 (11.5)	20 (9.9)	30 (12.9)	0.324
Conversion to open surgery, <i>n</i> (%)	6 (1.4)	0 (0)	6 (2.6)	0.021
R0 resection for HCC, <i>n</i> (%)	194 (100)	100 (100)	94 (100)	1
Margin width for HCC, mm, median (range)	8.0 (0.5–65)	10.0 (0.5–3.5)	7.5 (1–65)	0.355
R0 resection for CRLM, <i>n</i> (%)	146 (93.6)	61 (95.3)	85 (92.4)	0.465
Margin width for CRLM, mm, median (range)	4.5 (0–50)	5.5 (0–50)	3.6 (0–35)	0.017
Complication, <i>n</i> (%)	41 (9.4)	8 (3.9)	33 (14.2)	<0.001
Major complication, <i>n</i> (%)	22 (5.0)	4 (2.0)	18 (7.7)	0.006
Bile leakage, <i>n</i> (%)	8 (1.8)	1 (0.5)	7 (3.0)	0.052
Mortality, <i>n</i> (%)	1 (0.2)	0	1 (0.4)	0.351
Hospital stay, d, mean ± SD	6.4 ± 2.9	5.9 ± 3.0	6.8 ± 2.9	<0.001

Major complication: Claviene-Dindo classification grade IIIa or greater

sectionectomy, anterior sectionectomy, or central bisectionectomy were included in the Difficult Group. In the initial phase, we used hybrid technique to overcome the difficulty of operation on nine patients in Difficult Group.

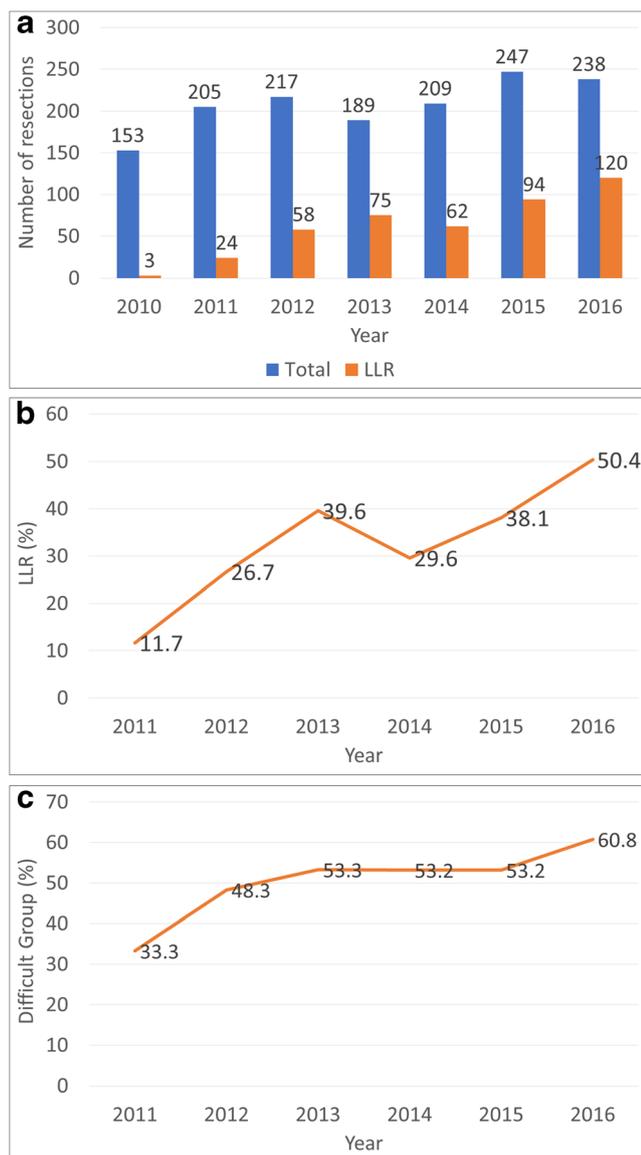
In the study published by Lin et al.,<sup>5</sup> by following standardized surgical procedures, using advanced instruments, and undergoing training program available in recent years, the learning of LLR was more efficient and smooth after the 2008 Louisville Statement. They proposed that a learning period of 22 cases was required for minor LLR. In this study, patients in the Simple Group had zero conversion rate and lower complication rate (3.9%).

Laparoscopic liver resection for tumors located in posterosuperior segments is more difficult than in anterolateral segments but is feasible in selected patients.<sup>14, 15</sup> The location of tumor in difficult area is associated with an increased risk of conversion.<sup>16</sup> Teramoto et al.<sup>17</sup> reported thoracoscopic approach for tumor located in segment 8. Guro et al.<sup>18</sup> compared open and laparoscopic liver resection for tumor located in segments 7 or 8. With the introduction of the Pringle maneuver, intercostal trocars, and semi-lateral patient positioning, the blood loss of LLR was significantly reduced. In this study, minor

hepatectomy was the most commonly used method for removal of tumors in the posterosuperior segments (*n* = 82, 54.3%). After full mobilization of the right liver, the resection plane of segment 7 was clear and visible. In this subgroup, four patients required conversion to laparotomy for control of bleeding. Three of these four patients are among our first 100 cases. Resection of posterosuperior segments is difficult and requires more attention to vessel injury.

Major LLR is more difficult and time-consuming and has a higher conversion rate than minor LLR.<sup>16</sup> However, a multicenter study showed that major LLR is feasible in selected patients with the operative time, blood loss, and conversion rate improving after the initial 15 cases.<sup>6</sup> The most common case of laparoscopic major hepatectomy was right hepatectomy.<sup>12</sup> The procedures of laparoscopic right hepatectomy were well established.<sup>19–24</sup>

In this study, major LLR included right hepatectomy, left hepatectomy, right anterior sectionectomy, right posterior sectionectomy, central bisectionectomy, and trisectionectomy. Right hepatectomy was the most commonly used method of major hepatectomy in our series (*n* = 52, 46.8%). The hybrid technique with hanging maneuver was performed on the



**Fig. 3** The trend of laparoscopic liver resection in our center. **a** Annual number of total liver resections and laparoscopic liver resections. **b** Trend in annual proportion of laparoscopic liver resections. **c** Trend in annual portion of Difficult Group in LLRs

initial major hepatectomy cases. Individual hilar dissection was performed in the early cases, while the Glissonian approach with stapler was performed in later cases. Pringle maneuver was required in 12 cases (10.8%). Parenchymal transection of the deep layer was first performed by using CUSA and subsequently change to clamp-crushing technique. Exposure of major hepatic vein was a routine procedure. As showed in Fig. 1, exposure of main hepatic vein was feasible, and pneumoperitoneum pressure reduced the oozing from the parenchyma and the hepatic vein. One patient required conversion to open during right posterior sectionectomy for uncontrolled bleeding. Complications occurred in 18 patients in this subgroup (16.2%), but no complications related to pulmonary embolism was noted.

Yoon et al. reported the feasibility of LLR for centrally located tumors close to the hilum, major hepatic veins, or inferior vena cava.<sup>25</sup> In our series, four patients with colorectal cancer liver metastases had positive resection margin. Twelve patients had complications (25%) included four bile leakage and one bile duct injury. Surgeon should pay more attention to prevent bile duct injury and make more efforts to check for bile leakage after parenchyma transection.

The 2008 Louisville Statement suggested that a surgeon should make efforts to control hemorrhage laparoscopically rather than emergently converting to open laparotomy.<sup>2</sup> Facile laparoscopic suturing is needed for major vessel injury. Conversion to a hand-assisted approach is often more orderly and controlled than conversion to a full laparotomy. In this study, 77 patients (17.7%) had blood loss exceeding 500 mL, 23 patients (5.3%) exceeded 1000 mL, and 6 patients (1.4%) exceeded 2000 mL, but only 5 patients (1.2%) required conversion to laparotomy to control bleeding. Of these five patients, three had right hepatic vein injury during partial hepatectomy of segment 7, one had portal vein injury during partial hepatectomy of segment 1, and one had right hepatic vein injury during right posterior sectionectomy. Surgical judgment should be used in individual cases to determine the extent of conversion.

Ban et al.<sup>26</sup> proposed a Difficulty Scoring System to predict the difficulty of LLR based on the extent of liver resection, tumor location, tumor size, liver function, and tumor proximity to major vessels. Tanaka et al.<sup>27</sup> reported a multicenter analysis to validate the difficulty scoring system. Tumor located in segment 7 or 8 has a score of 5 and all patients were included in intermediate and high difficulty levels. Resection of segment 1 (Caudate lobe) was not considered in the Difficulty Scoring System. In the current study, tumors located in segment 1, 4a, 7, or 8 were classified into Difficult Group.

Segmental resection of HCC requires exposure to surrounding blood vessels. The segmental resection score was 3 points, and all patients were included in intermediate and high difficulty levels. However, the proportion of segmentectomy was only 6.6%.<sup>27</sup> We prefer to perform partial hepatectomy for HCC in superficial layer and sectionectomy or hemihepatectomy for HCC in deep layer. In our series, a segmentectomy was only performed in 8 patients (1.8%). Extension of liver resection not less than a sectionectomy has a score of 4, and most of the patients were included in high difficulty level (92.9%).<sup>27</sup> In current study, right anterior sectionectomy and posterior sectionectomy were classified into Difficult Group.

In the low difficulty level group, only 1% of patients have tumors close to major vessel.<sup>27</sup> For beginners, parenchymal transection with exposure of major vessel or dissection of IVC is difficult, so proximity to major vessel is an indicator of the Difficult Group in the current study.

The proportion of Child-Pugh B cirrhosis was only about 7.5% and only 12.2% of patients with Child-Pugh B cirrhosis were classified into high difficulty level.<sup>27</sup> In the present study, since cirrhosis with portal hypertension was the exclusion criterion, only 32 patients (7.33%) had cirrhosis. It is difficult to assess the impact of cirrhosis on difficulty in our series.

Patients requiring multiple liver resection were classified into Difficult Group because the more transection surface resulted in longer operation time and more blood loss. The operation time, blood loss, postoperative complications, and hospital stay of our series are similar to the reported data and also show a direct correlation with the difficulty level.<sup>27</sup> Halls et al. reported that BMI > 35, neo-adjuvant chemotherapy, repeated liver resection, and concurrent procedure may increase the difficulty.<sup>28</sup>

Most published data show that short-term outcomes of LLR were different in early and late phases.<sup>29, 30</sup> As our experience accumulated, the proportion of patients in Difficult Group in the LLR population increased every year with an acceptable short-term outcome.

To the best of our knowledge, the current study is the first study based on the 2008 Louisville Statement to compare the difficulty of operation and postoperative outcomes of LLRs of the Simple Group and the Difficult Group. The major limitation of this study is a retrospective study which is mostly composed by a single surgeon's experience (90%). In addition, the proportion of cirrhosis in this series is very low and sample size of segmentectomy is limited as well. Due to the short follow-up time, we did not compare the long-term survival outcomes of LLRs between different groups.

## Conclusion

In conclusion, this study shows that the laparoscopic liver resection is safe for selected patients in Difficult Group. On the basis of the 2008 Louisville Statement, selection criteria of LLR are helpful to predict the difficulty of operation and the postoperative outcomes of LLR.

**Author Contribution** Te-Hung Chen was involved in study concept and design, data acquisition, analysis, interpretation, and manuscript drafting.

Hong-Ren Yang was involved in study concept and design, data acquisition, analysis, interpretation, and manuscript drafting.

Long-Bin Jeng was involved in study concept and design and data interpretation.

Shih-Chao Hsu was involved in study concept and design and data acquisition.

Chia-Hao Hsu was involved in study concept and design and data acquisition.

Chun-Chieh Yeh was involved in study concept and design and data acquisition.

Mei-Due Yang was involved in study concept and design and data acquisition.

William Tzu-Liang Chen was involved in study concept and design and data interpretation.

## Compliance with Ethical Standards

This study was approved by the Institutional Review Board of China Medical University Hospital (CMUH107-REC3-077).

**Conflict of Interest** The authors declare that they have no conflict of interest.

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