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# Outcomes of major laparoscopic liver resection for hepatocellular carcinoma

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ABSTRACT

*Background:* To compare the surgical outcomes of major laparoscopic liver resection (LLR) and open liver resection (OLR) for hepatocellular carcinoma (HCC).
*Methods:* We retrospectively reviewed the medical records of 177 patients who underwent major liver resection for HCC between January 2004 and June 2015. We divided the 177 patients into two groups according to the type of procedure: major LLR (LLR group; $n = 67$) and major OLR (OLR group; $n = 110$).
*Results:* Procedures in the LLR group were right hepatectomy (30 patients), right posterior sectionectomy (28), left hepatectomy (11), right anterior sectionectomy (6), extended right hepatectomy (6), and central bisectionectomy (2). Tumor size was greater in the OLR group than in the LLR group (6.3 ± 3.8 vs 4.1 ± 2.4 cm; $P = 0.016$). The mean indocyanine green retention rate at 15 min ($P = 0.698$) and serum α-fetoprotein ($P = 0.186$) were similar in both groups. The mean operation time was longer in the LLR group (416.6 ± 166.9 vs 332.5 ± 105.4 min; $P = 0.002$). Blood loss ($P = 0.319$), transfusion rate ($P = 0.260$), and R0 rate ($P = 0.255$) were similar in both groups. Hospital stay was shorter (11.3 ± 8.3 vs. 18 ± 21.4 days; $P = 0.007$) and the complication rate was lower (20.5% vs. 38.7%; $P = 0.005$) in the LLR group. The 5-year overall survival (77.3% vs 60.2%; $P = 0.087$) and disease-free survival (50.8% vs 40.1%; $P = 0.139$) rates were comparable in both groups.
*Conclusion:* Major LLR of HCC is feasible and oncologically safe when performed by experienced surgeons. Further refinements of the surgical technique are needed to reduce operation time.


## 1. Introduction

Since the introduction of laparoscopic liver resection (LLR) in the early 1990s, it has been widely performed worldwide and has become the standard of treatment [1], especially minor LLR for tumors located in the anterolateral segments of the liver [2,3]. Many studies have compared the feasibility, safety, and outcomes of LLR with those of open liver resection (OLR) and reported similar short-term outcomes [4]. However, tumors located in the posterosuperior part of the liver (segments 1, 7, 8 and the superior part of 4) are considered poor candidates for LLR owing to limited visibility and the difficulty of controlling bleeding [5]. Moreover, major LLR is sometimes required for LLR in the posterosuperior part of the liver [6,7].

Major LLR is a very challenging procedure that requires expertise and is limited to a few institutions because of its technical demands [8]. The Second Consensus Meeting stated that minor LLR is a standard practice, and that major LLR comprises innovative procedures in the exploration phase [9]. With accumulating experience of LLR, the development of new instruments, the improvements in surgical skills, and the introduction of novel techniques it has become possible to perform laparoscopic donor right hepatectomy, the most challenging type of major LLR [10–12]. Recent studies reported similar oncologic outcomes between LLR and OLR in patients with HCC [13,14]. However, there are few reports describing the long-term oncologic outcomes of major LLR for HCC. Therefore, this study sought to compare the surgical outcomes between major LLR and OLR in patients with HCC.

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## 2. Materials and methods

### 2.1. Patients

We retrospectively reviewed a database comprising prospectively collected data of 177 patients who underwent major LLR for HCC at a tertiary university hospital between January 2004 and November 2015. This study was approved by the hospital's Institutional Review Board and informed consent was taken from all patients. We retrieved the following information from the medical records: patient demographics, clinical presentation, preoperative characteristics, operative results, hospital course, complications, mortality, pathologic findings, and long-term follow-up data.

LLR was only performed in HCC patients with an adequate hepatic reserve in the absence of coagulopathy and portal hypertension [15,16]. We divided the patients into two groups according to the type of procedure: major LLR (LLR group; $n = 67$) and major OLR (OLR group; $n = 110$).

### 2.2. Definitions

All of the cirrhotic patients had histologically confirmed liver cirrhosis, as determined by a pathologist [17,18]. The severity of complications was graded using the Clavien–Dindo classification [19]. Postoperative complications were defined as those occurring up to 30 days after surgery. Postoperative mortality was defined as death within 90 days after surgery. Overall survival was calculated from the date of surgery to the date of death or the last follow-up.

Liver resection was defined according to the Brisbane 2000 terminology [20]. The extent of hepatectomy was defined as major (more than three segments) or minor. Right anterior sectionectomy and right posterior sectionectomy were also considered as major hepatectomy because these procedures are very difficult to perform by OLR or LLR [7,21].

### 2.3. Surgical procedures

The absence of severe portal hypertension and an adequate hepatic reserve are prerequisites for surgery in patients with HCC. Anatomical liver resection was the preferred type of resection, if indicated. The type of resection was selected based on the depth of the lesion(s), the number of lesions, the proximity of the lesion(s) to major vascular structures, and the hepatic reserve. Major liver resection was considered if the remaining liver function was expected to be adequate for a deep-seated lesion. Liver function was evaluated in terms of the indocyanine green retention rate at 15 min (ICG-R15) and computed tomographic volumetry. If the estimated volume of the future remnant liver was insufficient for right hepatectomy, preoperative portal vein embolization was performed [22].

The indications for LLR were similar to those for OLR in terms of the preoperative assessment of liver function, type of liver resection, and postoperative care [14]. However, LLR was not usually considered in patients with tumors > 5 cm in diameter and tumors invading or adjacent to the main portal pedicle or inferior vena cava, as well as patients with central lesions in the suprahepatic junction adjacent to the major hepatic vein [23].

The major LLR techniques used at our institution have been described in more detail elsewhere [6,7,11,12,15]. For right hemihepatectomy or right posterior sectionectomy, the liver was fully mobilized from the inferior vena cava as much as possible and multiple small hepatic veins were divided. The Glissonean approach was usually performed for inflow control. For left hemihepatectomy, after dividing the round ligament, we dissected the left falciform and left triangular ligaments until the left hepatic vein was exposed. After fully mobilizing the left liver, the left hepatic artery and the left portal vein were isolated and divided after applying Hem-o-lock clips. For anatomical resection, Pringle's maneuver was not performed.

### 2.4. Statistical analysis

All statistical analyses were performed using SPSS software version 23.0 (IBM Corp., Armonk, NY). Data are reported as the median (range). The $\chi^2$ test was used to compare categorical variables and independent-samples *t*-test was used to compare continuous variables between the OLR and LLR groups. Survival outcomes were analyzed using the Kaplan–Meier method and were compared using log-rank tests. *P*-values of <0.05 were considered statistically significant.

## 3. Results

There were no differences between two groups in terms of age, body mass index, and the presence of hepatitis, but the proportion of males was greater in the OLR group than in the LLR group (84.7% vs 73.5%, $P = 0.041$; Table 1). In terms of preoperative liver function, the serum albumin concentration was greater in the LLR group than in the OLR group (4.1 ± 0.4 vs 3.9 ± 0.52 g/dl; $P = 0.012$), but there were no differences in platelet count, total bilirubin, glutamic pyruvic transaminase, glutamic-oxaloacetic transaminase, and ICG-R15%. The rate of histologic cirrhosis was also similar between two groups (54.5% vs 55.5%; $P = 0.515$).

The serum α-fetoprotein concentration was not significantly different between the two groups (903.2 ± 4034.8 vs 1985.3 ± 6563.3 ng/ml; $P = 0.186$). The mean tumor size was significantly greater in the OLR group than in the LLR group (6.3 ± 3.8 vs 4.1 ± 2.4 cm; $P < 0.001$).

**Table 1**
Preoperative characteristics of patients with hepatocellular carcinoma who underwent major laparoscopic or open liver resection.

| | LLR group (N = 67) | OLR group (N = 110) | *P* value |
|---|---|---|---|
| Age (years) | 57.7 ± 11.1 | 59.1 ± 12.3 | 0.425 |
| Gender | | | |
| Male | 61 (73.5) | 94 (84.7) | 0.041 |
| Female | 22 (26.5) | 17 (15.3) | |
| BMI (kg/m$^2$) | 24.4 ± 2.9 | 23.7 ± 2.8 | 0.099 |
| Virology | | | 0.348 |
| Hepatitis B | 59 (71.1) | 73 (65.8) | |
| Hepatitis C | 7 (8.4) | 7 (6.3) | |
| Hepatitis B & C | 1 (1.2) | 0 (0) | |
| No hepatitis | 16 (19.3) | 31 (27.9%) | |
| Albumin (g/dl) | 4.1 ± 0.4 | 3.9 ± 0.52 | 0.012 |
| Platelet count (/μl) | 173.1 ± 55.3 | 188.2 ± 82.0 | 0.149 |
| PT (INR) | 1.08 ± 0.116 | 1.09 ± 0.095 | 0.439 |
| Bilirubin (mg/dl) | 0.78 ± 0.38 | 0.90 ± 0.61 | 0.118 |
| SGPT (U/l) | 49.4 ± 54.3 | 46.3 ± 49.8 | 0.682 |
| SGOT (U/l) | 50.2 ± 80.9 | 44.4 ± 40.5 | 0.513 |
| Child–Pugh classification | | | 0.031 |
| A | 79 (95.2) | 92 (88.1) | |
| B | 2 (2.4) | 11 (9.9) | |
| C | 2 (2.4) | 8 (7.2) | |
| ICG-R15 | 9.1 ± 8.3 | 9.5 ± 5.9 | 0.698 |
| Histologic cirrhosis | 36 (54.5%) | 61 (55.5%) | 0.515 |
| α-fetoprotein (ng/ml) | 903.2 ± 4034.8 | 1985.3 ± 6563.3 | 0.186 |
| Tumor size (cm) | 4.1 ± 2.4 | 6.3 ± 3.8 | 0.000 |

Values are expressed as the mean ± standard deviation or *n* (%).
LLR, laparoscopic liver resection; OLR, open liver resection; BMI, body mass index; PT, prothrombin time; INR, international normalized ratio; SGPT, serum glutamic-pyruvic transaminase; SGOT, serum glutamic-oxaloacetic transaminase; ICG-R15, indocyanine green retention rate at 15 min.