Asian Journal of Surgery (2019) 42, 180–188

Available online at www.sciencedirect.com

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journal homepage: www.e-asianjournalsurgery.com

ORIGINAL ARTICLE

The safety and efficacy of laparoscopic hepatectomy in obese patients

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Received 9 September 2017; received in revised form 9 October 2017; accepted 30 October 2017
Available online 20 December 2017

KEYWORDS
Laparoscopic hepatectomy;
Laparoscopic liver resection;
Obesity

Summary *Background:* Obesity is generally reported to increase the risk of surgical complications. There have been few reports of laparoscopic hepatectomy (LH) in obese patients. The purpose of this study was to compare the safety and efficacy of (1) LH versus open hepatectomy (OH) in obese patients and (2) LH in obese patients versus LH in non-obese patients.
Methods: We introduced LH at our institution in April 2014. LH was performed in 63 obese patients and 108 non-obese patients from April 2014 to May 2017. OH was performed in 79 obese patients from January 2010 to May 2017. This study retrospectively compared the short-term outcomes of the LH obese group with those of the OH obese group and the LH non-obese group.
Results: In patient characteristics, the LH obese group included a significantly higher percentage of patients with liver cirrhosis than the OH obese group. The LH obese group had fewer patients with a history of abdominal surgery but more with liver cirrhosis than the LH non-obese group. For short-term outcomes, the LH obese group had significantly less blood loss, fewer intraoperative transfusions, fewer positive surgical margins, and shorter postoperative hospital stays than the OH obese group. In contrast, only operation time was significantly different (longer) in the LH obese group than in the LH non-obese group. There were no significant differences in morbidity or mortality between the LH obese group and either the OH obese or the LH non-obese groups.
Conclusion: LH in obese patients is safe and effective.

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https://doi.org/10.1016/j.asjsur.2017.10.002
1015-9584/

1. Introduction

Obesity rates are increasing worldwide as a result of lifestyle changes.[1] This trend is also progressing rapidly in Japan. Obesity is generally associated with technical difficulties in surgery, and is reported to increase the risk of complications.[2–4] Furthermore, obesity sometimes results in chronic liver disease such as fatty liver and nonalcoholic steatohepatitis as well as other comorbidities, including diabetes mellitus and cardiovascular disease.[5–9] Therefore, obesity can further increase surgical risks.[10,11]

Recently, with the development and wide use of laparoscopic hepatectomy (LH), the indications for the procedure have expanded and its efficacy has been increasingly reported.[12–16] However, there have been few reports of LH in patients with obesity. Most of these reports have included relatively few cases and have compared LH in obese versus non-obese patients.[17–22]

We introduced LH at our institution in April 2014. We now use a laparoscopic approach for almost all hepatectomies that do not require extrahepatic bile duct resection or revascularization. The purpose of this study was to evaluate the safety and efficacy of (1) LH versus open hepatectomy (OH) in obese patients and (2) LH in obese versus non-obese patients.

2. Methods

2.1. Indications for LH

Until March 2016, the Japanese insurance system only covered a laparoscopic approach for partial hepatectomy and left lateral sectionectomy. However, beginning in April 2016, all laparoscopic anatomical hepatectomies without extrahepatic bile duct resection have been covered by the insurance system. Indications for LH at our institution currently include all types of hepatectomy for all intrahepatic diseases not requiring extrahepatic bile duct resection or revascularization. The laparoscopic approach is standard in all cases that satisfy these indications unless OH is desired by the patient, including patients with a history of abdominal surgery and hepatectomy, severe liver cirrhosis, and obesity.

2.2. Participants

A total of 182 LH procedures were performed at Kurashiki Central Hospital from April 2014 to May 2017. Among these, 11 patients underwent simultaneous surgery at other sites, including colorectal resection, gastroduodenal resection, and mastectomy; these patients were excluded from this study. Among the remaining 171 patients who underwent LH, 108 had a body mass index (BMI) below 25 kg/m^2 (LH non-obese group) and 63 had a BMI above 25 kg/m^2 (LH obese group). Thirteen of the 63 obese patients had a BMI above 30 kg/m^2 (LH highly obese group). There were two conversions from LH to open surgery, and the cases were classified as the LH group (LH non-obese group). All cases in the LH obese group underwent pure laparoscopic hepatectomy, and three cases in the LH non-obese group were treated by the hybrid technique. From January 2010 to May 2017, 352 OH were performed; 90 of these patients had a BMI above 25 kg/m^2 (OH obese group). Among these, 11 patients underwent simultaneous surgery at other sites, extrahepatic bile duct resection, or emergency surgery; the remaining 79 patients were included in this study. Sixteen of these 79 patients had a BMI above 30 kg/m^2 (OH highly obese group).

To evaluate the safety and efficacy of LH in obese patients, we compared patient characteristics, perioperative findings, pathological findings, and postoperative outcomes in the LH obese group with those in the OH obese group. The LH and OH highly obese groups were compared in the same way. We also analyzed differences between the LH obese and LH non-obese groups to evaluate the difficulties of LH in obese patients.

The data were retrospectively reviewed from medical records. This retrospective study was reviewed and approved by the Institution Review Board of Kurashiki Central Hospital. Patients were not required to give informed consent for this study because the analysis used anonymous clinical data that were obtained after each patient provided written consent for treatment.

2.3. Statistical analyses

Patient characteristics, tumor characteristics, perioperative factors, and short-term outcomes were expressed as median with range for continuous data and as number with percentage for categorical data. The LH and OH obese groups, LH and OH highly obese groups, and LH non-obese and obese groups were compared with the chi-square test or Fisher's exact test for categorical data and with the Mann–Whitney U test for continuous data. P values <0.05 were considered statistically significant. These analyses were performed with IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA).

3. Results

Patient and tumor characteristics and perioperative factors for the LH and OH obese groups, including clinicopathological and surgical data, are summarized in Table 1. In this study, anatomic resection was defined as resection not less than segmentectomy, including segmentectomy, sectionectomy, hemihepatectomy, bisectionectomy, and trisectionectomy. The LH obese group had a significantly higher percentage of patients with liver cirrhosis (47.6% vs. 22.1%; $p = 0.001$). There were no significant differences between the LH and OH obese groups in patient sex, age, BMI, history of abdominal surgery, type of chronic liver disease (including hepatitis virus), diabetes mellitus, indocyanine green retention rate at 15 min, Child–Pugh classification, previous transarterial chemoembolization or radiofrequency ablation, preoperative chemotherapy, maximum tumor diameter, number of lesions, number of resected sites, pathological diagnosis, type of procedure (anatomic resection or nonanatomic resection), or percentage of rehepatectomy cases.

Table 2 compares short-term outcomes between the LH and OH obese groups. There were no conversions from LH to

Table 1 Patient and tumor characteristics and perioperative factors in LH obese and OH obese groups.

Patient and tumor characteristics and perioperative factors	LH obese group (n = 63)	OH obese group (n = 79)	*P* value
Sex, male/female, number (%)	41 (65.1)/22 (34.9)	54 (68.4)/25 (31.6)	0.680[a]
Age, years, median (range)	70 (41—87)	67.5 (25—83)	0.277[b]
BMI, kg/m^2, median (range)	26.9 (25.0—33.9)	27.5 (25.0—35.9)	0.207[b]
History of abdominal surgery, number (%)	38 (60.3)	41 (51.9)	0.202[a]
Chronic liver disease, number (%)			0.054[a]
HBV	8 (12.7)	7 (8.9)	
HCV	18 (28.6)	19 (24.1)	
HBV and HCV	2 (3.2)	0	
Alcoholism	10 (15.9)	4 (5.1)	
NASH	5 (7.9)	11 (13.9)	
Others	0	3 (3.8)	
Diabetes mellitus, number (%)	23 (36.5)	34 (43.0)	0.430[a]
ICGR15, median (range)	11.3% (2.5—53.0%)	9.5% (2.3—56.0%)	0.395[b]
Liver cirrhosis, number (%)	30 (47.6)	17 (21.5)	0.001[a]
Child—Pugh classification, number (%)			0.399[c]
Grade A	62 (98.4)	76 (96.2)	
Grade B	1 (1.6)	3 (3.8)	
Grade C	0	0	
Previous TACE or RFA, number (%)	13 (20.6)	11 (13.9)	0.289[a]
Preoperative chemotherapy, number (%)	7 (11.1)	12 (15.2)	0.478[a]
Maximum tumor diameter, mm, median (range)	20 (4—110)	24 (2—150)	0.062[b]
Maximum tumor diameter ≧50 mm, number (%)	6 (9.5)	13 (16.5)	0.228[a]
Number of lesions, median (range)	1 (1—3)	1 (1—5)	0.289[b]
Number of resected sites, median (range)	1 (1—3)	1 (1—5)	0.770[b]
Pathological diagnosis, number (%)			0.787[a]
HCC	42 (66.7)	46 (58.2)	
CCC	0	6 (7.6)	
Combined HCC and CCC	4 (6.3)	1 (1.3)	
Metastatic tumor	14 (22.2)	22 (27.8)	
Others	3 (4.8)	4 (5.1)	
Nonanatomic/anatomic procedure, number (%)	37 (58.7)/26 (41.3)	36 (45.6)/43 (54.4)	0.119[a]
Segmentectomy, number (%)	8 (12.7)	7 (8.9)	
Sectionectomy, number (%)	14 (22.2)	27 (34.2)	
Bisectionectomy or hemihepatectomy, number (%)	4 (6.3)	7 (8.9)	
Trisectionectomy, number (%)	0	2 (2.5)	
Rehepatectomy, number (%)	11 (17.5)	10 (12.7)	0.423[a]

BMI, body mass index; HBV, hepatitis B virus; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis; ICGR15, indocyanine green retention rate at 15 min; TACE, transarterial chemoembolization; RFA, radiofrequency ablation; HCC, hepatocellular carcinoma; CCC, cholangiocellular carcinoma.

[a] Chi-square test.
[b] Mann—Whitney U-test.
[c] Fisher's exact test.

open surgery. The median operation time of 243 min (range 57—611 min) in the LH obese group and 240 min (range 60—1418 min; $p = 0.56$) in the OH obese group were comparable. The LH group had less blood loss (median 25 mL; range, minimal—1385 mL) than the OH group (median 630 mL; range, minimal—32,149 mL; $p < 0.001$), fewer intraoperative transfusions (0% vs. 31.6%; $p < 0.001$), and fewer positive surgical margins (1.6% vs. 10.1%; $p = 0.03$). There were no significant differences between the groups in morbidity, severe postoperative complications (Clavien—Dindo grade ≥ 3), or mortality. We experienced one postoperative liver failure which caused mortality in the LH obese group. The median postoperative hospital stay was 7 days (range 4—15 days) in the LH obese group and 10 days (range 6—74 days) in the OH obese group; this difference was significant ($p < 0.001$). Table 3 shows patient and tumor characteristics and perioperative factors in the LH and OH highly obese groups. Table 4 shows short-term outcomes of these groups. No significant differences in patient or tumor characteristics or perioperative factors were found. In the short-term outcomes, the LH highly obese group had significantly less blood loss (median 100 mL; range, minimal—750 mL) than the OH highly obese group (median 1031 mL; range, 32—32,149 mL; $p = 0.001$)

Table 2 Short-term outcomes in LH obese and OH obese groups.

Short-term outcomes	LH obese group (n = 63)	OH obese group (n = 79)	*P* value
Operation time, min, median (range)	243 (57–611)	240 (60–1418)	0.565[c]
Blood loss, mL, median (range)	25 (minimal–1385)	630 (minimal–32,149)	<0.001[c]
Intraoperative transfusion, number (%)	0	25 (31.6%)	<0.001[b]
Postoperative hospital stay, days, median (range)	7 (4–15)	10 (6–74)	<0.001[c]
Surgical margin positive, number (%)	1 (1.6)	8 (10.1)	0.037[d]
Morbidity, number (%)	3 (4.8)	9 (11.4)	0.158[b]
Liver failure, number (%)	1 (1.6)	0	
Bile leak, number (%)	0	1 (1.3)	
Liver abscess, number (%)	0	1 (1.3)	
Ascites, number (%)	1 (1.6)	0	
Bile duct stone, number (%)	0	1 (1.3)	
Intraabdominal abscess, number (%)	0	1 (1.3)	
Ileus, number (%)	1 (1.6)	1 (1.3)	
Pseudomembranous enterocolitis, number (%)	0	1 (1.3)	
Pneumonia, number (%)	0	2 (2.5)	
Wound infection, number (%)	0	1 (1.3)	
Severe postoperative complications,[a] number (%)	1 (1.6)	3 (3.8)	0.399[d]
Liver failure, number (%)	1 (1.6)	0	
Bile leak, number (%)	0	1 (1.3)	
Liver abscess, number (%)	0	1 (1.3)	
Bile duct stone, number (%)	0	1 (1.3)	
Mortality within 30 days, number (%)	0	0	
Mortality within 90 days, number (%)	1 (1.6)	0	0.444[d]

[a] Clavien–Dindo grade $\geq$ 3 complications.
[b] Chi-square test.
[c] Mann–Whitney U-test.
[d] Fisher's exact test.

and required fewer intraoperative transfusions (0% vs. 43.8%; $p = 0.007$). All other outcomes were comparable between the groups, including operation time and postoperative hospital stay.

Comparison of the LH non-obese and LH obese groups revealed that BMI was significantly higher in the obese group (Table 5). The LH obese group had a smaller percentage of patients with a history of abdominal surgery (60.3% vs. 75%; $p = 0.04$). However, the LH obese group had significantly higher percentages of patients with diabetes mellitus (36.5% vs. 22.2%; $p = 0.044$) and liver cirrhosis (47.6% vs. 23.1%; $p = 0.001$). The two groups did not differ in other patient or tumor characteristics or perioperative factors. As for short-term outcomes, only operation time was significantly different between the groups, with the LH obese group having longer surgeries (243 min for LH obese group vs. 192 min for LH non-obese group; $p = 0.006$) (Table 6). The rate of conversion to open surgery, blood loss, intraoperative transfusion, postoperative hospital stay, surgical margin status, morbidity, and mortality were all comparable between the LH obese and non-obese groups.

4. Discussion

Abundant visceral fat decreases the visibility of vessels and other structures, increases bleeding, and narrows the operative field during surgery. Therefore, surgery in patients with obesity is usually challenging and is associated with an increased risk of morbidity. Obesity increases the surgical risks of OH and has negative effects on surgery.[5–11]

The effects of obesity in laparoscopic surgery have also been reported. In laparoscopic colorectal surgery, BMI is a predictor for perioperative outcomes, with longer operation times, higher rates of conversion to open surgery, and higher morbidity, including anastomotic leakage and surgical site infection, reported in obese patients compared with non-obese patients.[23,24] However, a systematic literature review by Hotouras et al reported that although operation time was longer in patients with obesity, there were no significant differences in intraoperative blood loss or postoperative morbidity between obese and non-obese patients.[25] In addition, Vignali et al reported that laparoscopic colectomy had longer operation times but lower blood loss than open colectomy, and that overall morbidity did not differ between the two groups.[26] Reported operation times for laparoscopic gastrectomy are generally significantly longer for obese patients than for non-obese patients; however, this difference was not associated with increased intraoperative blood loss or morbidity.[27–30] In a comparison between laparoscopy-assisted distal gastrectomy (LADG) and open distal gastrectomy (ODG), Ohno et al found that blood loss was significantly less for LADG than for ODG, but that operation time and blood loss in

Table 3 Patient and tumor characteristics and perioperative factors in LH highly obese and OH highly obese groups.

Patient and tumor characteristics and perioperative factors	LH highly obese group (n = 13)	OH highly obese group (n = 16)	*P* value
Sex, male/female, number (%)	4 (30.8)/9 (69.2)	10 (62.5)/6 (37.5)	0.089[a]
Age, years, median (range)	69 (41–85)	64.5 (44–82)	0.329[b]
BMI, kg/m^2, median (range)	32.0 (30.0–33.9)	31.1 (30.1–35.9)	0.714[b]
History of abdominal surgery, number (%)	9 (60.3)	9 (51.9)	0.372[c]
Chronic liver disease, number (%)			0.516[a]
HBV	2 (15.4)	1 (6.3)	
HCV	2 (15.4)	3 (18.8)	
HBV and HCV	0	0	
Alcoholism	1 (7.7)	0	
NASH	2 (15.4%)	6 (37.5)	
Others	0	0	
Diabetes mellitus, number (%)	9 (69.2)	11 (68.8)	0.647[c]
ICGR15, median (range)	10.8% (3.0–40.5%)	8.8% (3.0–56.0%)	0.753[b]
Liver cirrhosis, number (%)	5 (38.5)	5 (31.3)	0.493[c]
Child–Pugh classification, number (%)			0.551[c]
Grade A	13	15 (93.8)	
Grade B	0	1 (6.2)	
Grade C	0	0	
Previous TACE or RFA, number (%)	1 (7.7)	2 (12.5)	0.580[c]
Preoperative chemotherapy, number (%)	2 (15.4)	3 (18.8)	0.604[c]
Maximum tumor diameter, mm, median (range)	38 (17–110)	32.5 (8–150)	0.982[b]
Maximum tumor diameter ≧50 mm, number (%)	3 (23.1)	4 (25)	0.626[c]
Number of lesions, median (range)	1 (1–3)	1 (1–3)	0.475[b]
Number of resected sites, median (range)	1 (1–2)	1 (1–2)	0.682[b]
Pathological diagnosis, number (%)			0.251[a]
HCC	7 (53.8)	9 (56.3)	
CCC	0	3 (18.8)	
Combined HCC and CCC	0	0	
Metastatic tumor	5 (38.5)	4 (25)	
Others	1 (7.7)	0	
Nonanatomic/anatomic procedure, number (%)	7 (53.8)/6 (46.2)	5 (31.3)/11 (68.8)	0.219[a]
Segmentectomy, number (%)	0	3 (18.8)	
Sectionectomy, number (%)	3 (23.1)	6 (35.3)	
Bisectionectomy or hemihepatectomy, number (%)	3 (23.1)	2 (12.5)	
Trisectionectomy, number (%)	0	0	
Rehepatectomy, number (%)	3 (23.1)	2 (12.5)	0.396[c]

BMI, body mass index; HBV, hepatitis B virus; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis; ICGR15, indocyanine green retention rate at 15 min; TACE, transarterial chemoembolization; RFA, radiofrequency ablation; HCC, hepatocellular carcinoma; CCC, cholangiocellular carcinoma.
[a] Chi-square test.
[b] Mann–Whitney U-test.
[c] Fisher's exact test.

LADG were negatively influenced by obesity.[31] Makino et al reported that obesity did not influence operative outcomes of LADG, including operation time and intraoperative blood loss, whereas obese patients undergoing ODG had longer operation times and more intraoperative blood loss than non-obese patients.[32] Thus, laparoscopic colorectal and gastric surgery is feasible and safe in obese patients but is somewhat difficult, sometimes requiring longer operation time. Therefore, a careful approach is required for patients with obesity.

Several reports have described the safety and efficacy of LH in patients with obesity.[17–22] However, most of those reports included relatively few cases and compared LH in obese versus non-obese patients. Hasegawa et al reported that obesity influenced the surgical difficulty of LH and prolonged the operation time.[17] Yu et al reported that obesity raised the LH conversion rate, but did not increase morbidity.[18] Nomi et al demonstrated that BMI did not negatively affect short-term outcomes, including operation time, intraoperative blood loss, and overall complications.[22] In our study, LH took significantly longer in obese patients than in non-obese patients. Although there were some differences in patient characteristics between the groups, such as a history of abdominal surgery and

Table 4 Short-term outcomes in LH highly obese and OH highly obese groups.

Short-term outcomes	LH highly obese group (n = 13)	OH highly obese group (n = 16)	*P* value
Operation time, min, median (range)	284 (111–520)	288.5 (86–1418)	0.914[b]
Blood loss, mL, median (range)	100 (minimal–750)	1031 (minimal–32,149)	0.001[b]
Intraoperative transfusion, number (%)	0	7 (43.8)	0.007[c]
Postoperative hospital stay, days, median (range)	9 (4–15)	10.5 (6–61)	0.144[b]
Surgical margin positive, number (%)	0	2 (12.5)	0.296[c]
Morbidity, number (%)	0	2 (12.5)	0.296[c]
Ileus, number (%)	0	1 (6.3)	
Pneumonia, number (%)	0	1 (6.3)	
Severe postoperative complications,[a] number (%)	0	0	
Mortality within 30 days, number (%)	0	0	
Mortality within 90 days, number (%)	0	0	

[a] Clavien–Dindo grade $\geq$ 3 complications.
[b] Mann–Whitney U-test.
[c] Fisher's exact test.

liver cirrhosis, other short-term outcomes were equivalent. The LH obese group had significantly higher rates of diabetes mellitus and liver cirrhosis than the LH non-obese group, which might have been a disadvantageous condition. In summary, LH in obese patients is safe, but can sometimes be more difficult than LH in non-obese patients.

Few reports have compared LH and OH in obese patients. Uchida et al reported that operation time and blood loss were significantly lower with LH than with OH in obese patients with BMI $\geq$25 kg/m^2.[20] However, that study was very small, including only 12 cases of LH and 10 cases of OH. Toriguchi et al also reported decreased intraoperative blood loss and shortened postoperative hospital stays with LH than with OH in obese patients (BMI $>$ 25 kg/m^2).[21] However, that study also had only 13 cases of LH. In these reports, the indications for LH were somewhat limited, with LH only performed in selected cases. Our study showed preferable results with LH in obese patients, with a relatively large number of cases (63 cases of LH and 79 of OH). At our institution, the indications for LH are almost the same as those for OH, without special exclusion criteria except for cases requiring extrahepatic bile duct resection or vascular reconstruction. Exclusion criteria by size are not decided, but it is certainly difficult to adopt LH for huge tumors larger than 15 cm or 20 cm. We may choose the open hepatectomy for such a huge tumors after we confirm the lesion by laparoscope and judge whether laparoscopic surgery is possible. In this study, such a huge tumor did not exist. Of course, there is some selection bias in this study. However, the selection of surgical procedure in the present study mainly depended on the date of surgery, because we started LH in April 2014, and because laparoscopic anatomical hepatectomies have been covered by the Japanese insurance system since April 2016. We believe that there was not much selection bias for LH. In fact, certain patient characteristics were disadvantageous in the LH group, including diabetes mellitus and liver cirrhosis. Despite these disadvantages, the LH group had better short-term outcomes with respect to blood loss, need for intraoperative transfusion, length of postoperative hospital stay, and surgical margin status. None of the LH group outcome parameters were inferior to those of the OH group.

Obesity is clearly associated with an increased risk of chronic liver diseases such as fatty liver and nonalcoholic steatohepatitis.[11] We must decide the surgical procedure cautiously and sometimes need to select parenchymal sparing resection rather than major anatomical resection. In this study, the type of hepatectomy was not significantly different between the LH non-obese and obese groups. Furthermore, obesity generally makes operation difficult. However, adipose tissues around and within the liver are not noticeable during hepatectomy. Therefore, liver parenchymal transection can be performed almost free from the disturbances of adipose tissues. It is certain that the body shape of obese patients makes the surgical procedure more difficult. The impact of body shape seems to be much greater in OH than in LH. The laparoscopic approach has several advantages in hepatectomy for obese patients. Laparoscopic surgery is not affected by a thick body wall once the trocars are placed. Laparoscopy provides good visualization even in a space narrowed by obesity, and the laparoscopic view can enable in situ resection even when there is excessive surrounding adipose tissue. The magnified laparoscopic view provides excellent visualization of the vasculature. Thus, we think that LH is a suitable procedure for obese patients.

This study has some limitations. First, this was a retrospective study, and randomized studies should be planned. However, it would currently be rather difficult to perform a randomized study because LH has already become widespread as a standard procedure. Second, this study did not have many patients classified as obese according to the WHO definition (BMI $\geq$ 30 kg/m^2). However, our findings demonstrate that LH had great advantages over OH, even for patients with higher BMI.

In conclusion, LH in obese patients is safe and effective, achieving good short-term outcomes. LH can be recommended as an optimal option for obese patients.

Table 5 Patient and tumor characteristics and perioperative factors in LH non-obese and LH obese groups.

Patient and tumor characteristics and perioperative factors	LH non-obese group (n = 108)	LH obese group (n = 63)	*P* value
Sex, male/female, number (%)	82 (75.9)/26 (24.1)	41 (65.1)/22 (34.9)	0.128[a]
Age, years, median (range)	70 (39—89)	70 (41—87)	0.997[b]
BMI, kg/m^2, median (range)	22.2 (15.6—24.9)	26.9 (25.0—33.9)	<0.001[b]
History of abdominal surgery, number (%)	81 (75)	38 (60.3)	0.044[a]
Chronic liver disease, number (%)			0.062[a]
HBV	14 (13.0)	8 (12.7)	
HCV	30 (27.8)	18 (28.6)	
HBV and HCV	2 (3.2)	2 (3.2)	
Alcoholism	7 (6.5)	10 (15.9)	
NASH	1 (0.9)	5 (7.9)	
Others	2 (1.9)	0	
Diabetes mellitus, number (%)	24 (22.2)	23 (36.5)	0.044[a]
ICGR15, median (range)	11.4% (0.8—81.1%)	11.25% (2.5—53.0%)	0.804[b]
Liver cirrhosis, number (%)	25 (23.1)	30 (47.6)	0.001[a]
Child—Pugh classification, number (%)			0.281[c]
Grade A	103 (95.4)	62 (90.6)	
Grade B	5 (4.6)	1 (9.4)	
Grade C	0	0	
Previous TACE or RFA, number (%)	12 (11.1)	13 (20.6)	0.089[a]
Preoperative chemotherapy, number (%)	24 (22.2)	7 (11.1)	0.069[a]
Maximum tumor diameter, mm, median (range)	21 (5—85)	20 (4—110)	0.910[b]
Maximum tumor diameter ≧50 mm, number (%)	7 (6.5)	6 (9.5)	0.329[c]
Number of lesions, median (range)	1 (1—4)	1 (1—3)	0.847[b]
Number of resected sites, median (range)	1 (1—4)	1 (1—3)	0.785[b]
Pathological diagnosis, number (%)			0.084[a]
HCC	53 (49.1)	42 (66.7)	
CCC	1 (0.9)	0	
Combined HCC and CCC	4 (3.7)	4 (6.3)	
Metastatic tumor	46 (42.6)	14 (22.2)	
Others	4 (3.7)	3 (4.8)	
Nonanatomic/anatomic procedure, number (%)	70 (64.8)/38 (35.2)	37 (58.7)/26 (41.3)	0.428[a]
Segmentectomy, number (%)	8 (7.4)	8 (12.7)	
Sectionectomy, number (%)	22 (20.4)	14 (22.2)	
Bisectionectomy or hemihepatectomy, number (%)	8 (7.4)	4 (6.3)	
Trisectionectomy, number (%)	0	0	
Rehepatectomy, number (%)	25 (23.1)	11 (17.5)	0.379[a]

BMI, body mass index; HBV, hepatitis B virus; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis; ICGR15, indocyanine green retention rate at 15 min; TACE, transarterial chemoembolization; RFA, radiofrequency ablation; HCC, hepatocellular carcinoma; CCC, cholangiocellular carcinoma.

[a] Chi-square test.
[b] Mann—Whitney U-test.
[c] Fisher's exact test.

Table 6 Short-term outcomes in LH non-obese and LH obese groups.

Short-term outcomes	LH non-obese group (n = 108)	LH obese group (n = 63)	*P* value
Conversion to open surgery, number (%)	2 (1.9)	0	0.398[d]
Operation time, min, median (range)	192 (43–497)	243 (57–611)	0.006[c]
Blood loss, mL, median (range)	minimal (minimal–6937)	25 (minimal–1385)	0.119[c]
Intraoperative transfusion, number (%)	6 (5.6)	0	0.060[d]
Postoperative hospital stay, days, median (range)	7 (3–86)	7 (4–15)	0.640[c]
Surgical margin positive, number (%)	7 (6.5)	1 (1.6)	0.137[d]
Morbidity, number (%)	15 (13.9)	3 (4.8)	0.061[b]
Liver failure, number (%)	0	1 (1.6)	
Liver abscess, number (%)	3 (2.8)	0	
Ascites, number (%)	0	1 (1.6)	
Intraabdominal abscess, number (%)	2 (1.9)	0	
Postoperative hemorrhage, number (%)	1 (0.9)	0	
Ileus, number (%)	2 (1.9)	1 (1.6)	
Pneumonia, number (%)	1 (0.9)	0	
Shunt obstruction for dialysis, number (%)	1 (0.9)	0	
Colon perforation, number (%)	1 (0.9)	0	
Delayed gastric emptying	1 (0.9)	0	
Fever of unknown cause, number (%)	1 (0.9)	0	
Anorexia, number (%)	1 (0.9)	0	
Wound infection, number (%)	1 (0.9)	0	
Severe postoperative complications,[a] number (%)	5 (4.6)	1 (1.6)	0.281[d]
Liver failure, number (%)	0	1 (1.6)	
Liver abscess, number (%)	1 (0.9)	0	
Intraabdominal abscess, number (%)	1 (0.9)	0	
Shunt obstruction for dialysis, number (%)	1 (0.9)	0	
Colon perforation, number (%)	1 (0.9)	0	
Postoperative hemorrhage, number (%)	1 (0.9)	0	
Mortality within 30 days, number (%)	1 (0.9)	0	0.632[d]
Mortality within 90 days, number (%)	1 (0.9)	1 (1.6)	0.602[d]

[a] Clavien–Dindo grade $\geq$ 3 complications.
[b] Chi-square test.
[c] Mann–Whitney U-test.
[d] Fisher's exact test.

Disclosures

Drs. Yusuke Ome, Kazuki Hashida, Mitsuru Yokota, Yoshio Nagahisa, Michio Okabe, and Kazuyuki Kawamoto have no conflicts of interest or financial ties to disclose.

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