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ORIGINAL ARTICLE

Retrospective Study

Benefit of laparoscopic liver resection in high body mass index patients

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Abstract

AIM: To explore the impact of body mass index (BMI) on surgical outcomes in patients undergoing laparoscopic liver resection (LLR).

METHODS: From January 2010 to February 2015, sixty-eight patients who underwent primary partial liver resection in our institute were retrospectively reviewed. Surgical outcomes of LLR were compared with those of open liver resection (OLR). In addition, we analyzed associations with BMI and surgical outcomes.

RESULTS: Among 68 patients, thirty-nine patients underwent LLR and 29 were performed OLR. Significant difference in operation time, blood loss, and postoperative hospital stay was observed. There were no significant differences in mortality and morbidity in two groups. Twenty-two patients (32.4%) were classified as obese (BMI $\geqslant$ 25). A statistically significant correlation was observed between BMI and operation time, between BMI and blood loss in OLR, but not in LLR. The operation time and blood loss of OLR were significantly higher than that of LLR in obese patients. Open liver resection and BMI were independent predictors for prolonged operation time and increased blood loss in multivariate analysis.

CONCLUSION: The present study demonstrated that

BMI had influenced to surgical outcomes of OLR. LLR was less influenced by BMI and had great benefit in obese patients.

Key words: Laparoscopic liver resection; Obesity; Body mass index; Prolonged operation time; Increased blood loss

Core tip: This study presented the correlation between body mass index (BMI) and surgical outcomes of 68 cases performed laparoscopic liver resection (LLR) and open liver resection (OLR). A statistically significant correlation was observed between BMI and operation time, between BMI and blood loss in OLR, but not in LLR. Open liver resection and BMI were independent predictors for prolonged operation time and increased blood loss in multivariate analysis. LLR in obese patients was safe and had great benefit without prolonged operation time and increased blood loss.

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INTRODUCTION

Obese patients have been increasing worldwide[1,2]. They have multiple co-morbidities such as diabetes mellitus, dyslipidemia and cardiovascular disease[3,4]. Obesity induce various liver diseases, including fatty liver, ranging from steatosis to non-alcoholic steatohepatitis (NASH). NASH induce liver cirrhosis and hepatocellular carcinoma (HCC) with it progress[5,6]. Moreover, obesity is known as independent risk factor for several malignancies, including liver cancer[6,7]. Regarding the surgical outcomes of liver resection for obesity patients, some studies showed obesity to be a significant predictor of an adverse postoperative course after liver resection[8,9]. However, other studies have demonstrated that obesity did not increase the risk of morbidity[10].

Laparoscopic surgery has several advantages, such as less destruction of abdominal wall, early post-operative recovery and less postoperative morbidity as compared to open surgery[11,12]. More than thirty years ago, obesity had been generally regarded as a contraindication for laparoscopic surgery because of associated technical difficulties[13]. Approximately ten years ago, several reports had suggested obesity as a risk factor in conversion[14,15]. Recently, it comes to be reported that laparoscopic surgery brings good results even in obese patients, including cholecystectomy, gastrectomy and colectomy[16-18]. The impact of obesity on the outcomes of laparoscopic liver resection (LLR), however, still remains a controversial matter as on the outcomes of open liver resection (OLR).

The aim of this study was to evaluate the surgical outcomes of LLR in obese/non-obese patients and OLR in obese/non-obese patients to clarify the benefit of LLR in obese patients.

MATERIALS AND METHODS

Patients characteristics and classification according to BMI

We retrospectively reviewed medical data from charts and surgical records of 255 patients who underwent liver resection at the Department of Gastroenterological and Pediatric Surgery, Oita University Faculty of Medicine, Oita, Japan, from January 2010 through February 2015. During the period, partial liver resection was performed in 111 patients. The patients with repeat liver resection (n = 24) and had multiple site of liver resections (n = 19) were excluded. Finally, we reviewed the records of 68 patients. The patients were divided into following two groups: an OLR group, performed until September 2012, and a LLR group, performed after October 2012.

We compared clinical parameters and surgical outcomes between the two groups. The correlation between body mass index (BMI) and surgical outcomes in each group was also investigated. Each patient's height and weight were measured preoperatively, and BMI (kg/m^2) was calculated as the weight (in kg) divided by the height squared (in m). According to the World health Organization, body weight was divided into three type; underweight (BMI < 18.5), normal weight (BMI 18.5-24.9), over weight (BMI 25.0-29.9), and obese (BMI > 30)[19]. In Japan, BMI ≥ 25 is considered as obese based on the definition by the Japan Society for the Study of Obesity and World Health Organization expert consultation[20]. In the present study, we defined patients with BMI ≥ 25 as obesity. We also used the difficulty scoring system for LLR. The difficulty was scored by the extent of liver resection, tumor location, tumor size, liver function, and tumor proximity to major vessels, as described previously[21].

Surgical procedure

The surgical technique of LLR has been described previously[22]. Ultrasonography was routinely performed to confirm the tumor. Liver parenchyma transection was performed by the combination of a cavitation ultrasonic surgical aspirator, ultrasonic scalpel, and monopolar soft coagulation system. OLR was performed with same positioning and with same devises during liver parenchyma transaction under intermittent Pringle maneuver.

Table 1 Comparison of patients' characteristics and surgical outcomes *n* (%)

	LLR (*n* = 39)	OLR (*n* = 29)	*P* value
Age (yr)	69.4 ± 10.2	68.3 ± 8.1	NS
Sex (Male/Female)	26/13	22/7	NS
HBV	6 (15.4)	4 (13.8)	NS
HCV	19 (48.7)	13 (44.8)	NS
Diagnosis			
Hepatocellular carcinoma	33 (84.6)	22 (75.9)	
Intrahepatic cholangiocarcinoma	2 (5.1)	1 (3.4)	
Metastatic liver tumor	2 (5.1)	6 (20.7)	
Hemangioma	2 (5.1)	0	
Body mass index (kg/m^2)	24.1 ± 4.1	23.9 ± 3.9	NS
Tumor size (mm)	27.3 ± 14.5	27.6 ± 11.6	NS
Surgical outcome			
Operation time (min)	226.1 ± 117.2	292.8 ± 86.7	0.009
Blood loss (mL)	109.3 ± 162.0	406.9 ± 425.6	0.001
Postoperative hospital stay (d)	12.8 ± 10.4	23.6 ± 30.1	0.042
Overall morbidity	4 (10.2)	7 (24.1)	NS
Grade Ⅰ	0	1	
Grade Ⅱ	3	4	
Grade Ⅲ (a/b)	1/0	1/1	
Grade Ⅳ	0	0	
Grade Ⅴ	0	0	
Bile leakage	1 (2.7)	2 (6.9)	NS

LLR: Laparoscopic liver resection; OLR: Open liver resection.

Statistical analysis

All variables are expressed as mean ± SD for continuous data and as number with percentages for categorical data. Statistical analysis was performed using Student's *t* for continuous variables and χ^2 test for categorical variables. The correlation between continuous variables was investigated by Pearson's rank correlation. Multivariate logistic regression analyses were performed to identify predictors associated with prolonged operation time and increased blood loss. In these analyses, the cutoff point for operation time and blood loss was determined using receiver operating characteristic (ROC) curve analysis. Statistical significance was set at $P < 0.05$. All statistical analyses were performed using SPSS for Windows software (IBM-SPSS, Inc., Chicago, IL, United States).

RESULTS

Patient characteristics

Among those 68 patients, thirty-nine underwent LLR and 29 were performed OLR. Patients' characteristics and surgical outcomes are shown in Table 1. Patients' characteristics were similar between the two groups. There were no open conversions in LLR group. LLR had lower operation time and blood loss than OLR, significantly. +LLR had also lower postoperative hospital stay than OLR. There were no significant differences in morbidity rate between the two groups.

Correlation between BMI and surgical outcomes

Correlation between BMI and surgical outcomes using Pearson's rank correlation test are shown in Figure 1. Significant correlations were found in the OLR group between BMI and operation time (R = 0.432, *P* = 0.019; Figure 1A) and between BMI and blood loss (R = 0.573, *P* = 0.001; Figure 1B). Otherwise, in the LLR group correlation between BMI and operation time was not significant (R = 0.209, *P* = 0.201; Figure 1C) and between BMI and blood loss also was not significant (R = 0.156, *P* = 0.344; Figure 1D).

Association with obesity and surgical outcomes in each group

In LLR group, twelve of 39 patients were high BMI (BMI ≥ 25). No significant differences in age, sex, viral status, tumor size, or preoperative laboratory data between obese patients and non-obese patients were found in LLR group. There was no significant difference in the operation time between non-obese patients and obese patients in the LLR group. Similarly, the blood loss of non-obese patients was not significantly different from that of obese patients. There were no significant differences in the incidence of postoperative complication among BMI in patients performed LLR. Distribution of difficulty score was not different between patients that were high BMI and patients that were not (data not shown). In the non-obese patients, LLR required a similar operation time, whereas operation time in LLR group was significantly shorter than that in OLR group in the obese patients (Figure 2A). Blood loss was significantly lower than that of OLR in the non-obese and obese patients (Figure 2B).

In OLR group, ten of 29 patients were high BMI (BMI ≥ 25). There were no differences in patients' characteristics between non-obese patients and obese patients who underwent OLR unless all obese patients were male.

Comparison between LLR and OLR in obese patients

In comparison between LLR and OLR in obese patients, there were similar in age, virus status, and preoperative laboratory data between LLR and OLR in obese patients, while gamma-GTP was significantly higher in the OLR group (Table 2). The operation time and blood loss of obese patients were significantly lower in LLR group. There was no significant difference in the incidence of complication between LLR and OLR.

Independent predictive factors for prolonged operation time and increased blood loss

Cutoff point of prolonged operation time was 200 minutes using ROC curving analysis. Univariate analysis showed BMI, OLR, tumor size, and ICG to be factors indicative of prolonged operation time. Multivariate analysis demonstrated that OLR [*P* < 0.001, Odds

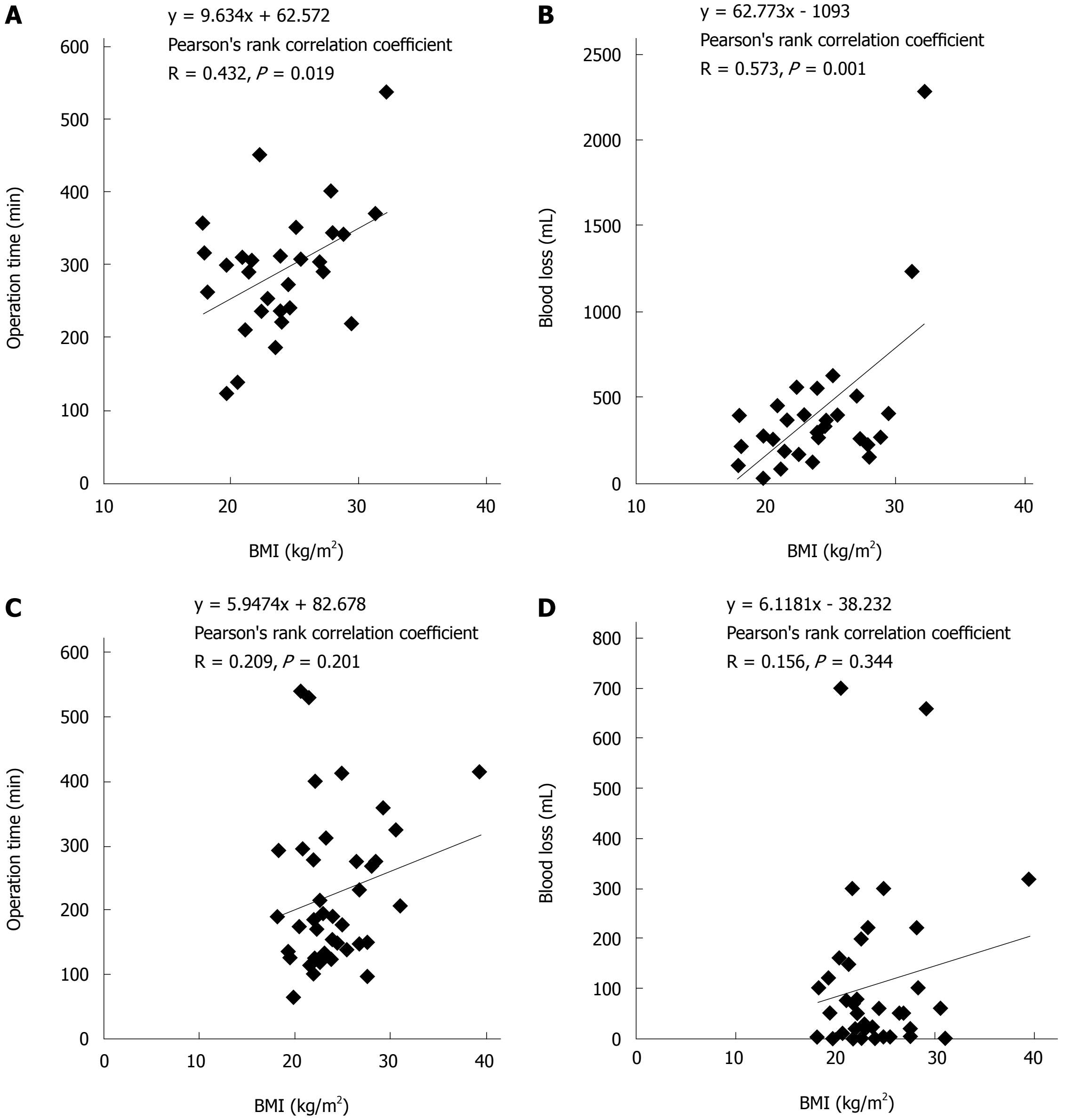

Figure 1 Scatter plot. A: Scatter plot showed the relationship between BMI and operation time in open liver resection; B: Scatter plot showed the relationship between BMI and blood loss in open liver resection; C: Scatter plot showed the relationship between BMI and operation time in laparoscopic liver resection; D: Scatter plot showed the relationship between BMI and blood loss in laparoscopic liver resection. BMI: Body mass index.

ratio (OR) = 16.244, 95%CI: 3.648-72.340], BMI (*P* = 0.024, OR = 1.259, 95%CI: 1.031-1.538), and tumor size (*P* = 0.047, OR = 1.056, 95%CI: 1.001-1.114) were independent predictive factors for prolonged operation time in all patients (Table 3).

In the analysis of increased blood loss, cutoff point was 215ml using ROC curving analysis. There were significant difference in OLR, BMI, prothrombin time (PT), and indocyanine green (ICG) test for increased blood loss using univariate analysis. Multivariate analysis showed that OLR (*P* < 0.001, OR = 27.736, 95%CI: 5.926-129.811), BMI (*P* = 0.035, OR = 1.233, 95%CI: 1.015-1.498), and PT (*P* = 0.030, OR = 0.947, 95%CI: 0.902-0.995) were independent predictive factors for increased blood loss significantly (Table 4).

DISCUSSION

Obese patients are predisposed to the development of various disease including diabetes mellitus, hypertension, coronary heart disease, airway obstruction and certain types of malignant tumors[6,7,23]. The real impact of obesity on the postoperative outcomes of surgical procedures was a controversial matter although obese patients are potentially at risk for poor outcomes of a wide variety of surgical procedures[24,25]. In liver resection, increased surgical risk was expected for obese patients underwent liver resection because of associated co-morbidities, underlying liver disease, and technical difficulties. However, recent reports had not demonstrated an

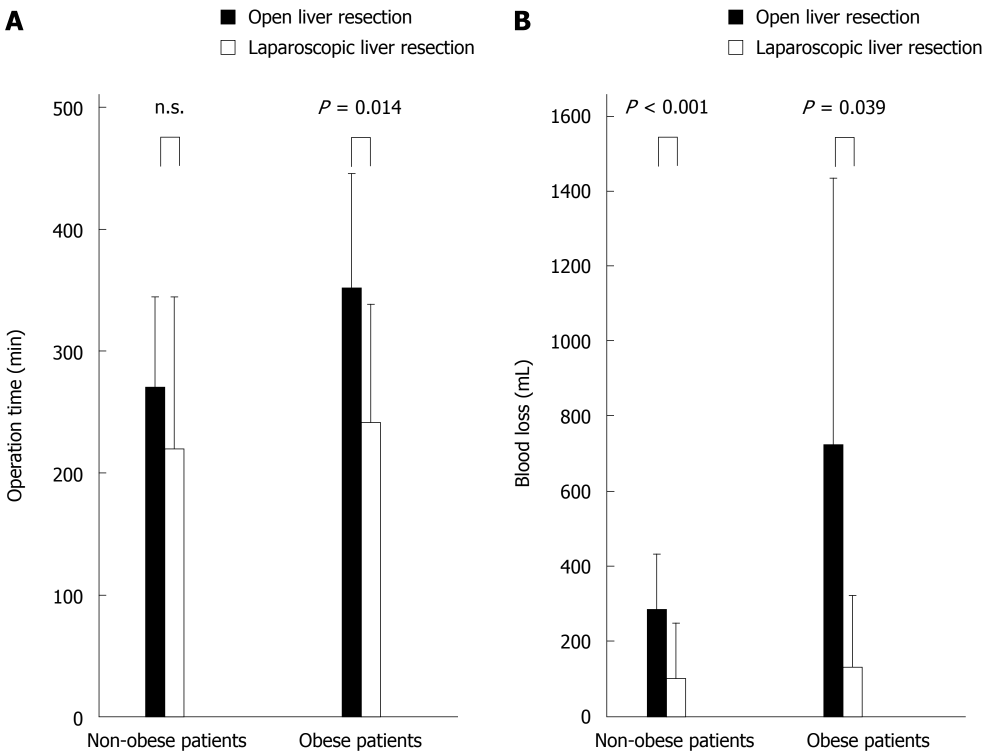

Figure 2 Surgical approach in obese and non-obese patients. A: Comparison of operation time according to the surgical approach in obese and non-obese patients; B: Comparison of blood loss according to the surgical approach in obese and non-obese patients.

Table 2 Comparison of patients' characteristics and surgical outcomes in patients with obesity

	LLR (n = 12)	OLR (n = 10)	P value
Patients' characteristics			
Age	70.5 ± 9.4	67.1 ± 6.2	NS
Sex (Male/Female)	7/5	10/0	0.020
HBV	1	2	NS
HCV	7	2	NS
Body mass index (kg/m^2)	29.0 ± 3.7	28.2 ± 2.3	NS
Tumor size (mm)	23.8 ± 8.7	26.0 ± 11.6	NS
Liver weight (g)	47.1 ± 35.5	60.8 ± 61.2	NS
Surgical outcome			
Operation time (min)	241.3 ± 97.6	346.7 ± 83.8	0.014
Blood loss (mL)	128.3 ± 193.1	635.5 ± 655.1	0.039
Postoperative hospital stay (d)	11.6 ± 3.3	20.8 ± 15.4	0.094
Complication, n (%)	1 (8.3)	1 (10)	NS
Biloma	0	0	NS

LLR: Laparoscopic liver resection; OLR: Open liver resection.

increased risk of liver resection in obese patients[10,26,27]. Utsunomiya *et al*[10] reported that obesity alone might not have an adverse effect on the surgical outcomes of patients with primary HCC. Viganò *et al*[28] showed that severe morbidity rate and mortality were similar to between obese and non-obese patients, even in cirrhosis or after major liver resection.

Laparoscopic surgeries for obese patients were considered as difficult because of limited visualization of surgical fields with cumbersome fat tissue. In laparoscopic colectomy, obesity has been reported to raise the risk of conversion to laparotomy[14,15]. However, some reports showed that obesity did not have an adverse impact on the technical difficulty and postoperative outcomes of laparoscopic colectomy[18,29]. There were several reports of obesity in laparoscopic gastrectomy and laparoscopic cholecystectomy and results were similar to laparoscopic colectomy[16,17].

Over the last decade, the number of LLR has rapidly increased. An indication of LLR has been extended to major liver resection[30,31]. With advances in instruction and technique, LLR had been performed safely. Nguyen *et al*[32] summarized that LLR was safe with acceptable morbidity and mortality for minor and major liver resection. Furthermore, the survival rate after LLR for hepatic malignancies was not inferior to that of open liver resection[30-32]. There were few reports have indeed analyzed the impact of obesity on the postoperative outcomes of patients undergoing LLR although LLR is considered as a safe and effective procedure for the management of surgical liver disease[33,34]. Toriguchi *et al*[33] reported that LLR in obese patients resulted in decreased intraoperative blood loss and shorter postoperative hospital stay compared with OLR. And Nomi *et al*[34] demonstrated that BMI did not negatively affect the postoperative short-term outcomes. Similar to OLR, it is not clear whether LLR is safe and feasible for obese patients.

In the present study, our results suggested that LLR in obese patients could be performed as safely as non-obese patients with the same risk of postoperative complication and with lower operation time and blood

Table 3 Univariate and multivariate analysis on prolonged operation time

	Operation time		Univariate	Multivariate	
	< 200	⩾ 200	*P* value	*P* value	OR (95%CI)
Number of patients	25	43			
Age (yr)	71.5 ± 8.4	67.4 ± 9.6	0.082		
Sex (Male/Female)	16/9	32/11	0.363		
Body mass index (kg/m^2)	22.7 ± 2.6	24.8 ± 4.5	0.019	0.024	1.259 (1.031-1.538)
HBV	2	8	0.304		
HCV	12	20	0.906		
Open liver resection < 0.001	3	26	< 0.001	< 0.001	16.244 (3.648-72.340)
Tumor size (mm)	23.3 ± 9.9	29.8 ± 14.4	0.049	0.047	1.056 (1.001-1.114)
Total bilirubin (mg/dL)	0.77 ± 0.28	0.79 ± 0.31	0.829		
Albumin (g/dL)	3.94 ± 0.59	3.91 ± 0.46	0.848		
Prothrombin time (%)	101.4 ± 21.9	98.2 ± 17.2	0.508		
Indocyanine green (%)	11.8 ± 11.1	18.9 ± 14.8	0.042		
Aspartate transaminase (U/L)	36.8 ± 20.5	39.1 ± 20.9	0.669		
Alanine transaminase (U/L)	30.2 ± 22.8	33.3 ± 22.3	0.596		
γ-glutamy transpeptidase (U/L)	57.5 ± 48.3	64.8 ± 51.3	0.567		
Alkaline phosphatase (U/L)	315.6 ± 109.9	306.0 ± 105.5	0.725		
Cholinesterase (U/L)	176.6 ± 127.0	188.5 ± 115.3	0.649		
White blood cell (/mm^3)	4342 ± 1383	4638 ± 1748	0.470		
Hemoglobin (g/dL)	12.8 ± 1.9	13.1 ± 2.1	0.598		
Hematocrit (%)	36.9 ± 7.3	39.0 ± 5.6	0.185		
Platelet count (× 10^3/mm^3)	14.5 ± 7.7	13.2 ± 6.0	0.433		

LLR: Laparoscopic liver resection; OLR: Open liver resection.

Table 4 Univariate and multivariate analysis on increased blood loss

	Blood loss		Univariate	Multivariate	
	< 215	⩾ 215	*P* value	*P* value	OR (95%CI)
Number of patients	40	28			
Age (yr)	68.5 ± 10.1	68.1 ± 4.5	0.558		
Sex (Male/Female)	26/14	22/6	0.227		
Body mass index (kg/m^2)	23.1 ± 3.4	25.3 ± 4.5	0.027	0.035	1.233 (1.015-1.498)
HBV	4	6	0.297		
HCV	20	12	0.561		
Open liver resection	8	21	< 0.001	< 0.001	27.736 (5.926-129.811)
Tumor size (mm)	26.0 ± 11.4	29.4 ± 15.5	0.303		
Total bilirubin (mg/dL)	0.76 ± 0.30	0.81 ± 0.30	0.490		
Albumin (g/dL)	3.98 ± 0.55	3.84 ± 0.43	0.287		
Prothrombin time (%)	103.2 ± 20.3	93.9 ± 15.6	0.046	0.030	0.947 (0.902-0.995)
Indocyanine green (%)	13.4 ± 10.7	20.3 ± 16.9	0.044		
Aspartate transaminase (U/L)	34.3 ± 19.8	43.9 ± 20.7	0.056		
Alanine transaminase (U/L)	28.3 ± 19.6	37.6 ± 25.2	0.955		
γ-glutamy transpeptidase (U/L)	52.6 ± 50.1	75.7 ± 47.4	0.060		
Alkaline phosphatase (U/L)	310.1 ± 107.1	308.6 ± 107.3	0.955		
Cholinesterase (U/L)	178.9 ± 130.0	191.6 ± 103.0	0.669		
White blood cell (/mm^3)	4339 ± 1540	4802 ± 1716	0.249		
Hemoglobin (g/dL)	12.8 ± 1.9	13.4 ± 2.2	0.218		
Hematocrit (%)	37.0 ± 6.5	40.0 ± 5.7	0.056		
Platelet count (× 10^3/mm^3)	14.7 ± 7.6	12.3 ± 4.6	0.114		

LLR: Laparoscopic liver resection; OLR: Open liver resection.

loss than that of non-obese patients. Additionally, BMI significantly correlated with operation time and blood loss in OLR, however, no such correlation was demonstrated in LLR. Operation time and blood loss of LLR in obese patients were not increased compared with those of OLR in obese patients. In addition, multivariate analysis showed that both BMI and OLR were independent predictive factors for prolonged operation time and increased blood loss. These result suggested that LLR was less influenced by BMI, and it was thought that LLR was suitable procedure for not only non-obese patients but also obese patients. However, there was a limitation in the present study. A few patients in this study were classified as obese (BMI ⩾ 30 kg/m^2) according to the WHO classification. Therefore, whether or not the present study was applicable to the group including many obese patients was still not clear and needs to be determined in future studies.

In conclusion, it was found that BMI was correlated with operation time and blood loss in OLR, but not in LLR. Therefore, LLR was less influenced by BMI and had a greater benefit in obese patients.

COMMENTS

Background

Obesity has been associated with worse surgical outcomes than those of non-obese patients. The impact of body weight on surgical outcomes of laparoscopic liver resection (LLR) remains poorly evaluated, although LLR has been widely adopted.

Research frontiers

Obesity is known as independent risk factor for several malignancies including liver cancer. Therefore, it is important to clarify the correlation between obesity and surgical outcomes of LLR.

Innovations and breakthroughs

This study indicated that LLR rather than open liver resection should be chosen in the obese patients. LLR was less influenced by body mass index (BMI).

Applications

In Japan, obese is considered as BMI ≥ 25 based on the definition by the Japan Society for the Study of Obesity and World Health Organization expert consultation.

Terminology

According to the WHO, obesity is defined as BMI ≥ 30. However, in this study, we defined obesity as BMI ≥ 25.

Peer-review

The manuscript entitled "The Benefit of Laparoscopic Liver Resection in High Body Mass Index Patients" by Uchida *et al* was well-presented and written. The authors revealed the correlation between BMI and surgical outcomes of 68 cases performed LLR and open liver resection.

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