The impact of obesity on short-term outcomes after the laparoscopic liver resection: a single-institution experience

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Abstract

Introduction: *Obesity is a major public health problem and a well-known cause of multiple comorbidities. With the increasing application of minimally invasive surgery for benign and malignant liver lesions, the results of laparoscopic liver resection (LLR) in obese patients are of great interest.*
Aim: *To evaluate the short-term operative outcomes after LLR in obese patients and compare them to patients with normal weight and overweight.*
Material and methods: *All 235 consecutive patients undergoing LLR from 2008 to 2023 were retrospectively analysed. Patients were categorized into 3 groups based on their body mass index (BMI): normal weight (18.5–24.9 kg/m²), overweight (25–29.9 kg/m²), and obese (≥ 30 kg/m²). The groups were then compared regarding preoperative data and intra- and postoperative outcomes.*
Results: *Despite higher ASA score and associated comorbidities in the obese group, there were no significant differences in intraoperative complication (blood loss, damage to surrounding structures, conversion rate) between BMI groups (20.8% vs. 16.8% vs. 22.7%, p = 0.619). There were no significant differences in overall morbidity (34.7% vs. 27.7% vs. 29.5%, p = 0.582), as well as major morbidity (15.9% vs. 11.8% vs. 11.4%, p = 0.784) or mortality rates (1.4% vs. 1.7% vs. 0.0%, p = 1.000). Univariate logistic regression did not show BMI or obesity as a predictive variable for intraoperative complication.*
Conclusions: *Obesity is not a significant, strong risk factor for worse short-term outcomes, and LLR may be considered also in patients with overweight and obesity.*

Key words: *laparoscopy, hepatectomy, body-mass index, obesity, treatment outcome.*

Introduction

Obesity is a major public health issue in Western countries. The worldwide prevalence of overweight and obesity in the population has nearly tripled since 1975 and now represents 39% of the world population [1]. Obesity is a well-known cause of multiple comorbidities; the most significant is insulin resistance, which has been recognized as an integral feature of metabolic syndrome and cardiovascular diseases [2]. Moreover, obesity is presumably associated with an increased risk of complications after surgery. Although numerous studies have investigated the effects of obesity on surgical outcomes, there is still no consensus on the topic [3, 4]. While some studies have shown that obesity is a definitive risk factor for surgical complications, others have challenged this notion by demonstrat-

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ing that obesity alone may not necessarily increase the risk [4–6].

Laparoscopic liver resection (LLR) may be considered a safe alternative to traditional open liver surgery, and these procedures have been increasing worldwide [7]. Three consensus conferences acknowledged the benefits of this approach when experts applied it to selected patients and encouraged its dissemination [8–10]. With the increasing application of minimally invasive surgery for benign and malignant liver lesions, the results of LLR in obese patients are of great interest. In a recent systematic review, Kwan *et al.* studied the impact of body mass index (BMI) on surgical outcomes in LLR [11]. Most studies did not show associations between BMI groups and intra- and postoperative complications. The authors concluded that current evidence shows that LLR in obese patients is safe; however, further studies are still needed [11].

In our everyday practice, we have been observing an increase in the proportion of obese patients undergoing LLR for various indications. Intrinsically, we feel that surgery on these patients poses a greater challenge for the surgeon during the operation and the patients on their path to recovery.

Aim

This study aimed to evaluate the short-term operative outcomes after LLR in obese patients and compare them to patients with normal weight and overweight.

Material and methods

Patients

A retrospective review of a prospectively maintained database of all consecutive patients who underwent LLR in a single tertiary referral centre was performed. Data were collected from the first LLR in this centre (April 2008) until October 2023. The surgeon responsible for implementing LLR in this centre (AI) operated the patients or supervised the procedures. All patients were discussed in multidisciplinary team meetings to assess the feasibility of the laparoscopic approach, dependent on disease characteristics and expertise. With time, a higher level on the learning curve has been reached, and difficulty scores have become available to guide the selection of more complex cases [12, 13]. Surgical techniques were applied as reported previously, and laparoscopic intraoperative ultrasound of the liver was mandatory [14–17].

Patients gave their consent that anonymous data could be used for research at the time of the surgery. The patient's medical records were anonymized and de-identified before analysis. The local Ethics Committee waived the requirement for approval due to the retrospective nature of this study.

Inclusion and exclusion criteria

The inclusion criterion for the study was patients who underwent elective LLR for benign or malignant lesions. Only pure LLR was performed. The exclusion criteria were patients who underwent hybrid/hand-assisted resections, cyst fenestrations, or liver biopsies [18].

Definitions and clinical variables

Based on World Health Organization definitions and preoperative BMI scores, all patients were categorized into 3 groups: a normal weight group (BMI = 18.5–24.9 kg/m^2), an overweight group (BMI = 25–29.9 kg/m^2), and an obese group (BMI ≥ 30 kg/m^2) [1]. The groups were compared regarding preoperative data and intra- and postoperative outcomes.

Patients' demographics, preoperative clinical parameters, operative details, histopathological data, and postoperative outcomes were analysed from the database. Diagnoses were based on final pathology.

Only pure LLR was done. Absolute contraindications for the laparoscopic approach included the need for en bloc multi-visceral resection, vascular resection and reconstruction, hepato-jejunostomy, and resections for hilar cholangiocarcinoma.

The nomenclature for describing liver segments and resections is based on *The Brisbane 2000 Terminology of Liver Anatomy and Resections* [19]. The classification of resections (minor versus major) is based upon the largest volume of liver resection and reflects the proposal from the Louisville Statement 2008 [8]. In addition to this classification, technical major resections, which do not meet the criteria of anatomical major resections but include the technically demanding segments 1, 4a, 7, and 8, have been included [20]. Concurrent procedures are minor LLRs, which were done along with main operations (colorectal resections, lymphadenectomies, nephrectomies, adrenalectomies, and microwave or radiofrequency ablations).

The histological surgical margins for malignant lesions were defined as microscopically positive (< 1 mm, R1) or negative (R0). R0 resection was defined as the complete removal of the tumours with clear microscopic margins.

The conversion was defined as the requirement for laparotomy at any time of the procedure, except for the extraction of the resected specimen.

Postoperative 90-day morbidity and mortality were graded according to the Clavien-Dindo classification and based on the most severe complication; grades 1–2 representing minor complications that only required medical therapies as treatment, and grades 3a–5 representing complications that required radiological or surgical intervention, the use of organ support, and fatality [21].

Length of hospital stay was defined as the time from completion of the operation to discharge. Patients were discharged when the following criteria were met: to be able to tolerate oral fluids and a solid diet in order that intravenous fluid supplementation was not required, pain controlled with oral analgesics, mobility at the level to take care of themselves, and normalized or improving liver function tests.

The difficulty of the liver resection was assessed by the Iwate scoring model and the Southampton difficulty score, which are used to predict the risk of intraoperative and postoperative complications [9, 22].

Outcomes

The primary endpoint of the study was an intraoperative complication. It was described as an objective marker of a complex operation, and its key markers were blood loss of over 775 ml, unintentional damage to the surrounding structures, and conversion to an open approach [22].

Established indicators of technical difficulties, such as blood loss, blood transfusion requirements, operative time, the need for the hepatic pedicle clamping, its duration, and R0 resection, were used as surrogate endpoints [17].

The secondary endpoint was a postoperative complication, defined as morbidity and mortality according to the Clavien-Dindo classification [21]. Surrogate markers were the length of hospital stay and readmission rate.

Statistical analysis

Statistical analysis was performed using SPSS (version 29.0, IBM Corp., Armonk, NY, USA). The *p*-value < 0.05 was considered statistically significant.

Categorical variables were displayed as a number and percentage. The differences between categorical variables were tested using the Fisher-Freeman-Halton test. Continuous variables were expressed as median (interquartile range (IQR)) and analysed with the Kruskal-Wallis test because the distribution of data was non-normal [23]. Univariate binary logistic regression was performed [24]. The results are shown as an odds ratio (Exp [B]) with a confidence interval (CI).

Results

Preoperative characteristics and surgery-related characteristics

A total of 235 subjects were enrolled in this study. There were no underweight patients (BMI < 18.5 kg/m^2). Our study population also consisted of 11 (4.9%) patients with obesity class 2 (BMI ≥ 35 kg/m^2) and 2 (0.9%) patients with obesity class 3 (BMI ≥ 40 kg/m^2) [25]. Due to their low frequency, they were assigned to the obese group. The preoperative characteristics of patients in the 3 groups are given in Table I, and surgery-related characteristics are given in Table II.

Intraoperative outcomes

Intraoperative outcomes are given in Table III. The rate of intraoperative complications among groups was statistically insignificant ($p = 0.619$). The greatest share of the sum was contributed by conversion and the smallest by damage to the surrounding structures. Among surrogate outcomes, transfusion was required most frequent in the normal-weight group ($p = 0.036$).

Postoperative outcomes

Postoperative outcomes are given in Table IV. The morbidity rates were insignificant. Regarding 90-day mortality, 1 patient in the normal-weight group died from ischaemic colon perforation and multiorgan failure. Two patients in the overweight group died, one of post hepatectomy liver failure and the other because of pneumonia. There was no 90-day mortality in the obese group.

Table I. Preoperative characteristics of 235 patients in the 3 groups

Variable	Normal weight (*n* = 72; 30.6%)	Overweight (*n* = 119; 50.6%)	Obese (*n* = 44; 18.7%)	*P*-value
Age [years]	64 (IQR 54–73)	66 (IQR 57–72)	62 (IQR 53–66)	0.105
Male sex	37 (51.4%)	75 (63.0%)	30 (68.2%)	0.137
BMI [kg/m^2]	23.0 (IQR 21.2–24.1)	27.4 (IQR 26.3–28.4)	33.3 (IQR 31.2–33.3)	0.000
ASA 3 or 4	17 (23.6%)	27 (22.7%)	23 (52.3%)	0.001
Comorbidities present (yes)	39 (54.2%)	81 (68.1%)	39 (88.6%)	< 0.001
Number of comorbidities	1 (IQR 1–1)	1 (IQR 1–1)	1 (IQR 1–2)	< 0.001
Chronic obstructive pulmonary disease	5 (6.9%)	2 (1.7%)	1 (2.3%)	0.174
Arterial hypertension	21 (29.2%)	60 (50.4%)	18 (40.9%)	0.015
Diabetes mellitus	8 (11.1%)	24 (20.2%)	15 (34.1%)	0.012
Cardiovascular disease	8 (11.1%)	10 (8.4%)	11 (25.0%)	0.022

ASA – American Society of Anesthesiologists, BMI – body mass index, IQR – interquartile range.

Table II. Surgery-related characteristics of 235 patients in the 3 groups

Variable	Normal weight (*n* = 72; 30.6%)	Overweight (*n* = 119; 50.6%)	Obese (*n* = 44; 18.7%)	*P*-value
Previous abdominal surgery	29 (40.3%)	41 (34.5%)	21 (47.7%)	0.287
Previous liver surgery	5 (6.9%)	5 (4.2%)	2 (4.5%)	0.679
Malignant liver tumour	51 (70.8%)	89 (74.8%)	32 (72.7%)	0.891
Bilateral liver tumours	2 (2.8%)	8 (6.7%)	4 (9.1%)	0.785
Size of the largest tumour [mm]	40 (IQR 23–63)	40 (IQR 27–55)	41 (25–55)	0.998
Multiple liver tumours	12 (16.7%)	25 (21.0%)	12 (27.3%)	0.386
Posterosuperior location	22 (31.9%)	34 (29.6%)	11(26.8%)	0.837
Deep location	24 (34.8%)	31 (27.0%)	10 (24.4%)	0.412
Proximity to the inferior vena cava	13 (18.8%)	21 (18.3%)	8 (19.5%)	0.974
Major liver resection	25 (34.7%)	38 (31.9%)	11 (25.0%)	0.558
Concurrent procedures	23 (31.9%)	53 (44.5%)	21 (47.7%)	0.146
Median Southampton difficulty score	3 (IQR 3–6)	4 (IQR 3–6)	4 (IQR 2–6)	0.880
Median Iwate score	5 (IQR 3–9)	5 (IQR 4–8)	5 (IQR 3–7)	0.705
Cirrhosis[a]	11 (15.3%)	22 (18.5%)	12 (27.3%)	0.280
Steatosis[a]	7 (9.7%)	23 (19.3%)	19 (43.2%)	< 0.001

[a]Confirmed by the histopathological examination, IQR – interquartile range.

Univariate logistic regression for intraoperative complication

Variables from Tables I and II were tested in univariate binary logistic regression for the outcome of intraoperative complications. Statistically significant variables along with BMI and the group with obesity are given in Table V.

Discussion

This study evaluated the impact of obesity on the short-term outcomes after LLR and refuted our clinical supposition that LLR on patients with obesity was associated with more complications. The results showed that short-term outcomes were similar among the normal weight, the overweight, and the obesity group.

Table III. Intraoperative outcomes in the 3 groups

Outcome	Normal weight (*n* = 72)	Overweight (*n* = 119)	Obese (*n* = 44)	*P*-value
Intraoperative complication	15 (20.8%)	20 (16.8%)	10 (22.7%)	0.619
Blood loss > 775 ml	4 (5.6%)	7 (5.9%)	5 (11.4%)	0.401
Damage to surrounding structures	1 (1.4%)	3 (2.5%)	0 (0.0%)	0.820
Conversion	11 (15.3%)	14 (11.8%)	7 (15.9%)	0.695
Surrogate outcomes:				
Blood loss [ml]	120 (IQR 43–308)	150 (IQR 20–330)	165 (IQR 50–388)	0.694
Transfusion required	12 (16.7%)	7 (5.9%)	6 (13.6%)	0.036
Operative time [min]	160 (IQR 112–210)	160 (IQR 120–210)	160 (IQR 110–188)	0.627
Hepatic pedicle clamping	20 (27.8%)	40 (55.6%)	12 (16.7%)	0.631
Total hepatic pedicle clamping duration [min]	30 (IQR 23–43)	33 (IQR 29–45)	33 (IQR 14–44)	0.476
R0 resection	49 (92.5%)	92 (94.8%)	36 (97.3%)	0.755

IQR – interquartile range.

Table IV. Postoperative outcomes in the 3 groups

Outcome	Normal weight (*n* = 72)	Overweight (*n* = 119)	Obese (*n* = 44)	*P*-value
Overall morbidity (CD 1–5)	25 (34.7%)	33 (27.7%)	13 (29.5%)	0.582
Major morbidity (CD ≥ 3)	11 (15.9%)	14 (11.8%)	5 (11.4%)	0.784
Mortality	1 (1.4%)	2 (1.7%)	0 (0.0%)	1.000
Length of the hospital stay	6 (IQR 4–10)	6 (IQR 5–7)	5 (IQR 4–8)	0.674
Readmission rate	5 (6.9%)	7 (5.9%)	1 (2.3%)	0.644

CD – Clavien-Dindo classification, IQR – interquartile range.

A few decades ago, obesity was generally considered a contraindication for laparoscopic surgery due to attributed technical difficulties. However, recent studies have shown that laparoscopic surgery can be considered a standard procedure in patients with obesity [11, 26]. To date, several studies have examined the relationship between obesity and perioperative outcomes in LLR, but there is still a significant degree of heterogeneity, and applicability to the Western population is questionable [11]. Overall, surgical outcomes do not seem to be overwhelmingly worse in patients with obesity, but some newer studies bring the negative impact of obesity on LLR back into question [27, 28].

As expected, the obese group in our study had statistically higher rates of comorbidities and, specifically, higher rates of diabetes mellitus. It has been shown that this disease directly influences short-term postoperative outcomes with an increased risk of morbidity [29]. Our study did not confirm this be-

Table V. Univariate binary logistic regression analysis for intraoperative complications

Variable	*P*-value	Exp (B) [95% CI]
Body-mass index	0.822	1.0 [0.9–1.1]
The obese group	0.504	1.3 [0.6–2.9]
Tumour size ≥ 50 mm	0.001	3.0 [1.5–5.9]
Posterosuperior location	< 0.001	11.5 [5.3–25.1]
Deep location	< 0.001	10.6 [3.9–22.7]
Proximity to the inferior vena cava	< 0.001	24.1 [10.0–56.0]
Major liver resection	< 0.001	10.0 [4.7–21.1]
Southampton difficulty score ≥ 5	< 0.001	10.3 [4.7–22.9]
Iwate score ≥ 6	< 0.001	19.2 [6.6–56.1]
Cirrhosis	0.026	2.3 [1.1–4.9]

CI – confidence interval.

cause the obese group had similar overall and major morbidity rates as the normal weight group. These results are reflected by the similar length of hospital stay in all 3 BMI groups and similar readmission rates, which were lowest in the obese group. This could be partly because of the smaller incisions and faster wound healing in the laparoscopic approach, a well-known benefit that might be even more pronounced in patients with obesity with several comorbidities. The benefits of reduced abdominal wall trauma in LLR translate into earlier postoperative rehabilitation and may facilitate cardiopulmonary recovery in patients with obesity [28].

Patients with higher BMI have an increased risk of developing non-alcoholic fatty liver disease, a spectrum of diseases ranging from liver steatosis to cirrhosis [30]. In our study, the rate of steatosis was significantly higher ($p < 0.001$) in the obese group (43.2%), while it was low in the normal-weight group (9.7%) and overweight group (19.3%). However, the presence of cirrhosis did not significantly differ amongst different BMI groups. This could be due to selection bias because patients with liver cirrhosis might be less eligible to undergo laparoscopic or open liver resection. It has been shown that liver cirrhosis affects intraoperative technical difficulty and postoperative outcomes [30, 31].

Many difficulty scoring systems (e.g. the Iwate score and the Southampton difficulty score) have been implemented to predict the risk of intra- and postoperative complications after LLR [12, 13]. Increased difficulty is assumed to be associated with estimated blood loss, prolonged operative time, as well as morbidity and mortality [11]. The median Iwate score in our study did not differ among different BMI groups, meaning the difficulty of performing liver resections was similarly distributed. Consequently, we found similar rates of intraoperative complications as well as postoperative morbidity and mortality rates irrespective of the BMI. Furthermore, when we univariably tested BMI and obesity in predicting intraoperative complications, they were insignificant, and factors known from difficulty scoring systems again proved their significance (Table V) [9, 22, 32, 33].

Only 2 studies demonstrated longer operative time in the obese group than in the normal-weight group [28, 34]. Furthermore, Lee *et al.* only showed longer operative time in the overweight group [35]. More commonly, the results showed superiority of the laparoscopic approach over open liver surgery in terms of shorter operative time [26, 36]. It can be seen as an important benefit of laparoscopic surgery in this group of patients. Laparoscopy provides a magnified view and clearly shows small structures, such as bile ducts and blood vessels. There is better visualization of deep vascular structures and better exposure of the right hepatic lobe. These are all benefits in an obese patient with a wide, deep abdomen and a thick layer of subcutaneous fat, which can be difficult to retract for adequate exposure in the open method [11, 34].

Previously, poor surgical field exposure due to obesity, difficulty in controlling bleeding, and difficulty in developing a surgical field due to adhesions were shown to be a cause of conversion to open surgery [37]. However, our results did not show higher conversion rates in the obese group, which is accordant with current literature [27, 28, 34, 38, 39]. Conversely, Yu *et al.* showed a much higher conversion rate in obese patients, the main indication being unclear exposure [40]. It should be noted that this is a study based on an Asian population, where differences in the distribution of BMI among the population exist compared to Western nations. For the same BMI, there is a higher body fat percentage in Asian compared to Western patients, with a higher ratio of intraperitoneal rather than subcutaneous fat [11], which might contribute to a higher conversion rate in the Asian study of the population with obesity and other discrepancies when comparing Western and Asian studies.

Another major intraoperative complication is excessive blood loss. Only Chua *et al.* were able to show higher rates of intraoperative blood loss in obese patients [27]. The authors noted that their negative impact of obesity compared to other studies might be because 28% of patients underwent a major hepatectomy in their population, and more than half were in technically challenging locations, as opposed to the study by Yu *et al.* in which most patients underwent a minor hepatectomy for mostly benign lesions [40]. In our study, 72.7% of patients in the obese group had a malignant lesion, and the rate of major hepatectomy was 25.0%, comparable to the population in the study of Chua *et al.* [15, 16, 27].

Our results show that there were no higher rates of estimated bleeding intraoperatively in the obese group. Hepatic pedicle clamping is the traditional technique of controlling bleeding in liver resection, and it was not used more commonly when performing LLR on our group of obese patients [17]. In laparoscopy, pneumoperitoneum reduces bleeding from exposed vessels at the transected surface of the liver, making this another benefit of laparoscopy in obese patients with a higher number of comorbidities that lessen their cardiovascular reserve [41].

BMI has a non-specific role as an anthropometric measure of obesity. Therefore, it might explain why the distinct negative association between BMI and perioperative outcomes cannot be shown. A high BMI may be a result of increased fat-free mass rather than true visceral or peripheral adiposity [27, 42]. This questions whether other measures for body fat composition are more accurate at determining outcomes after LLR, for example, body shape index, which measures waist circumference adjusted for height and weight. Ratti *et al.* postulate that this index may be more useful than BMI in determining the difficulty of LLR because it more accurately assesses central obesity [43].

Apart from intraoperative complication, a textbook outcome (absence of intraoperative adverse events of grade II or higher, postoperative bile leak grade B or C, severe postoperative complications, readmission within 30 days after discharge, in-hospital mortality, and the presence of R0 resection margin) and benchmarking have been emerging as desired treatment outcomes and study endpoints that could be a future perspective of our work [44–46].

This study has some limitations. Due to its retrospective nature, there is bound to be some selection bias, especially in the context of selecting obese patients with many comorbidities for surgery. The rate of extremely obese patients was too low to create a separate group. What is more, this is a single-institution study with a modest sample size, which can have some effect on the calculation of regression analyses and the interpretation of our results.

Conclusions

Surgeons will encounter more and more overweight and obese patients. Therefore, it is important to understand the effect of elevated BMI on the outcomes of these patients. Our results suggest that obesity is not a significant, strong risk factor for worse short-term outcomes, and LLR may be considered also in patients with overweight and obesity.

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Conflict of interest

The authors declare no conflict of interest.

References

1. Obesity and overweight: World Health Organization; 2023 [06/23/2023]. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.
2. Andolfi C, Fisichella PM. Epidemiology of obesity and associated comorbidities. J Laparoendosc Adv Surg Tech A 2018; 28: 919-24.
3. Bamgbade OA, Rutter TW, Nafiu OO, Dorje P. Postoperative complications in obese and nonobese patients. World J Surg 2007; 31: 556-61.
4. Tjeertes EK, Hoeks SE, Beks SB, et al. Obesity: a risk factor for postoperative complications in general surgery? BMC Anesthesiol 2015; 15: 112.
5. Dindo D, Muller MK, Weber M, Clavien PA. Obesity in general elective surgery. Lancet 2003; 361: 2032-5.
6. Ri M, Aikou S, Seto Y. Obesity as a surgical risk factor. Ann Gastroenterol Surg 2018; 2: 13-21.
7. Ciria R, Cherqui D, Geller DA, et al. Comparative short-term benefits of laparoscopic liver resection: 9000 cases and climbing. Ann Surg 2016; 263: 761-77.
8. Buell JF, Cherqui D, Geller DA, et al. The international position on laparoscopic liver surgery: the Louisville Statement, 2008. Ann Surg 2009; 250: 825-30.
9. Wakabayashi G. What has changed after the Morioka consensus conference 2014 on laparoscopic liver resection? Hepatobiliary Surg Nutr 2016; 5: 281-9.
10. Abu Hilal M, Aldrighetti L, Dagher I, et al. The Southampton Consensus Guidelines for laparoscopic liver surgery: from indication to implementation. Ann Surg 2018; 268: 11-8.
11. Kwan B, Waters PS, Keogh C, et al. Body mass index and surgical outcomes in laparoscopic liver resections: a systematic review. ANZ J Surg 2021; 91: 2296-307.
12. Ivanecz A, Plahuta I, Magdalenic T, et al. The external validation of a difficulty scoring system for predicting the risk of intraoperative complications during laparoscopic liver resection. BMC Surg 2019; 19: 179.
13. Ivanecz A, Plahuta I, Magdalenic T, et al. Evaluation of the Iwate model for predicting the difficulty of laparoscopic liver resection: does tumor size matter? J Gastrointest Surg 2021; 25: 1451-60.
14. Ivanecz A, Krebs B, Stozer A, et al. Simultaneous pure laparoscopic resection of primary colorectal cancer and synchronous liver metastases: a single institution experience with propensity score matching analysis. Radiol Oncol 2018; 52: 42-53.

15. Plahuta I, Magdalenić T, Turk Š, et al. Achievements in surgical treatment for colorectal liver metastases from 2000 until 2020 = Dosežki kirurškega zdravljenja bolnikov z jetrnimi zasevki raka debelega črevesa in danke od 2000 do 2020. AMB 2022; 15: 41-53.
16. Turk S, Plahuta I, Magdalenic T, et al. Two-stage hepatectomy in resection of colorectal liver metastases - a single-institution experience with case-control matching and review of the literature. Radiol Oncol 2023; 57: 270-8.
17. Serednicki W, Hołówko W, Major P, et al. Minimizing blood loss and transfusion rate in laparoscopic liver surgery: a review. Videosurgery Miniinv 2023; 18: 213-23.
18. Ivanecz A, Plahuta I, Mencinger M, et al. The learning curve of laparoscopic liver resection utilising a difficulty score. Radiol Oncol 2021; 56: 111-8.
19. Strasberg SM, Belghiti J, Clavien PA, et al. The Brisbane 2000 terminology of liver anatomy and resections. HPB 2000; 2: 333-9.
20. Di Fabio F, Samim M, Di Gioia P, et al. Laparoscopic major hepatectomies: clinical outcomes and classification. World J Surg 2014; 38: 3169-74.
21. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 2009; 250: 187-96.
22. Halls MC, Berardi G, Cipriani F, et al. Development and validation of a difficulty score to predict intraoperative complications during laparoscopic liver resection. Br J Surg 2018; 105: 1182-91.
23. Habibzadeh F. Statistical data editing in scientific articles. J Korean Med Sci 2017; 32: 1072-76.
24. Nick TG, Campbell KM. Logistic regression. Methods Mol Biol 2007; 404: 273-301.
25. Defining Adult Overweight & Obesity: Centers for Disease Control and Prevention; 2022 [09/20/2023]. Available from: https://www.cdc.gov/obesity/basics/adult-defining.html.
26. Heise D, Bednarsch J, Kroh A, et al. Laparoscopic hepatectomy reduces postoperative complications and hospital stay in overweight and obese patients. World J Gastrointest Surg 2021; 13: 19-29.
27. Chua DW, Syn N, Koh YX, et al. Association of standardized liver volume and body mass index with outcomes of minimally invasive liver resections. Surg Endosc 2023; 37: 456-65.
28. Zimmitti G, Sijberden JP, Osei-Bordom D, et al. Indications, trends, and perioperative outcomes of minimally invasive and open liver surgery in non-obese and obese patients: an international multicentre propensity score matched retrospective cohort study of 9963 patients. Int J Surg 2022; 107: 106957.
29. Fischer A, Fuchs J, Stravodimos C, et al. Influence of diabetes on short-term outcome after major hepatectomy: an underestimated risk? BMC Surg 2020; 20: 305.
30. Goh BKP, Syn N, Lee SY, et al. Impact of liver cirrhosis on the difficulty of minimally-invasive liver resections: a 1:1 coarsened exact-matched controlled study. Surg Endosc 2021; 35: 5231-8.
31. Zhang H, Kang D, Liu F, et al. Risk factors associated with postoperative complications and prolonged postoperative length of stay after laparoscopic liver resection. Videosurgery Miniinv 2022; 17: 515-23.
32. Kawaguchi Y, Fuks D, Kokudo N, Gayet B. Difficulty of laparoscopic liver resection: proposal for a new classification. Ann Surg 2018; 267: 13-7.
33. Hasegawa Y, Wakabayashi G, Nitta H, et al. A novel model for prediction of pure laparoscopic liver resection surgical difficulty. Surg Endosc 2017; 31: 5356-63.
34. Ome Y, Hashida K, Yokota M, et al. The safety and efficacy of laparoscopic hepatectomy in obese patients. Asian J Surg 2019; 42: 180-8.
35. Lee SJ, Hauch A, Kane E, et al. Effect of obesity on perioperative outcomes after laparoscopic hepatectomy. Hepatoma Res 2016; 2: 323-27.
36. Uchida H, Iwashita Y, Saga K, et al. Benefit of laparoscopic liver resection in high body mass index patients. World J Gastroenterol 2016; 22: 3015-22.
37. Masuda T, Endo Y, Amano S, et al. Risk factors of unplanned intraoperative conversion to hand-assisted laparoscopic surgery or open surgery in laparoscopic liver resection. Langenbecks Arch Surg 2022; 407: 1961-69.
38. Viganò L, Kluger MD, Laurent A, et al. Liver resection in obese patients: results of a case-control study. HPB (Oxford) 2011; 13: 103-11.
39. Nomi T, Fuks D, Ferraz JM, et al. Influence of body mass index on postoperative outcomes after laparoscopic liver resection. Surg Endosc 2015; 29: 3647-54.
40. Yu X, Yu H, Fang X. The impact of body mass index on short-term surgical outcomes after laparoscopic hepatectomy, a retrospective study. BMC Anesthesiol 2016; 16: 29.
41. Yoshida H, Taniai N, Yoshioka M, et al. Current status of laparoscopic hepatectomy. J Nippon Med Sch 2019; 86: 201-6.
42. Runkel M, Diallo TD, Lang SA, et al. The role of visceral obesity, sarcopenia and sarcopenic obesity on surgical outcomes after liver resections for colorectal metastases. World J Surg 2021; 45: 2218-26.
43. Ratti F, D'Alessandro V, Cipriani F, et al. Influence of body habitus on feasibility and outcome of laparoscopic liver resections: a prospective study. J Hepatobiliary Pancreat Sci 2016; 23: 373-81.
44. Görgec B, Benedetti Cacciaguerra A, et al. Assessment of textbook outcome in laparoscopic and open liver surgery. JAMA Surg 2021; 156: e212064.
45. Hołówko W, Serednicki W, Bartkowiak M, et al. Early adoption of laparoscopic liver surgery in Poland: a national retrospective cohort study. Int J Surg 2023. doi: 10.1097/JS9.0000000000000840.
46. Goh BKP, Han HS, Chen KH, et al. Defining global benchmarks for laparoscopic liver resections: an international multicenter study. Ann Surg 2023; 277: e839-48.

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