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ORIGINAL ARTICLE

8 years with laparoscopic liver surgery: a referral center experience

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ABSTRACT

Objective: Laparoscopic liver surgery (LLR) was first performed in 1992 and LLR began to be performed for many benign and malignant etiologies, especially hepatocellular carcinoma (HCC) and colorectal cancer metastases (CRC). Recent studies have shown that LLR has less bleeding, shorter hospital stay (LOS), faster recovery, and similar long-term oncologic outcomes compared to open surgery. This study aims to examine the results of LLR, which has been performed for 8 years in our institution, which is one of the referal centers in the field of hepatopancreaticobiliary surgery.

Methods: Twenty-nine patients who underwent LLR for malignant and benign reasons in our hospital between January 2016 and March 2024 were included in the study, and 416 patients who underwent open surgery, and laparoscopic ablation. Data were obtained retrospectively from the hospital registry system.

Results: 18 (62.1%) of the patients were male and the median age was 57 (41-62.5). 23 (79.31%) of the patients underwent surgery for malignant reasons. The most common indications for surgery were HCC (24.14%) and CRC (20.69%). Median blood loss was 200 (100-375) ml. Median LOS was three (3-5) days, and 30-day readmission rate was 3.45%. Clavian-Dindo ≥3 complication grade was seen in 13.79% of patients and no mortality was observed in any patient. R0 resection was achieved in 73.91% of patients. Disease recurrence developed in 56.52% of patients at a median follow-up of 22.1 (9.9-48.5) months. Of the patients who developed recurrence in the liver, recurrence developed at the surgical margin in 13.04%, and in other liver segments in 30.43%. Median overall survival was 48.5 months, and median recurrence-free survival was 21 months. 1-, 3-, and 5-year overall survival were 85%, 76%, and 48%, respectively, while 1- and 3-year recurrence-free survival were 71% and 34%, respectively.

Conclusion: In this study, it was shown that LLR is a safe alternative to traditional open surgery in terms of length of hospital stay, blood loss, recurrence rates, and survival rates in parallel with the literature, and that although the surgical margin was positive, recurrence developed mostly in other liver segments, and in some patients, no recurrence was observed despite positive margins.

Keywords: surgery, liver neoplasms, liver cancer, minimally invasive surgery, liver.

INTRODUCTION

Following the introduction of laparoscopic surgery hepatobiliary surgery in the 1990s, the first anatomical liver resection was performed in 1996 [1]. In the following years, laparoscopic surgery began to be used for more complex procedures due to less pain, faster recovery, cosmetic benefits, and increased experience. To ensure appropriate patient selection, standardization of surgical techniques, and improvement of outcomes, the first International Laparoscopic Liver Surgery Consensus Meeting was held in Louisville in 2008 [2]. Subsequently, the Moriaka consensus meeting in 2014 and the Southampton consensus meeting in 2017 established the standards for laparoscopic liver surgery (LLR) [3,4]. The indications of LLR is varied from benign liver diseases such as focal nodular hyperplasia (FNH) to malignant diseases, including hepatocellular carcinoma (HCC) and colorectal cancer metastases (CRC). In appropriate patients, LLR may result in less intraoperative bleeding, shorter hospital stay, faster recovery with similar long-term oncologic outcomes compared to open surgery [5-8]. Additionally, studies have shown that in cirrhotic patients, there is a lower incidence of postoperative ascites and liver failure, along with earlier initiation of adjuvant chemotherapy, which results in improved survival outcomes [9,10].

Our center is one of the referal centers in Turkey for hepatobiliary surgery. The living donor liver transplantation program was initiated in our institution in 2015, and LLR was performed for the first time in 2016. The aim of this study is to examine the outcomes of LLR procedures performed in our department over the past eight years for benign and malignant conditions.

PATIENTS AND METHODS

Patient Selection

Patients who applied our department between January 2016 and March 2024, and underwent LLR were included in the study. A total of 445 liver surgeries were performed, 29 (6.52%) of which were LLR. The exclusion criteria were as follows: <18 years old, open liver resections, laparoscopic and open microwave ablations (MWA), and patients in whom LLR was added to the primary surgery due to invasion of adjacent organs into the liver. Flow chart is shown in Figure 1.

Demographic, Clinical and Laboratory Features

Patients' demographic, clinical and laboratory characteristics were recorded retrospectively from hospital records. History of previous abdominal surgery, type and location of hepatic lesion, and imaging findings were evaluated. The operative findings, pathological results, surgical margin, postoperative findings, complications, blood replacement status, and length of hospital stay (LOS) were examined from the hospital records. Resection marjin was determined by histopathological analysis. In the postoperative follow-up, recurrence at the resection site, recurrence in another segment, or recurrence in another organ were evaluated separately.

Scores and Definitions

Charlson Comorbidity Index (CCI) is an accurate, easy, readily applicable, and a widely used score to calculate the mortality risk from comorbid diseases [11]. It predicts the 1-year mortality by weighting the comorbid diseases from 1 to 6, and the result is given by the total sum of the weights. The diseases included in this scoring system are as follows: myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic obstructive pulmonary disease, connective tissue disease, peptic ulcer disease, liver disease, diabetes mellitus, hemiplegia, moderate to severe chronic kidney disease, solid tumor, leukemia, and lymphoma. The higher the CCI is, the higher the risk of mortality, and the severity of the comorbidities [11].

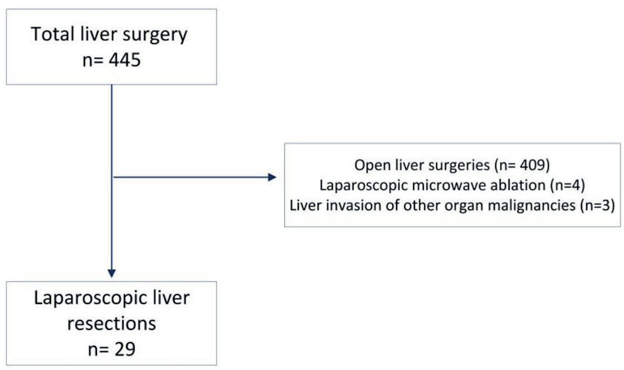

Figure 1. Flow chart

The American Society of Anesthesiologists (ASA) Score is the physical status classification system developed to predict the operative risk based on six classes (I-VI) [12]. I—a normal, healthy patient, II—a patient with mild systemic illness, III—a patient with severe systemic illness, IV—a patient with a severe systemic illness that is a constant threat to life, V—Moribund patient who is not expected to survive without the surgery, VI—a declared brain-dead patient whose organs are being removed for donor purposes.

Clavien-Dindo Classification is a widely used tool to evaluate postoperative complications (morbidity and mortality) [13,14]. The Clavien-Dindo Classification ranges from Grade I to Grade V as follows:

Grade I is any deviation from the normal recovery period after surgery without any need for a pharmacological or invasive procedure,

Grade II is any deviation from the normal recovery period after surgery requiring pharmacological treatment,

Grade III is any deviation from the normal recovery period after surgery requiring surgical, endoscopic, or radiological procedure (IIIa procedure not under general anesthesia; IIIb procedure under general anesthesia),

Grade IV is any deviation from the normal recovery period after surgery with life-threatening complications,

Grade V is the death of the patient after surgery.

The Iwate criteria is a surgical difficulty scoring system that was shown to be associated with operation time, estimated blood loss, open conversion rate, major complication rates, liver failure, and in-hospital death for minimally invasive liver surgery [15]. The total score is scored from 0 to 12 and is divided into 4 difficulty levels: low (0-3), intermediate (4-6), advanced (7-9), and expert (10-12). Variables were categorized into 6 groups: tumor location (1-5 points), hepatic resection type (0-4 points), tumor size (0-1 points), proximity to major blood vessels (0-1 points), Child-Pugh score (0-1 points), and hand-assisted/hybrid resection (0-1 points).

Brisbane 2000 terminology was used to describe tumor locations and surgical area. Couinaud's segments II, III, IVb, V, and VI were defined as anterolateral segments, segments I, IVa, VII, and VIII were defined as posterosuperior segments, segment II, and III were defined as left lateral sections [16].

Surgical Technique

Trocar sites are shown in Figure 2. After creating pneumoperitoneum, resection was performed under 12 mmHg pressure. Pringle maneuver preparation was performed through 5th trocar using tape and an 18-number chest tube in patients who were thought to have a risk of bleeding, were close to the portal hilus, had an Iwate score of 4 and above, and had fragile liver tissue secondary to hepatosteatosis. However, the Pringle maneuver was not performed in every patient who underwent Pringle preparation. In patients who underwent Pringle maneuver, a maximum of 3 cycles of 15 minutes of clamping and 10 minutes of unclamping were performed. The Pringle maneuver has been used as a method to reduce bleeding in open surgeries for many years. It is also used in laparoscopic liver surgery as a technique to reduce both bleeding and transfusion requirements. Other benefits include a clearer operational field with an improved visualization of

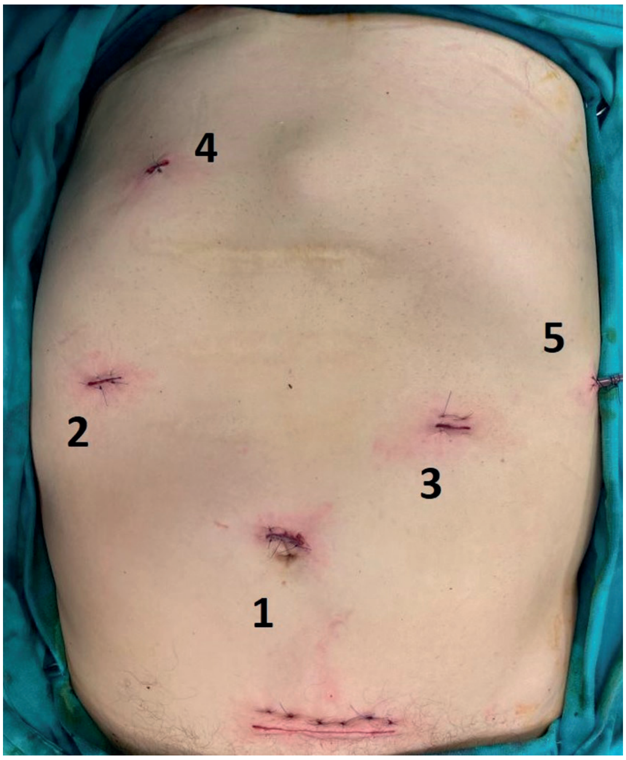

Figure 2. Trocar sites for laparoscopic liver resections **1.** Camera port **2-3.** Operation ports **4.** Asistance port **5.** Pringle maneuver port

intrahepatic vascular and biliary structures by the surgeon during the procedure [17]. Intraoperative laparoscopic ultrasonography was performed on all patients to evaluate the entire liver parenchyma. Likewise, resection margins and degree of proximity to major vessels were determined ultrasonographically. Hepatic transections were performed using a laparoscopic ligasureTM vessel sealing system (Medtronic, Minneapolis, USA) and an ultrasonic dissector (CUSA ExcelTM; Integra Lifesciences Corporation, Plainsboro, New Jersey, USA). Bipolar coagulation was used for minor bleeding and larger structures were controlled with endoclips, endoloop, and endoscopic linear staplers. Anatomic resections were performed by glissonian approach [18]. Nonanatomic resections were performed to provide safe surgical margins. If necessary, a Jackson-Pratt drain was placed in the surgical field from the 5th trocar (Figure 2). The specimen was extracted using a plastic bag through an additional 5-8 cm pfannenstiel incision.

Statistical Analysis

IBM SPSS Statistics for Windows, version 26.0 (SPSS Inc, Chicago, IL, USA) was used to perform the statistical analyses. The Mann–Whitney U test was used and continuous variables were presented as median and IQR values. The categorical variables were presented as frequency values. For categorical variables, chi-squared or Fischer's test was used when appropriate. Correlation analysis between variables was performed using the Spearman test for non-parametric variables. Correlation was determined using ρ (rho) value. Overall survival (OS) and recurrence free survival (RFS) were estimated using Kaplan-Meiers's analysis. A p-value < 0.05 was accepted as statistically significant.

RESULTS

Of a total of 29 patients who underwent LRR, eighteen (62.1%) were male and the median age was 57 years (41-62.5). Median body mass index (BMI) was 26 (23.69-29.2). While three (10.3%) of the patients were ASA III, the others were ASA I and II. Median CCI was six (3-8) and nine (31.03%) of the patients had a history of previous abdominal surgery. Twenty three LLR were for malignancy, including HCC (n=6), mix type (HCC+cholangiocarcinoma, one), CRC (n=6), malign melanoma metastases (n=4), lung cancer metastases (n=2), and one patient for each breast cancer metastases, gall bladder cancer, gastric cancer metastases, and testicular cancer metastases. Six LLR were for benign diseases, including hemangioma (n=2), and one patient for each hepatic adenoma, benign vascular neoplasia, biliary cyst adenoma, hepatolithiasis. Of the metastatic lesions, five (33.33%) were synchronous and ten (66.66%) were metachronous metastases. Cirrhosis was present in three (10.3%) patients. When maximum tumor sizes were examined, the median tumor diameter was 3.4 (2-4.95) cm. There were multifocal tumors in three (13.04%) patients. In five (17.24%) patients, the mass was close to major vessels. When the surgeries were examined in terms of difficulty levels, the median IWATE score was found four (2-5). It was determined that 12 (41.38%) patients had low difficulty level, 15 (51.72%) patients had intermediate difficulty level, and two (6.9%) patients had advanced difficulty level. Patients characteristics, tumor locations, and laboratory findings are summarized in Table 1.

Intraoperative and Postoperative Outcomes

Surgery was performed mostly on segments 2, 3 and 6. Table 2 summarizes the surgeries performed. Three patients (10.4%) had combined precedures for colorectal cancer (left lateral sectionectomy+ right lobe MWA+ open right hemicolectomy, left lateral sectionectomy+ laparoscopic left hemicolectomy or segment 2 metastasectomy+ laparoscopic left hemicolectomy). Two patients underwent two segments liver resections (segment 3 and 5).

Median operation time was 150 (120-197.5) minutes. Median estimated blood loss was 200 (100-375) mL. Four patients (13.79%) required intraoperative blood transfusion and the median transfusion rate was 400 (400-700) mL. Intraoperative total fluid transfusion rate was median 2000 (1450-2450) mL. Pringle maneuver was applied to five (17.24%) patients. The median pringle time in these patients was 20 (17.5-31) minutes. Two (6.9%) patients underwent conversion to open surgery, one for controlling bleeding during segment 8 resection, and the other because exposure could not be achieved during laparoscopic right hemicolectomy after laparoscopic left lateral sectionectomy+MWA. The median LOS was three (3-5) days. Six (20.69%) patients required postoperative intensive care unit (ICU) admission, and the median ICU stay was 1.5 (1-

Table 1. Demographic, clinical, and laboratory features

	Laparoscopic Liver Resection (n=29)
Sex (n,%)	
Male	18 (62.1)
Female	11 (37.9)
Age, median (IQR), years	57 (41-62.5)
Body mass index, median (IQR), kg/m^2	Med
Association of Anesthesiologist Classification, n (%)	
I: healthy	10 (34.5)
II: mild systemic disease	16 (55.2)
III: severe systemic disease	3 (10.3)
Charlson Comorbidity Index, median (IQR)	6 (3-8)
Previous abdominal surgery, n (%)	9 (31.03)
Neoadjuvant systemic theraphy, n (%)	12 (41.38)
Surgical etiology, n (%)	
Benign	6 (20.69)
Hemangioma	2 (6.9)
Adenoma	1 (3.45)
Benign vascular neoplasia	1 (3.45)
Biliary cyst adenoma	1 (3.45)
Hepatolithiasis	1 (3.45)
Malign	23 (79.31)
Primary	8 (27.59)
Hepatocellular carcinoma	6 (20.69)
Mixt type carcinoma (cholangio+hepatocellular)	1 (3.45)
Gall bladder carcinoma	1 (3.45)
Secondary	15 (51.72)
Colorectal cancer	6 (20.69)
Malign malenoma	4 (13.79)
Lung cancer	2 (6.90)
Breast cancer	1 (3.45)
Gastric cancer	1 (3.45)
Testicular cancer	1 (3.45)
Timing of metastases, n (%)	
Synchronous	5 (33.33)
Metachronous	10 (66.66)
Liver cirrhosis, n (%)	3 (10.3)
Maximum diameter of largest lesion (cm)*, median (IQR)	3.4 (2-4.95)
Proximity to major vessels, n(%)	5 (17.24)
Multifocal tumor**, n (%)	2 (8.70)
Number of tumor**, median (IQR)	1 (1-1)

Table 1. Continued.

	Laparoscopic Liver Resection (n=29)
Tumor locations, n (%)	
Segment II	4 (12.9)
Segment III	8 (25.8)
Segment II-III	4 (12.9)
Segment IVa	1 (3.23)
Segment IVb	3 (9.68)
Segment IVb-V	1 (3.23)
Segment IVb-V-gall bladder	1 (3.23)
Segment V	2 (6.45)
Segment VI	5 (16.13)
Segment V-VI	1 (3.23)
Segment VII	0
Segment VIII	1 (3.23)
IWATE score, median (IQR)	4 (2-5)
0-3 (low), n (%)	12 (41.38)
4-6 (intermediate), n (%)	15 (51.72)
7-9 (advanced), n (%)	2 (6.90)
10-12 (expert), n (%)	0

2) days. 30-day hospital readmission occurred in one (3.45%) patient and 90-day readmission occurred in four (13.79%) patients. Major adverse events (C-D ≥3a) were seen in 4 (13.79%) patients. One of them was treated with percutaneous drainage due to pleural effusion, one with endoscopic retrograde cholangiopancreatography (ERCP) + percutaneous drainage due to bile leakage, and two with percutaneous drainage due to postoperative fluid collection. Pathological examination results of 23 patients who underwent surgery due to malignancy revealed that surgical margins were negative (R0) in 17 (73.91%) patients and positive (R1+R2) in six (26.09%) patients. Surgical characteristics and outcomes are shown in Table 3.

Oncologic Outcomes and Recurrence

Of the 29 patients who underwent LLR, 23 were operated for malignant reasons. The median length of follow-up (including patients who died in postoperative period) was 22.1 (9.9-48.5) months. Disease recurrence was observed in 13 (56.52%) patients during postoperative follow-up. Recurrence was seen in the liver in 10 (43.48%)

Table 2. Surgial procedures

n, (%)	Laparoscopic liver resections (n=29)
Left lateral sectionectomy	6 (20.69)
+microwave ablation+open right hemicolectomy	1 (3.45)
+laparoscopic left hemicolectomy	1 (3.45)
Segment 2 resection	3 (10.34)
+laparoscopic left hemicolectomy	1 (3.45)
Segment 3 resection	5 (17.24)
Segment 4a resection	1 (3.45)
Segment 4b resection	3 (10.34)
Segment 4b+5 resection	2 (6.90)
Segment 6 resection	5 (17.24)
Segment 5-6 resection	1 (3.45)
Segment 3 and 5 resection	2 (6.90)
Lung cancer metastases	1 (3.45)
Hepatocellular carcinoma	1 (3.45)
Segment 8 resection	1 (3.45)

patients and in the extrahepatic area in 7 (30.43%) patients (some patients had both hepatic and extrahepatic recurrence). When liver recurrences were analyzed, three (13.04%) patients developed recurrence at the surgical site, and 7 (30.43%) patients developed recurrence in the other segments of the liver. The median time between surgery and the first recurrence was 10 (5.5-19.5) months. (Table 3) Median OS was 48.5 months. 1-year OS is 85%, 3-year OS is 76%, and 5-year OS was 48%. Median RFS is 21 months. 1-year RFS is 71% and 3-year RFS is 34%. (Figure 3) As of August 2024, seven (30.43%) patients died. Of the alive patients, 10 (43.48%) of them are disease-free.

When the seven patients with positive surgical margins were examined, it was seen that no recurrence was observed in two patients, recurrence developed in the resection margin in only one patient, and recurrence developed in other segments of the liver in the remaining three patients during the follow-up period. Recurrence analysis according to positive surgical margins is shown in Table 4.

The affect of surgical experience on the results was determined by comparing the results of the first 15 and last 14 patients. Accordingly, no statistically significant difference was found between the two groups in terms of operative time, intraoperative bleeding, complications, surgical margins and recurrence (p=0.16; 0.32; 0.26; 0.32; 0.32, respectively), while the median hospital stay was significantly reduced (4 (3-5), and 3 (2-4) days, respectively; p=0.018).

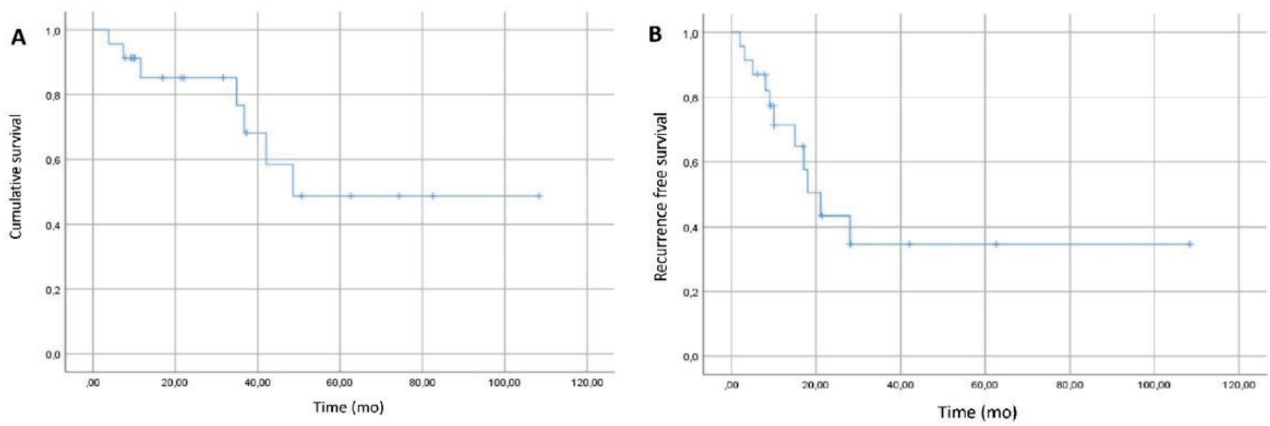

Figure 3. Kaplan-Meier Survival Curves, **A.** Overall survival **B.** Recurrence free survival

Table 3. Surgical characteristics and outcomes

	Laparoscopic Liver Resections (n=29)
Operation time (min), median (IQR)	150 (120-197.5)
Synchronous non-liver abdominal surgery, n (%)	3 (10.34)
Estimated blood loss (ml), median (IQR)	200 (100-375)
Intraoperative blood transfusion (patients), n (%)	4 (13.79)
amount of transfusion (ml), median (IQR)	400 (400-700)
Intraoperative total fluid transfusion (ml), median (IQR)	2000 (1450-2450)
Pringle maneuver performed, n (%)	5 (17.24)
Duration of pringle maneuver (min), median (IQR)	20 (17.5-31)
Conversion to open surgery, n (%)	2 (6.90)
Length of hospital stay (day), median (IQR)	3 (3-5)
Intensive care unit admission (patient), n (%)	6 (20.69)
if yes, length of admission (day), median (IQR)	1.5 (1-2)
Prolonged admission (>10 days), n (%)	1 (3.45)
30-days readmission, n (%)	1 (3.45)
30-days return to operating room, n (%)	0
90-days readmission, n (%)	4 (13.79)
Major adverse events (C-D ≥3a), n (%)	4 (13.79)
Clavien-Dindo classification, n (%)	
I	25 (86.21)
II	0
IIIa	4 (13.79)
IIIb	0
IV	0
V	0
Surgical margin*, n (%)	
Negative (R0)	17 (73.91)
Positive (R1+R2)	6 (26.09)
Total recurrence (patients)*, n (%)	13 (56.52)
Liver recurrence*, n (%)	10 (43.48)
Surgical site	3 (13.04)
Different segment	7 (30.43)
Extrahepatic recurrence*, n (%)	7 (30.43)
Time to first recurrence after surgery (month), median (IQR)	10 (5.5-19.5)
Overall survival* (month) median	48.5
Recurrence free survival* (month) median	21

C-D, Clavien-Dindo classification

*Evaluation was made only for malignant patients (n=23)

Correlation analysis

No correlation was found between the amount of intraoperative bleeding and IWATE score, complications, LOS, major vessel involvement and recurrence (p= 0.67; 0.14; 0.9; 0.09; 0.13, respectively). There was no correlation between the total amount of fluid transfusion and complications and LOS (p=0.25; 0.30, respectively). While no correlation was found between IWATE score and complications, surgical margin positivity and, recurrence (p=0.09; 0.09; 0.84; respectively), a positive direction, moderately strong, statistically significant correlation was found with the duration of surgery (p=0.008, ρ=0.49) (Figure 4).

Table 4. Surgical margin positivity and recurrence analysis

Primary pathology	Surgical site	Recurrence area	Time to recurrence after surgery	Current living situation
Hepatocellular carcinoma	Segment 3	No recurrence	49 months (disease free)	alive
Breast cancer metastases	Segment 4b	Surgical area (segment 4b)	18 months	alive
Lung cancer metastases	Segment 3 and 5	Segment 6 and 4-8	5 months	alive
Malign melanoma metastases	Segment 2	Segment 5-6 and 4-8	8 months	alive
Malign melanoma metastases	Segment 3	No recurrence	9 months (disease free)	alive
Testicular carcinoma metastases	Segment 4b	Multiple segments	2 months	exitus

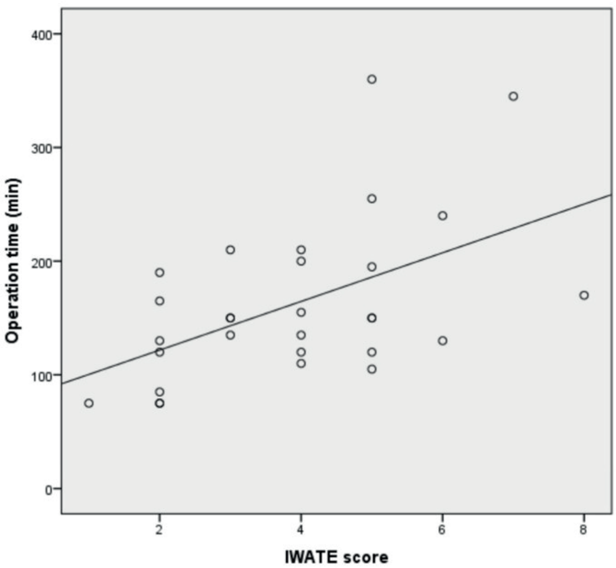

Figure 4. IWATE score and operating time correlation analysis

DISCUSSION

This study shows that LLR is an effective alternative to traditional open surgery in selected malignant and benign patients, with low complication rates, short hospital stays, and acceptable overall survival rates.

Following the introduction of laparoscopic techniques in many fields, the use of laparoscopy has also become increasingly common in hepatobiliary surgery. The first anatomical LLR was performed in 1996 as a left lateral sectionectomy (LLS) [1]. With experience, laparoscopy began to be defined as the standard treatment for LLS [4,8,19,20]. While LLR was performed in 2.3% of all liver surgeries in 2000, this rate increased to 7.5% have malignant causes [5]. According to a meta-analysis, 75% of malignant patients are HCC and CRC [21]. In our study, 6.52% of all liver surgeries were LLR and 79.31% of the indications were malignancies. Additionally, 56.52% of all malignancies in our study were CRC and HCC.

When the advantages of LLR were examined, the previous studies showed that there were fewer wound complications, less amount of bleeding, shorter surgery time with similar oncological results compared to open liver surgery [5-7]. It was also shown that there was less postoperative ascites and liver failure in the cirrhotic patient group [9]. In addition, laparoscopy is accepted as a surgical method that can be used safely in donor hepatectomy surgeries [22,23]. In a study conducted on liver transplant patients, 60% of the patients experienced wound problems such as wound tension, paresthesia, and hypertrophic scarring in the first year after surgery, and these problems continued in the long term in 35% of the patients [24]. Additionally, the incidence of incisional hernia after open liver surgery has been reported to be approximately 30% [25,26]. The incidence of surgical site infection and wound complications after LLR is very low [27]. In our study, similar to the literature, no surgical site infection or incisional hernia was observed in any patient.

Another benefit of LLR is less bleeding and less need for blood transfusion compared to open surgery. In the study by Bagante et al., where they examined the results of 2542 open hepatectomy and 612 LLR patients, it was observed that there was a statistically significant less need for blood transfusion and pringle maneuver in the LLR group (7.5% vs. 21.3%, $p<0.001$; 11.4% vs. 29.3%, $p<0.001$, respectively) [5]. In the same study, bile leakage occurred in 2.9% of the LLR group compared to 10.3% in the open surgery group ($p<0.001$). A meta-analysis of 9000 patients showed less estimated blood loss, and less blood transfusion, (322 ml vs 572 ml, $p<0.001$; 4.02% vs 9.57%, $p<0.001$; respectively) [21]. In contrast, in the randomized controlled "Orange II Plus study", one of the most recent studies in the literature comparing the results of laparoscopic and open major hemihepatectomies in 16 centers from Europe, the median blood loss was reported to be similar in LRR and open surgery groups (450 [300-775] mL, and 450 [300-785] mL, respectively) (p=0.79) [28]. According to the results of the randomized controlled “LapOpHuva study” comparing laparoscopic and open surgery in patients with CRC liver metastasis, median operative time was 120 (90-180) minutes, median blood loss was 100 (50-300) ml, blood transfusion rate was 4.2%, pringle maneuver was performed in 30.2% of patients, and clamping time median was 15 (8-20) minutes [29]. In a recent study of 1258 patients in which the results of low risk patients were examined by expert surgeons and the benchmark criteria for LLR were determined, the operation time was defined as median of 200 (113-288) minutes, estimated blood loss as median of 100 (0-225) mL, intraoperative blood transfusion rate as 4.4%, and open conversion rate as 4.8% [30]. Similarly in our study, median of 200 (100-375) ml intraoperative blood loss occurred, but the need for blood transfusion was slightly higher (13.79%), and a median of 400 (400-700) ml blood transfusion was required. Consistent with the literature, pringle maneuver was performed in 17.24% of patients and median clamping time was calculated as 20 (17.5-31) min. However, the surgery time was slightly longer (median 150 (120-197.5) min), but conversion to open rate occurred in only 2 patients (6.9%).

In laparoscopic surgeries, the postoperative inflammatory response is less, thus the physical impact of the surgery is reduced and faster recovery is observed [31,32]. For this reason, the LOS is shorter than open surgery. In a study examining the quality of life after LLR, the median LOS for LLR was 2.2 (1.88-2.54) days, while it was 4 (3.71-4.29) days in open surgery (p<0.001). In the same study, body pain in the first month after surgery was significantly lower in the LLR group (p=0.003) [20]. In another study, median LOS was reported to be 3 (2-5) days in the LLR group while it was 6 (5-8) days in the open surgery group (p<0.001). The readmission rate was 7.5% for LLR [5]. A meta-analysis showed that LOS was shorter in both minor and major hepatectomy groups compared to open surgery (8.28±4.49 vs 13.54±8.8 days, p<0.001; 8.3±4.28 vs 16.67±8.3 days, p<0.001, respectively) [21]. In the “Orange II Plus study,” LOS was reported as median 5 (4-7) days in the laparoscopy arm and 6 (5-7) days in the open surgery arm (p = 0.002). In the same study, readmission rate was reported as 13.3% [28]. In the benchmark study by Goh et al., median LOS was reported as 5 (4-7) days, 30-day readmission as 2.5% [30]. Our study showed a similar median LOS of 3 (3-5) days, with comparable 30-day and 90-day readmission rates (3.45%, 13.79%; respectively).

When the results of LLR were examined from an oncological perspective, it was stated that the resection margin and R0 resection rate were similar to LLR and open surgery [21]. In a recent anatomical liver resection study, the R0 resection rate in patients who underwent LLR was 77.9%, the R1-R2 resection rate, the recurrence rate, and the liver only recurrence rate were 19.1%, 48.5%, and 26.5%, respectively [28]. In the LapOpHuva study, R0 resection margin was obtained in 95.8% of patients, recurrence was seen in 67.7% of patients, and liver only recurrence was seen in 15.6% of patients [29]. According to the long-term results of the Oslo-Comet trial, recurrence developed in 67% of patients and liver only recurrence was observed in 33.75% of patients [33]. In the study by Goh et al., the R1 resection rate was determined as 4.5% [30]. In this current study, we showed that the R0 resection rate for malignant patients was 73.91%, while recurrence developed in 56.52% of patients during the follow-up period, and liver recurrence was seen in 43.48% of patients. When liver recurrences were examined, 13.04% recurrence was observed in the surgical site and 30.43% was observed in other segments. We attribute our R1-R2 resection rate being slightly higher than the literature to the fact that we have not yet completed the learning curve. Despite this, the overall recurrence and intrahepatic recurrence sites seen in patients were comparable to the literature.

Previous studies demonstrated the overall morbidity after LLR as 11 to 48%, and 30-day mortality is 0-2% [5,21,27,34]. The Orange II Plus study reported a 90-day liver-specific morbidity as 13.9% in the LLR group [28]. In the LapOpHuva study, the C-D≥3a complication rate was 6.25%, while 1-, 3-, and 5-year OS rates were 92.5%, 71.5%, and 49.3%, and 1-, 3-, and 5-year RFS were 72.7%, 33.5%, and 22.7%, respectively [29]. According to the long-term results of the Oslo-Comet trial, 1-, 3-, and 5- year OS rates were reported as 96.6%, 71.4%, 54.1%, and 1-, 3-, and 5- year RFS rates were reported as 55.5%, 35.9%, 29.7%, respectively. According to univariable analysis, there was no relationship between R1 (<1mm) resection and

RFS and OS, while in patients with R2 resection, RFS was shortened (p = 0.002) but OS did not change (p = 0.39) [33]. In terms of benchmark criteria, 90-day morbidity was reported as 13.8% with a 90-day mortality as 0.2% [30]. In our study, overall morbidity was shown to be 13.79% and 90-day mortality was 0%. Additionally, in malignant patients, the median RFS was found 21 months, and the median OS was 48.5 months. 1-, 3-, and 5-years OS were 85%, 76%, and 48%, and 1- and 3-years RFS were 71% and 34%.

It is stated that there is a learning curve of about 40-60 surgeries for LLR [35]. Chua et al. reported the learning curve in their study involving approximately 28% minor, 21% major, and 50% minor+major hepatectomies, with a median of 43 (18-60) patients [36]. In addition to the number of surgeries, the degree of difficulty of the surgery also affects the results. Although various difficulty scoring systems have been used, the IWATE scoring system is the most commonly used for laparoscopic and robotic liver surgeries. This score was created by examining the Japanese cohort after the 2014 Morioka consensus meeting, and scoring system correlates with conversion to open surgery, morbidity level, in-hospital mortality, and liver failure [3,15,37,38]. The median Iwate score of the surgeries in our study was four (2-5) and 51.72% of the patients had intermediate difficulty. Unlike the literature, a correlation relationship with Iwate score was found only between the duration of surgery ($p=0.008$, $\rho=0.49$), but this relationship could not be demonstrated in other parameters. Since the total number of LLRs performed is 29, we still have not been able to complete the learning curve. When the results of the first 15 surgeries were compared with the last 14 surgeries, the only statistically significant difference was found in the LOS results (median four (3-5) days vs three (2-4) days, respectively, $p=0.018$). No statistically significant difference was found in other parameters. We believe the results will improve as the number of surgeries increases.

Our study has some limitations. First, the number of patients was quite limited. Only 6.59% of patients underwent laparoscopic surgery. We attribute this to the fact that our hospital is a referral center for hepatobiliary surgery, and the patient group consists mostly of difficult and redo patients. The other limitation was that it was a retrospective and single center study, and the results of LLR could not be compared with the results of open surgery. In further studies, the results of 409 open hepatectomy patients not included in this study can be compared with the results of 29 laparoscopic liver surgeries using the propensity score match analysis method.

CONCLUSION

LLR is a safe and feasible alternative to traditional open surgery, in terms of hospital stay, blood loss, recurrence rates, and survival rates. In this era where minimally invasive surgery is evolving into robotic surgeries, further studies comparing the results of robotic and laparoscopic liver surgery are needed.

Author contribution

Study conception and design: HAD, ABD; data collection: HAD, DD; analysis and interpretation of results: HAD, DD, OC, ABD; draft manuscript preparation: HAD, OC. All authors reviewed the results and approved the final version of the manuscript.

Ethical approval

The study was approved by the Hacettepe University Health Sciences Research Ethics Committee (Protocol no. SBA 24/551 // 21.05.2024).

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Conflict of interest

The authors declare that there is no conflict of interest.

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