Original article

Outcome after laparoscopic and open resections of posterosuperior segments of the liver

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Background: **Laparoscopic resection of posterosuperior (PS) segments of the liver is hindered by limited visualization and curvilinear resection planes. The aim of this study was to compare outcomes after open and laparoscopic liver resections of PS segments.**

Methods: **Patients who underwent minor open liver resection (OLR) and laparoscopic liver resection (LLR) between 2006 and 2014 were identified from the institutional databases of seven tertiary referral European hepatobiliary surgical units. Propensity score-matched analysis was used to match groups for known confounders. Perioperative outcomes including complications were assessed using the Dindo–Clavien classification, and the comprehensive complication index was calculated. Survival was analysed with the Kaplan–Meier method.**

Results: **Some 170 patients underwent OLR and 148 had LLR. After propensity score-matched analysis, 86 patients remained in both groups. Overall postoperative complication rates were significantly higher after OLR compared with LLR: 28 *versus* 14 per cent respectively ($P = 0·039$). The mean(s.d.) comprehensive complication index was higher in the OLR group, although the difference was not statistically significant (26·7(16·6) *versus* 18·3(8·0) in the LLR group; $P = 0·108$). The mean(s.d.) duration of required analgesia and the median (range) duration of postoperative hospital stay were significantly shorter in the LLR group: 3·0(1·1) days *versus* 1·6(0·8) days in the OLR group ($P < 0·001$), and 6 (3–44) *versus* 4 (1–11) days ($P < 0·001$), respectively. The 3-year recurrence-free survival rates for patients with hepatocellular carcinoma (37 per cent for OLR *versus* 30 per cent for LLR; $P = 0·534$) and those with colorectal liver metastases (36 *versus* 36 per cent respectively; $P = 0·440$) were not significantly different between the groups.**

Conclusion: **LLR of tumours in PS segments is feasible in selected patients. LLR is associated with fewer complications and does not compromise survival compared with OLR.**

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Introduction

A laparoscopic approach for the resection of hepatic lesions is becoming widely accepted. Laparoscopic hepatectomy is as safe as an open liver resection (OLR) approach when performed by experienced surgeons. Despite the technical challenges and a steep learning curve, many centres have implemented laparoscopic liver resection (LLR) programmes in the past decade. Successful outcomes have been reported for minor resections of anterolateral segments[1–11].

An international consensus conference on LLR confirmed the benefits of the laparoscopic approach, which include reduced blood loss, fewer complications, shorter duration of hospital stay and equivalent oncological outcomes compared with the open approach[12]. However, LLR is associated with a longer duration of surgery[1,3,4,6–16]. The claimed benefits of LLR are based on retrospective cohort studies and meta-analyses of non-randomized studies. Propensity score-matched analysis is able to minimize bias in retrospective studies, allowing a more accurate comparison between procedures[14]. Studies[17–19] using propensity score-matched analysis have shown improved outcomes for patients who underwent LLR compared with OLR.

LLR for posterosuperior (PS) segments (segments I, IVa, VII and VIII) is challenging. Curvilinear resection surfaces are required for a parenchyma-preserving approach[20–26]. Technical difficulties relate to the limited working space and exposure of the deepest liver parenchyma for transection surfaces close to the diaphragm, difficulties in evaluating the resection margin by ultrasonography, and control of haemorrhage from the tributaries of major hepatic veins and inferior vena cava. Hence, LLR has not been recommended for PS segments, and some authors[20,27–29] have recommended laparoscopic major hepatectomy for PS-sided lesions rather than parenchyma-preserving procedures.

As a consequence, LLR for PS segments should be considered a technically complex operation, and the new proposed difficulty scoring system grades tumours in PS segments with the highest score[30–33]. The aim of the present study was to analyse the surgical and oncological outcomes of OLR and LLR for PS segments.

Methods

In this retrospective cohort study, data were collected from seven tertiary referral European hepatobiliary surgical units' databases between January 2006 and December 2014. Participating centres specialized in hepatobiliary surgery, with at least 10 years of experience, and with high-volume activity (more than 100 hepatectomies annually). LLR of PS segments was performed at each centre after 30–60 LLRs of anterolateral segments had been undertaken, including some major hepatectomies. The study was approved by the local institutional review board (number B670201627205-2016/0089).

Inclusion criteria for the study were: hepatic resection of lesions located in PS segments; patients aged 18–80 years; OLR or LLR for no more than two benign or malignant lesions; lesions 5 cm or less in size and located solely in segments I, IVa, VII or VIII. Excluded were patients with liver lesions involving anterior or left segments, lesions compressing the major hepatic veins or inferior vena cava, repeat liver resections, hepatic resections combined with colectomy or other abdominal procedures, and resections of more than two segments or palliative procedures. Data were collected in single-centre databases and reviewed retrospectively.

The preoperative investigation was similar for OLR and LLR procedures, and included blood tests, ultrasonography of the liver, spiral CT or MRI; PET–CT was carried out when conventional imaging was equivocal. In each institution, the indication for surgery and approach were discussed in a multidisciplinary meeting. Indications for resection of hepatocellular carcinoma (HCC) were: single lesion, absence of severe portal hypertension and normal bilirubin level (Child–Pugh grade A). Indications for resection of benign liver tumours were: liver cell adenoma, symptomatic focal nodular hyperplasia, and haemangiomas and lesions with uncertain diagnoses. Most of the inclusion criteria were set according to the Louisville guidelines[1].

The terminology for liver anatomy and resection was based on the Brisbane classification[33]. The Dindo–Clavien classification[34] and the comprehensive complication index (CCI)[35] were used to describe overall morbidity.

Biliary leak was defined as a bilirubin concentration in drain fluid at least three times the serum bilirubin level on or after postoperative day 3, according to the International Study Group of Liver Surgery[36]. Ascites was defined as postoperative daily fluid drainage from the abdomen exceeding 10 ml per kg bodyweight[37]. Urinary tract infection was diagnosed in the presence of a positive urine culture that required systemic antibiotic therapy. Pleural effusion was defined as fluid in the thoracic cavity associated with atelectasis requiring percutaneous drainage. A margin width of less than 1 mm at microscopic evaluation of the resection specimen was defined as R1 (non-radical margin).

The immediate postoperative analgesia protocols were different in the participating centres, but all used continuous epidural or patient-controlled analgesia. Length of analgesia requirement was defined as the time between date of operation and withdrawal of continuous use of non-steroidal anti-inflammatory drugs or opioids.

Operative technique for laparoscopic liver resection

For tumours located in segments VII and VIII, patients were placed in the supine position; the operating table was tilted leftward by 15–45° during the procedure. The standard lithotomy position was suitable for tumours located in segment I or the superior part of segment IV. Patients were positioned with a head-up tilt (30° reverse

Trendelenburg) with the legs apart and the surgeon standing between them, or on the patient's right side. One or two intercostal trocars and the Pringle manoeuvre were used, based on the surgeon's preference and the centre's policies. Intraoperative ultrasonography (IOUS) was used universally to locate the tumours and to plan the resection lines according to anatomical landmarks (major hepatic veins and/or portobiliary pedicles). For parenchymal transection, either a surgical aspirator (CUSA Excel®, Integra, Plainsboro, New Jersey, USA; SonoSurg, Olympus, Tokyo, Japan; Sonoca, Söring, Quickborn, Germany) or high-energy device (Harmonic® scalpel, Ethicon, Somerville, New Jersey, USA; LigaSure™, Medtronic, Minneapolis, Minnesota, USA; Aquamantys System, Medtronic; AutoSonix™, Medtronic; Erbejet®, Erbe, Tübingen, Germany; Thunderbeat, Olympus; Lotus, Newton Abbot, UK) was used. Intraparenchymal vessels were dealt with by titanium or Hem-o-Lok® (Weck, Durham, North Carolina, USA) clips. The specimen was removed in a plastic bag; wedge resection or segmentectomies were extracted via one of the trocar sites (after widening), whereas a Pfannenstiel incision was usually used for bisegmentectomies.

Operative technique for open liver resection

Laparotomy was performed through a right subcostal incision extended to the midline. Hepatic IOUS was always used before starting the resection for diagnostic reassessment and improved definition of the edges for parenchyma-sparing resections. Parenchymal transection was performed with different devices according to the preference of each centre, and intraparenchymal vessels were managed by suturing or titanium clips. Portal triad clamping was used when there was major bleeding.

Statistical analysis

Continuous data with a normal distribution are reported as mean(s.d.) values and compared using two-sided Student's *t* tests. Continuous data that were not normally distributed are reported as median (range) values and compared with the Mann–Whitney *U* test. For categorical variables, comparisons between groups were performed using the χ^2 test with Yates' correction, or Fisher's exact test when appropriate.

To overcome bias from the different distribution of co-variables among patients in the two study groups, a propensity score-matched analysis was performed in a one-to-one match using the nearest-neighbour matching method with no replacement. The following co-variables were used: age, sex, year of operation, indication for resection (benign or malignant), previous abdominal surgery, underlying liver disease, perioperative chemotherapy, tumour location, number and size of tumours (maximum of 2 lesions with the largest not exceeding 5 cm), and type of resection (wedge resection, segmentectomy or bisegmentectomy). The matching algorithm was based on logistic regression and tested by a histogram of the propensity score, and a dot plot of standardized mean differences. Matching was done when the difference in the logit of the propensity score between nearest neighbours was within a calliper-width equal to 0·2 times the s.d. of the logit of the propensity score.

Statistical significance was set at $P < 0{\cdot}050$. Recurrence-free survival was evaluated by means of the Kaplan–Meier method and compared with the log rank test. Statistical analysis was performed using SPSS® version 19.0 for Windows® (IBM, Armonk, New York, USA). Propensity score matching was done using the extension program for SPSS®[38].

Results

Some 318 liver resections were included; 170 patients underwent OLR and 148 had LLR (*Table 1*). Tumour number and size, previous abdominal surgery and involved segments were different between the groups. After propensity score matching, OLR and LLR groups were well balanced (86 patients) (*Table 2*). As mean differences for each co-variable after the matching process were less than 0·25, the imbalance was not great.

Operations

The median (range) duration of operation was longer in the LLR group than in the OLR group: 215 (52–540) *versus* 180 (90–420) min respectively ($P = 0{\cdot}019$) (*Table 3*). In the LLR group, 19 patients with HCC were treated using seven segmentectomies and 12 atypical resections. In the OLR group, 17 patients with HCC underwent four anatomical and 13 non-anatomical resections. Intercostal trocars were used in ten resections involving segments VII and VIII. Conversion to an open approach was necessary for oncological reasons in three patients (2 with a tumour in segment VII and 1 with a lesion in segment VIII). There were no intraoperative deaths.

Postoperative outcomes

One death was recorded in the OLR group on day 20 after surgery owing to a massive myocardial infarction.

Table 1 Demographics and tumour characteristics before propensity score matching

	OLR ($n = 170$)	LLR ($n = 148$)	P‡
Age (years)*	64·6 (34–83)	62·6 (23–80)	0·122§
Sex ratio (M : F)	101 : 69	82 : 66	0·544
BMI (kg/m^2)†	25·6(3·1)	25·2(3·2)	0·259¶
Indication for liver resection			0·041
CRLM	88 (51·8)	87 (58·8)	
HCC	40 (23·5)	19 (12·8)	
NCRLM	23 (13·5)	15 (10·1)	
CCC	5 (2·9)	4 (2·7)	
Benign	14 (8·2)	23 (15·5)	
Cirrhosis	38 (22·4)	18 (12·2)	0·026
Preoperative chemotherapy	72 (42·4)	49 (33·1)	0·115
ASA fitness grade			0·191
I	38 (22·4)	34 (23·0)	
II	80 (47·1)	84 (56·8)	
III	48 (28·2)	28 (18·9)	
IV	4 (2·4)	2 (1·4)	
Co-morbidity	92 (54·1)	67 (45·3)	0·144
Cardiac	56 (32·9)	47 (31·8)	0·916
Pulmonary	19 (11·2)	10 (6·8)	0·242
Other	45 (26·5)	31 (20·9)	0·308
Previous abdominal surgery	98 (57·6)	42 (28·4)	< 0·001
Segments involved			< 0·001
VII	43 (25·3)	52 (35·1)	
VIII	32 (18·8)	50 (33·8)	
IVa	19 (11·2)	22 (14·9)	
I	18 (10·6)	6 (4·1)	
Mixed	58 (34·1)	18 (12·2)	
No. of lesions			< 0·001
1	129 (75·9)	138 (93·2)	
2	41 (24·1)	10 (6·8)	
Largest tumour size (mm)*	32 (6–50)	23 (8–50)	< 0·001§

Values in parentheses are percentages unless indicated otherwise; values are *median (range) and †mean(s.d.). OLR, open liver resection; LLR, laparoscopic liver resection; CRLM, colorectal liver metastasis; HCC, hepatocellular carcinoma; NCRLM, non-colorectal liver metastases; CCC, central cholangiocarcinoma. ‡χ^2 test, except §Mann–Whitney U test and ¶Student's t test.

In the LLR group, 12 of 86 patients (14 per cent) had a complication, compared with 24 of 86 (28 per cent) in the OLR group (*Table 4*). The grade of complications according to Dindo–Clavien and the CCI were not significantly different between the groups. The mean(s.d.) CCI was lower in the LLR group (18·3(8·0) *versus* 26·7(16·6) in the OLR group), but failed to reach statistical significance ($P = 0·108$). The mean(s.d.) duration of postoperative analgesic requirement was significantly longer in the OLR group than in the LLR group (3·0(1·1) *versus* 1·6(0·8) days respectively; $P < 0·001$). Median (range) duration of hospital stay was longer following OLR than after LLR (6 (3–44) *versus* 4 (1–11) days respectively; $P < 0·001$).

Table 2 Patient characteristics after propensity score matching

	OLR ($n = 86$)	LLR ($n = 86$)	P‡
Age (years)*	63·9 (34–83)	64 (27–80)	0·857§
Sex ratio (M : F)	50 : 36	54: 32	0·640
BMI (kg/m^2)†	25·4(3·5)	25·5(3·7)	0·837¶
Indication for liver resection			0·991
CRLM	52 (60)	49 (57)	
HCC	17 (20)	19 (22)	
NCRLM	9 (10)	9 (10)	
CCC	2 (2)	2 (2)	
Benign	6 (7)	7 (8)	
Cirrhosis	17 (20)	19 (22)	0·851
Preoperative chemotherapy	42 (49)	32 (37)	0·166
ASA fitness grade			0·837
I	20 (23)	17 (20)	
II	41 (48)	47 (55)	
III	24 (28)	21 (24)	
IV	1 (1)	1 (1)	
Co-morbidity	43 (50)	38 (44)	0·541
Cardiac	27 (31)	28 (33)	1·000
Pulmonary	8 (9)	5 (6)	0·564
Other	18 (21)	18 (21)	1·000
Previous abdominal surgery	59 (69)	56 (65)	0·746

Values in parentheses are percentages unless indicated otherwise; values are *median (range) and †mean(s.d.). OLR, open liver resection; LLR, laparoscopic liver resection; CRLM, colorectal liver metastasis; HCC, hepatocellular carcinoma; NCRLM, non-colorectal liver metastases; CCC, central cholangiocarcinoma. ‡χ^2 test, except §Mann–Whitney U test and ¶Student's t test.

Pathology

The mean number and size of resected lesions were similar between the two groups. The proportion of patients with a microscopic non-radical (pR1) resection was not significantly different (*Table 3*).

Oncological outcomes

Hepatic tumour recurrence was seen in 31 of 86 patients (36 per cent) after LLR and in 20 of 86 patients (23 per cent) after OLR. Treatment of recurrences in the LLR group was repeat LLR in 11 patients, OLR in four, chemotherapy in eight and palliative treatment in eight patients. In the OLR group, repeat OLR was performed in six patients, chemotherapy in 12, and two patients had palliative treatment.

Extrahepatic tumour recurrence occurred in 13 patients (15 per cent) after LLR and in eight (9 per cent) after OLR. No patient with an R1 resection had recurrence at the resection margin.

The 3-year recurrence-free survival rate for patients with HCC was 37 and 30 per cent in the OLR and LLR groups respectively ($P = 0·534$), and that for colorectal metastases was 36 *versus* 36 per cent respectively ($P = 0·440$) (*Fig. 1*).

Table 3 Characteristics of the operation and pathology of the resection specimens

	OLR (*n* = 86)	LLR (*n* = 86)	*P*‡
Segments involved			0·895
VII	34 (40)	32 (37)	
VIII	26 (30)	29 (34)	
IVa	13 (15)	15 (17)	
I	4 (5)	2 (2)	
Mixed	9 (10)	8 (9)	
Type of resection			0·596
Wedge	55 (64)	57 (66)	
Segmentectomy	28 (33)	28 (33)	
Bisegmentectomy	3 (3)	1 (1)	
Duration of surgery (min)*	180 (90–420)	215 (52–540)	0·019§
Estimated blood loss (ml)*	200 (0–4000)	200 (0–2000)	0·508§
Pringle manoeuvre	45 (52)	28 (33)	0·014
Total time in Pringle manoeuvre (min)*	25 (5–118)	30 (15–127)	0·003§
Parenchymal transection device			0·188
Surgical aspirator + energy devices	56 (65)	50 (58)	
Energy devices	28 (33)	36 (42)	
Other	2 (2)	0 (0)	
Intercostal trocars	–	10 (12)	–
Conversion to open approach	–	3 (3)	–
No. of lesions*	1 (1–2)	1 (1–2)	0·178§
1	76 (88)	81 (94)	0·280
2	10 (12)	5 (6)	
Largest tumour size (mm)*	30 (8–50)	26 (10–50)	0·099§
Margin width (mm)*	6·5 (0–21)	5·5 (0–20)	0·423§
Non-radical resection margin (pR1)†	4 of 80 (5)	8 of 79 (10)	0·356

Values in parentheses are percentages unless indicated otherwise; *values are median (range). †Neoplastic lesions only. OLR, open liver resection; LLR, laparoscopic liver resection. ‡χ^2 test, except §Mann–Whitney *U* test.

Discussion

The first study, by Bueno and colleagues[39], that focused on LLR for lesions of the PS segments was a single-centre cohort study. These authors compared 20 LLR with 21 OLR procedures, and reported a lower rate of complications, less blood loss and a reduced length of stay for patients in the LLR group. The present study compared the perioperative outcome and survival in a population matched for various prognostic parameters. The demographics and tumour characteristics of the study population were different between the groups, suggesting that LLR is generally performed in selected patients. After propensity score matching, the two groups were well balanced. The study shows that the parenchyma-preserving laparoscopic approach for PS segments is technically feasible, and the outcome is similar to that for the open technique. In addition, reduced overall morbidity was found in patients who had LLR compared with those having OLR. Oncological outcomes were similar between the groups. No drawbacks to the laparoscopic approach were observed.

Table 4 Postoperative outcomes

	OLR (*n* = 86)	LLR (*n* = 86)	*P*‡
Overall complications	24 (28)	12 (14)	0·039
Dindo–Clavien classification			0·106
I	1 (1)	4 (5)	
II	15 (17)	6 (7)	
III	7 (8)	2 (2)	
IV	0 (0)	0 (0)	
V	1 (1)	0 (0)	
Type of complication	(*n* = 27)	(*n* = 13)	
Ascites	6	1	
Pneumonia	4	2	
Pleural effusion with atelectasis	4	4	
Biliary leak	2	1	
Urinary tract infection	2	1	
Cut surface collection	2	2	
Atrial fibrillation	2	0	
Cut surface bleeding	1	2	
Pulmonary embolism	1	0	
Neurological	1	0	
Urinary retention	1	0	
Cardiac arrest	1	0	
Comprehensive complication index*	26·7(16·6)	18·3(8·0)	0·108§
Analgesia requirement (days)*	3·0(1·1)	1·6(0·8)	< 0·001§
Duration of postoperative stay (days)†	6 (3–44)	4 (1–11)	< 0·001¶

Values in parentheses are percentages unless indicated otherwise; values are *mean(s.d.) and †median (range). OLR, open liver resection; LLR, laparoscopic liver resection. ‡χ^2 test, except §Student's *t* test and ¶Mann–Whitney *U* test.

The number of patients with a tumour-positive resection margin (pR1) was higher in the LLR group, although the difference was not statistically significant. This could be explained by a difference in the technique of LLR, in which the direction of parenchymal transection is caudal–cranial with more limited exposure of the liver and reduced mobilization. In addition, interpretation of IOUS is more difficult with the laparoscopic approach, and the technique of parenchymal transection is not standardized. However, it is considered that the non-radicality of the tumour resection could potentially be decreased by adjusting the surgical technique with more optimal patient positioning (30° left-sided rotation), using special equipment (flexible laparoscope), employing intercostal trocars, using intraoperative ultrasound guidance during the parenchymal transection, and having the surgeon use dissection devices with both hands.

The current paradigm in oncological liver surgery is a parenchyma-preserving liver resection[40]. For colorectal liver metastases, there should always be a focus on the

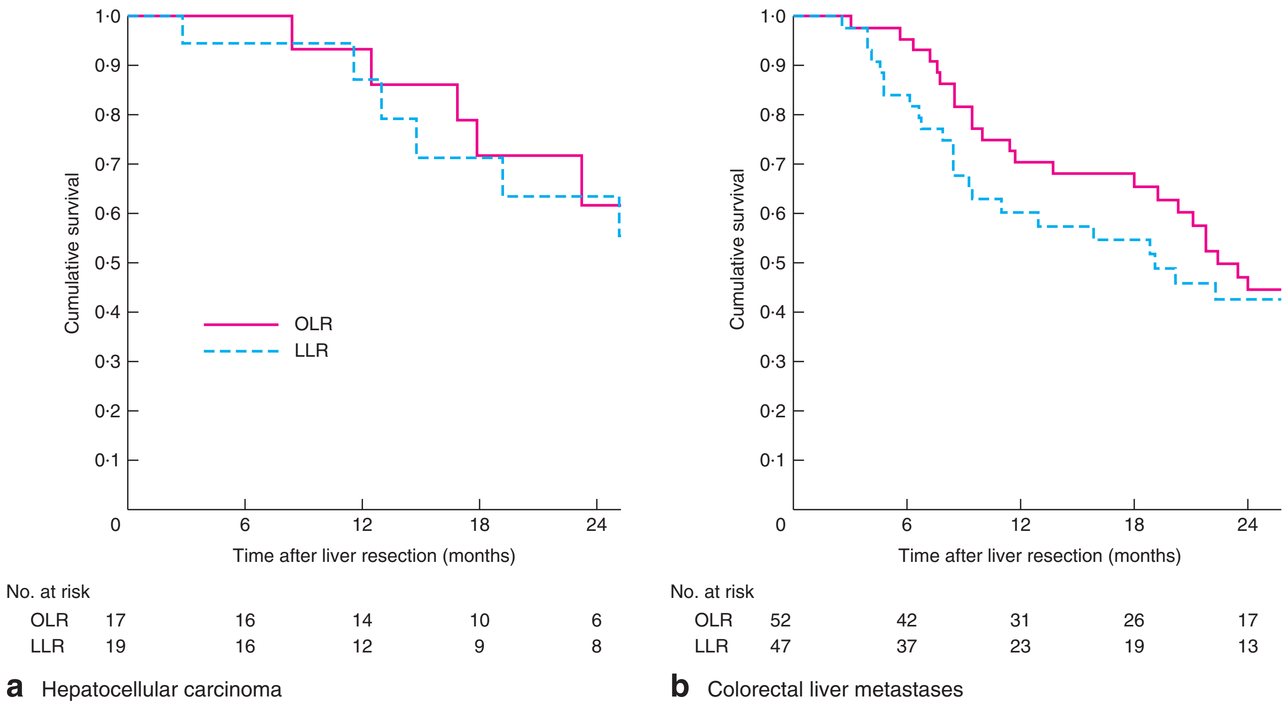

Fig. 1 Recurrence-free survival in propensity score-matched patients with **a** hepatocellular carcinoma and **b** colorectal liver metastases. OLR, open liver resection; LLR, laparoscopic liver resection. a $P = 0{\cdot}534$, b $P = 0{\cdot}440$ (log rank test)

possibility of re-resecting a recurrence. Tumour relapse is seen in at least two-thirds of patients, and repeated hepatic resections could be performed safely with similar oncological outcomes to anatomical resections but with less morbidity[41–45]. Furthermore, the impact of a positive resection margin, defined as less than 1 mm from the circumferential margin, on survival is still debated. Recent studies[44,46] did not show a significant difference in recurrence-free survival between patients with close surgical margins *versus* those with wider resection margins. It is important to emphasize that this study showed no recurrences at the surgical site in patients with a microscopic non-radical resection.

The parenchyma-preserving LLR of PS segments requires extensive training and should be attempted only after gaining experience in open liver surgery and LLR of anterolateral segments[23]. A recent systematic review and meta-analysis[13] of the literature confirmed LLR as a safe alternative to OLR that may be offered to a growing number of selected patients. The management of neoplastic liver lesions in segments VII and VIII is a challenge, especially when a parenchyma-preserving hepatic resection is aimed for. A right hepatectomy was typically performed for tumours close to the right hepatic vein and its confluence with the vena cava. Makuuchi and co-workers[47] reported the first resections for tumours in segments VII and VIII, sparing segments V and VI, and providing good outflow through a large accessory inferior right hepatic vein. At present, open resections for liver tumours in the right posterior sector are undertaken with preservation of as much liver parenchyma as possible. In laparoscopic approaches, a right hepatectomy or right posterior sectionectomy can be technically easier owing to less parenchymal transection, a more accessible and recognizable plane of resection, and better haemostasis following hilar division of inflow. Nevertheless, if a limited oncological parenchyma-preserving laparoscopic resection cannot be carried out laparoscopically, an open resection should be performed rather than an extended laparoscopic resection. A laparoscopic parenchyma-preserving hepatic resection is undoubtedly more difficult owing to multiple curvilinear resection surfaces, especially for tumours in the PS segments. LLR for segments VII and VIII is technically difficult because the operative field is far from the conventional abdominal trocar site, and the liver poses an obstacle to free movement of the laparoscopic instruments. An interesting and useful technical solution is to use the last right intercostal spaces to insert one or two trocars. In the present study, this technique was used for ten resections of tumours in segments VII and VIII. No conversions or complications (overall pulmonary complications) were recorded in these patients.

The PS segments are located deep within the liver, and between the liver and the diaphragm. Hence, fluid collections in the right subdiaphragmatic space are the main complications seen after resection of these segments[48]. Effusion from the cut surface of the liver and/or the retrohepatic peritoneum often leads to other related thoracic complications (reactive pleural effusion, atelectasis or pneumonia), prolonging the patient's recovery. In the present study, LLR was associated with some improved perioperative outcomes, including a lower incidence of postoperative complications, reduced duration of requirement for analgesia and shorter postoperative hospital stay. The meticulous parenchymal dissection, enabled by the more detailed and enhanced laparoscopic view, may improve the precision and safety of the dissection compared with that afforded by open parenchymal transection. To gain good access, OLR for PS segments requires a large incision. This may cause severe postoperative pain and discomfort, delaying physical recovery. The early mobilization of the patient after laparoscopic surgery may also reduce the occurrence of intra-abdominal fluid collections at the cut liver surface[49].

The incidence of ascites due to decompensation of the liver in patients with Child–Pugh grade A cirrhosis after LLR was lower than after OLR. However, the difference was not statistically significant. One of the advantages of laparoscopy is preservation of the abdominal wall collaterals and less manipulation, which may lead to a decreased risk of liver decompensation. Finally, this benefit could be a consequence of a more limited use of the Pringle manoeuvre to control blood loss, owing to the pneumoperitoneum and the meticulous parenchymal dissection allowed by laparoscopic magnification[48]. Conversion for bleeding was not needed. The lower rate of usage of the Pringle manoeuvre in the LLR group may be directly correlated to the haemostatic properties of the pneumoperitoneum and reduction in blood loss from the cut surface of the liver. Interestingly, the present study did not demonstrate a reduction in blood loss in the LLR group, similar to findings in a study from Japan of major LLR in patients with HCC[19]. However, patients who underwent LLR had a shorter hospital stay and less morbidity than those in the OLR group.

Despite the fact that the oncological results were not the main focus of this study, the 3-year recurrence-free survival rates were similar in the two groups. This suggests that LLR of lesions in PS segments may yield the same oncological results as open surgery, while providing some better short-term outcomes.

Limitations of the study are the retrospective data analysis over a long interval, the non-standardized surgical technique with use of different devices, the mixed tumour types included, and differences in the histology of HCC (microvascular invasion) impacting overall recurrence-free survival. Patients with lesions compressing the major hepatic veins were excluded from the study. Superficial lesions (wedge resections) and deep lesions (segmentectomy or bisegmentectomy) were well matched by propensity scoring in the two groups, so the type of resection may be representative of the depth of the lesion resected.

Disclosure

The authors declare no conflict of interest.

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