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Original Article

Laparoscopic *versus* open resection of intrahepatic cholangiocarcinoma: nationwide analysis

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Abstract

Background: The relevance of laparoscopic resection of intrahepatic cholangiocarcinoma (ICC) remains debated. The aim of this study was to compare laparoscopic (LLR) and open (OLR) liver resection for ICC, with specific focus on textbook outcome and lymph node dissection (LND).

Methods: Patients undergoing LLR or OLR for ICC were included from two French, nationwide hepatopancreatobiliary surveys undertaken between 2000 and 2017. Patients with negative margins, and without transfusion, severe complications, prolonged hospital stay, readmission or death were considered to have a textbook outcome. Patients who achieved both a textbook outcome and LND were deemed to have an adjusted textbook outcome. OLR and LLR were compared after propensity score matching.

Results: In total, 548 patients with ICC (127 LLR, 421 OLR) were included. Textbook-outcome and LND completion rates were 22.1 and 48.2 per cent respectively. LLR was independently associated with a decreased rate of LND (odds ratio 0.37, 95 per cent c.i. 0.20 to 0.69). After matching, 109 patients remained in each group. LLR was associated with a decreased rate of transfusion (7.3 *versus* 21.1 per cent; $P = 0.001$) and shorter hospital stay (median 7 *versus* 14 days; $P = 0.001$), but lower rate of LND (33.9 *versus* 73.4 per cent; $P = 0.001$). Patients who underwent LLR had lower rate of adjusted TO completion than patients who had OLR (6.5 *versus* 17.4 per cent; $P = 0.012$).

Conclusion: The laparoscopic approach did not substantially improve quality of care of patients with resectable ICC.

Introduction

Despite initial slow development, the laparoscopic approach has gained increasing popularity for liver surgery where it is now widely accepted for various procedures, including left lateral sectionectomy and atypical resections in the so-called easily accessible segments[1–3]. In addition to improved immediate postoperative outcomes and quality of life, the laparoscopic approach also seems to provide at least similar oncological outcomes to the open approach for hepatocellular carcinoma (HCC)[4] and liver metastases[5,6].

Intrahepatic cholangiocarcinoma (ICC) is the second most frequent primary liver tumour and its incidence is steadily increasing[7]. This tumour, however, currently represents less than 10 per cent of the indications for liver resection in expert centres[8]. In contrast to HCC, resectable ICC is associated with lymph node metastases in approximately 40 per cent of patients at the time of surgery[9]. Lymph node dissection (LND) should therefore be performed routinely. The latest AJCC classification recommends retrieving at least six lymph nodes for adequate staging[10,11]. LND has not been incorporated into existing difficulty scoring systems

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for laparoscopic liver resection (LLR)[12–14]. Adequate laparoscopic LND requires a high level of expertise in both hepatopancreatobiliary (HPB) and laparoscopic surgery. Only a few studies[15–18] have analysed the additional value of laparoscopy in patients with ICC.

Implementation of standard laparoscopic resection for an oncological indication requires adherence to fundamental oncological principles and better postoperative outcomes. For ICC, the quality of healthcare provided by laparoscopic resection should therefore be compared with that of open liver resection (OLR) in terms of oncological criteria including LND and textbook outcome. The latter is a composite measure of desirable postoperative outcomes (transfusion, resection margin status, morbidity, mortality, transfusion, hospital stay, readmission), which, when all achieved, represent the ideal hospital admission[19]. This should be evaluated in large multicentre cohorts. The present study aimed to compare outcomes of LLR *versus* OLR for ICC in nationwide cohorts of patients, with a specific focus on textbook outcome and LND.

Methods

This was a retrospective multicentre study. Data from two French nationwide voluntary surveys initiated by the French Surgical Association (AFC) were merged. The first included all adult patients who underwent OLR for resectable cholangiocarcinoma from 22 surgical HPB centres between January 2000 and November 2012 (AFC-CC study group)[20]. Data from eight centres were updated recently, allowing inclusion of patients up to 2017. The second survey included all adult patients undergoing LLR for malignant or benign lesions from 29 HPB units between January 2000 and November 2017 (AFC-LLR study group)[21].

All adult patients who underwent LLR or OLR for resectable ICC enrolled in the two cohorts were included. Patients who had liver resection without curative intent, combined resection of the liver and an adjacent organ, vascular or biliary reconstruction or hand-assisted/hybrid LLR were excluded. Patients who underwent LLR were analysed on an intention-to-treat basis, including those who required conversion to open surgery. Standardized and anonymized data from each participating centre were provided after institutional approval had been obtained. The expertise of a centre in LLR was defined using a cut-off of 30 LLRs per year, as described previously[19].

Given its purely observational nature and as no patient was contacted for the purpose of this study, informed written consent was waived according to French legislation.

Surgical procedure and lymph node dissection

Indications for the laparoscopic approach, LND, surgical techniques, and operative strategies varied widely across centres throughout the study period and according to the expertise of the surgeons. The value of systematic LND was recognized progressively during the study interval, and there was no consensus regarding type and extent of LND. Hence, LND was defined as the harvest of any node from the hepatoduodenal ligament with or without extension to the retropancreatic area and common hepatic artery. LND was characterized as a dichotomous variable in the database, but the precise extent of LND was not available. Assessment of the quality of LND was therefore based on the pathological report.

All intraoperative parameters, including vascular clamping, blood loss, and duration of surgery, were recorded. The extent of liver resection was defined according to the Brisbane classification of liver resections[22], in which major resection comprises resection of three or more contiguous Couinaud's segments. Anterolateral segments included segments II, III, IVb, V, and VI, whereas segments I, IVa, VII, and VIII were defined as posterosuperior segments. The difficulty of the procedure was assessed according to the three-level IMM classification[14], which has been validated externally for both laparoscopic and open approaches[23]. This classification encompasses three levels of difficulty: grade 1 (low difficulty) includes wedge resection (3 cm or less) and left lateral sectionectomy; grade 2 (intermediate difficulty) includes anterolateral segmentectomy and left hepatectomy; and grade 3 (high difficulty) includes posterosuperior segmentectomy, right posterior sectionectomy, right hepatectomy, extended right hepatectomy, central hepatectomy, and extended left hepatectomy.

Quality of surgical care and textbook outcome

A textbook outcome was defined as reported previously[19], and was considered to have been achieved in patients who fulfilled all of the following six outcomes: R0 surgical margin, no perioperative transfusion, no postoperative complications, no prolonged hospital stay (defined as a postoperative stay no longer than the 50th percentile for the combined LLR and OLR cohorts), no unplanned readmission (within 90 days of surgery), and no postoperative death. In line with the endpoints used in the setting of liver resection[24], the follow-up of textbook endpoints was extended to the first 90 days after operation in the present study.

Postoperative morbidity was graded according to the Dindo–Clavien classification, with severe morbidity defined by a grade of at least III[25]. Posthepatectomy liver failure was defined according to the criteria of the International Study Group of Liver Surgery, and was considered only for patients who experienced at least grade B liver failure[26].

Quality of lymph node dissection

LND was assessed based on pathological reports, and was deemed to have been carried out when at least one pedicular lymph node had been harvested from around the hepatoduodenal ligament. The dissection was described as adequate AJCC LND when at least six nodes had been harvested in accordance with the eighth version of the AJCC classification for ICC[10]. The LND was regarded as positive (N+ status) when at least one metastatic lymph node was present, regardless of the number of lymph nodes harvested. Unknown AJCC nodal status (AJCC Nx) was recorded for patients with a combined absence of positive LND and adequate AJCC LND.

As LND also represents a surrogate for the quality of oncological surgery, the composite variable 'adjusted textbook outcome' was created, which comprised achievement of both the textbook criteria and LND.

Statistical analysis

Continuous data are expressed as median (i.q.r.), and were compared using the Student's t test or Mann–Whitney U test, as appropriate. Categorical data are presented as numbers with percentages, and were analysed using Pearson's χ^2 test or Fisher's exact test, as appropriate. $P < 0.050$ was considered statistically significant. To identify factors associated with LND and textbook outcome, two separate stepwise logistic regression analyses were performed using all clinically relevant preoperative variables. A clinically relevant cut-off of 5 cm was used to categorize tumour size[27,28]. This cut-off was validated using logistic regression and a bootstrap procedure (2000 times).

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To further assess the influence of the laparoscopic approach on short-term results with specific emphasis on both textbook outcome and LND completion, a propensity score matching analysis was performed[29]. The propensity score was estimated by means of a multivariable logistic regression model, with laparoscopic *versus* open approach as dependent variables, and matching variables (ASA grade III or more, tumour size 5 cm or larger, portal vein embolization, extent of resection, liver resection difficulty level) as co-variables. Matching was performed 1 : 1 without replacement (greedy matching algorithm), with a caliper width equal to 0 of the propensity score. The standardized mean differences (SMDs) of the variables of interest disappeared when matched patients were compared. For continuous and categorical variables, SMD variables were calculated using the following formulas: $SMD = \frac{m(LLR)-m(OLR)}{\sqrt{\frac{\sigma^2(LLR)}{2}+\frac{\sigma^2(OLR)}{2}}}$ and $SMD = \frac{p(LLR)-p(OLR)}{\sqrt{\frac{p(LLR)\left(1-p(LLR)\right)}{2}+\frac{p(OLR)\left(1-p(OLR)\right)}{2}}}$, respectively, where m represents the mean, p is prevalence, and σ is variance[29].

To assess the evolution of practices in LND, the study period was divided into three intervals based on the 33rd and 66th percentiles of the number of included patients (2000–2004, 2005–2010, 2011–2017).

Disease-free survival (DFS) was defined as the time from surgery to first recurrence, death or last follow-up; and overall survival (OS) as the time from surgery to the date of death from all causes or last follow-up. Postoperative deaths by 90 days were excluded from DFS analyses. OS and DFS were compared between groups using the Kaplan–Meier method. A stepwise backward Cox multivariable regression analysis including all available clinically relevant prognostic variables was used to identify prognostic factors for DFS and OS.

All statistical analyses were done using SPSS® version 24 software (IBM, Armonk, New York, USA).

Results

Among 4400 patients who underwent LLR in the AFC-LLR survey, 127 from 22 HPB centres constituted the cohort of patients undergoing LLR for ICC (*Fig. 1*), with a median of 7 (i.q.r. 3–18) included per centre. Six HPB centres were identified as expert centres in LLR.

Among 557 patients who underwent liver resection for ICC in the AFC-CC survey, records of 421 patients were retrieved from the abovementioned 22 HPB centres and constituted the control cohort undergoing OLR for ICC; a median of 15 (5–28) was included per centre.

During the three study intervals (2000–2004, 2005–2010, 2011–2017), 177, 176, and 68 enrolled patients respectively underwent OLR, and 6, 7, and 114 had LLR. Clinicopathological data are shown in *Table 1*.

Lymph node dissection

LND was more often performed in OLR (53.4 *versus* 30.7 per cent; $P < 0.001$), and adequate AJCC LND was achieved more often with the open approach (27.3 *versus* 14.2 per cent; $P = 0.002$). The overall rate of LND decreased in the most recent interval (53.6, 55.2, and 35.7 per cent; $P = 0.001$); 62.6 per cent of patients were operated by laparoscopic approach during this interval. Among patients undergoing OLR, the rate of LND did not change over time (53.1, 55.1, and 50 per cent for the three time intervals respectively; $P = 0.744$).

Among patients who had LND, the median number of nodes harvested was 4 (i.q.r. 2–7). The number of nodes harvested increased during the study (median 3, 3, and 5 nodes in 2000–2004, 2005–2010, and 2011–2017 respectively; $P = 0.048$). Patients undergoing LND had a lower BMI, lower ASA grade, lower rate of severe fibrosis, and larger tumours than patients who did not undergo LND. Patients who had LND more frequently underwent major resection (78.8 *versus* 51.4 per cent; $P = 0.001$). The rate of LND increased with difficulty of the resection (26, 50.0 and 52.3 per cent in grades 1, 2, and 3 respectively; $P = 0.001$). Tumour diameter larger than 5 cm was independently associated with LND completion (odds ratio (OR) 1.94, bootstrap 95 per cent c.i. 1.09 to 3.51). The laparoscopic approach was independently associated with decreased likelihood of LND. The results of multivariable analysis of factors associated with LND are summarized in *Table 2*.

After matching, patients who underwent LLR had decreased rates of both LND (OR 0.19, 95 per cent c.i. 0.10 to 0.35) and adequate AJCC LND (OR 0.49, 0.23 to 0.99) than those who had OLR. Patients in the LLR group had a higher rate of AJCC Nx status (OR 4.76, 2.50 to 9.10).

Table S1 shows a comparison of outcomes after liver resection with and without LND. Patients who underwent LND had a higher rate of negative margins (83.3 *versus* 75.4 per cent; $P = 0.021$) and prolonged hospital stay (60.1 *versus* 45.1 per cent; $P = 0.001$), but achieved a similar rate of textbook outcome (19.7 *versus* 24.3 per cent; $P = 0.195$) and other individual textbook-outcome criteria as patients who did not have LND.

Of 127 patients who had LLR, 75 (59.1 per cent) were operated in one of the six expert centres for LLR, whereas 52 (40.9 per cent) had surgery in one of the remaining 17 non-expert centres for LLR. Oncological quality of the resection according to the expertise of the centre is shown in *Fig. S1*. No statistical differences were observed between patients operated on in expert and non-expert centres.

The rate of LND (9, 28, and 49 per cent in grades 1, 2, and 3 respectively; $P = 0.001$) and adequate LND (9, 9, and 23 per cent respectively; $P = 0.073$) increased with the difficulty of LLR. In multivariable analysis, factors associated with LND among patients who underwent LLR included ASA grade, level of difficulty (especially major resections), and severe fibrosis (*Table S2*).

Textbook outcome

Postoperative death, severe complication, and any complication occurred in 22 (4.0 per cent), 107 (19.5 per cent), and 249 (45.4 per cent) patients respectively. A textbook outcome was achieved in 121 patients (22.1 per cent). The results of multivariable analysis of factors associated with textbook outcome are shown in *Table 3*.

After matching, 109 patients who underwent LLR were compared with 109 who underwent OLR. All patients had a single tumour. LLR was associated with less frequent intraoperative transfusion (OR 0.30, 95 per cent c.i. 0.11 to 0.73) and a lower rate of prolonged hospital stay (OR 0.27, 0.15 to 0.49) than OLR, but similar rates of postoperative complications ($P = 0.587$), severe complications ($P = 0.530$), postoperative death ($P = 0.517$), and negative margin ($P = 0.842$). Overall, a textbook outcome was not achieved more frequently in LLR than OLR (30.3 *versus* 21.1 per cent; $P = 0.121$). The distribution of textbook-outcome criteria according to type of surgical approach is shown in *Fig. 2*. The LLR group had a lower rate of adjusted textbook outcome (OR 0.33, 0.11 to 0.86).

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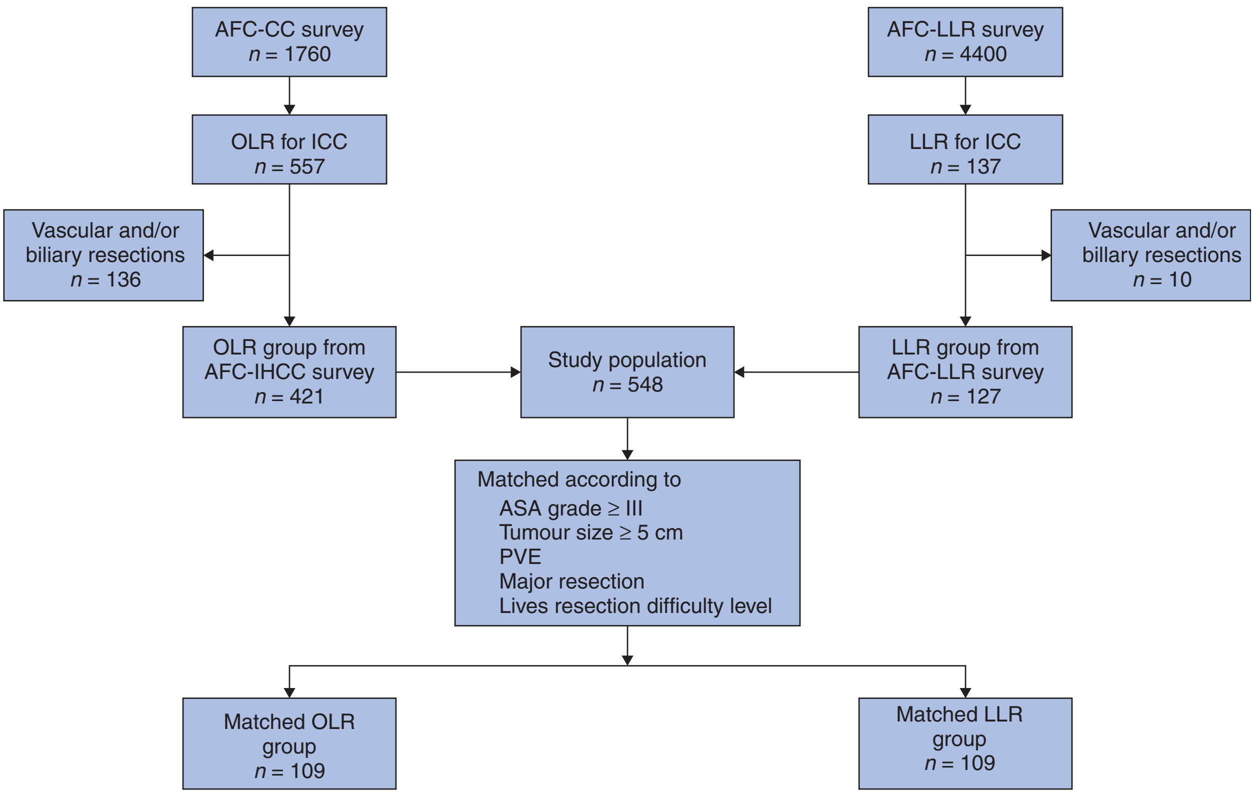

Fig. 1 Study flow chart

AFC, French Surgical Association; CC, cholangiocarcinoma; LLR, laparoscopic liver resection; OLR, open liver resection; ICC, intrahepatic cholangiocarcinoma; PVE, portal vein embolism.

Survival

After a median follow-up of 26 (95 per cent c.i. 23 to 29) months, 247 patients (47.0 per cent) had experienced recurrence. One-, 3-, and 5-year OS rates were 83.9, 58.2, and 35.2 per cent respectively; corresponding DFS rates were 68.4, 35.9, and 28.7 per cent.

Age, tumour size, and nodal status were independent prognostic factors for DFS (*Table 4*). Tumour size and nodal status were independent prognostic factors for OS. Neither surgical approach (laparoscopic or open), textbook outcome nor adjusted textbook outcome were prognostic factors for DFS or OS.

Discussion

Laparoscopic resection was associated with less blood loss, a lower transfusion rate, and shorter hospital stay, but also a lower rate of LND. The latter suggests that the laparoscopic approach for ICC is currently suboptimal. LND is presently acknowledged as part of the standard treatment for ICC. The decreased rate of LND in the most recent interval of the present study is likely related to the concomitant increase in the rate of LLR. Indications for LLR could be extended to ICC provided that the feasibility of adequate laparoscopic LND is secured.

The concept of textbook outcome has been described previously as a combination of six criteria representing the ideal hospitalization for a patient after surgery[19]. Compared with other liver malignancies qualifying for surgery[30,31], the relatively low rates of textbook outcome in this multicentre cohort study indicate that liver resection for ICC remains a complex clinical situation. This is reflected by the substantial proportion of grade 3 liver resections and major resections, and high conversion rate of LLR. In particular in the setting of ICC, the laparoscopic approach should be developed cautiously and safely[32].

Each textbook-outcome criterion has been shown to be associated with long-term prognosis. Negative margin is an important prognostic factor, especially in patients with N0 disease. Short-term results of liver resection, including blood loss, transfusion, and complications, have been reported to influence survival of patients with ICC[33,34]. Duration of hospital stay and readmission rate are associated with postoperative recovery, which in turn is associated with administration of adjuvant therapy[5]. Adjuvant treatment has been validated in patients with biliary tract cancers[35]. The fact that LND is not taken into account in the evaluation of textbook outcome precludes an appropriate assessment of oncological quality for patients with resectable ICC. Therefore, the authors strongly recommend including adequate LND in the textbook outcome for ICC. The important prognostic value of nodal staging is widely acknowledged and was confirmed in the present study. Adequate nodal staging allows stratification of postoperative management[11,36]. Tumour factors including tumour size and nodal stage obviously correlate with variables included in (adjusted) textbook outcome. This interaction probably explains why the composite outcome measure (adjusted) textbook outcome was not an independent prognostic factor for survival in the present study.

Expertise is key in technically demanding surgery. The low number of resections for ICC in each centre per year highlights the difficulty in gaining experience. The subgroup analysis of textbook outcome for LLR in expert centres did not show

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Table 1 Comparison of patients undergoing open or laparoscopic liver resection in the whole and matched populations

	Whole population				Matched population			
	OLR (*n* = 421)	LLR (*n* = 127)	SMD	P¶	OLR (*n* = 109)	LLR (*n* = 109)	SMD	P¶
Comparison of SMDs for matching variables								
ASA grade ≥ III	141 (33.5)	46 (36.2)	0.057		38 (34.9)	38 (34.9)	< 0.001	
Tumour size > 5 cm	264 (62.7)	50 (39.4)	0.479		45 (41.3)	45 (41.3)	< 0.001	
Major resection	299 (71.0)	55 (43.3)	0.583		52 (47.7)	52 (47.7)	< 0.001	
Portal vein embolization	31 (7.4)	5 (3.9)	0.152		4 (3.7)	4 (3.7)	< 0.001	
Liver resection difficulty level								
Grade 1	39 (9.3)	33 (26.0)	0.449		22 (20.2)	22 (20.2)	< 0.001	
Grade 2	121 (28.7)	47 (37.0)	0.177		44 (40.4)	44 (40.4)	< 0.001	
Grade 3	261 (62.0)	47 (37.0)	0.516		43 (39.4)	43 (39.4)	< 0.001	
Comparison of demographic, intraoperative, and postoperative data								
Demographic characteristics and underlying liver								
Age (years)*	62 (54–69)	67 (60–72)		0.002#	61 (52–68)	67 (60–72)		0.001#
BMI (kg/m^2)*†	25.4 (22.2–29.1)	25.8 (23.1–29.7)		0.061#	25.8 (22.9–29.3)	25.8 (23.0–29.3)		0.705#
Severe fibrosis (F3–F4)	78 (18.5)	37 (29.1)		0.010	21 (19.3)	30 (27.5)		0.314
Severe steatosis (≥ 33%)	89 (21.1)	24 (18.9)		0.584	23 (21.1)	23 (21.1)		0.999
Intraoperative details								
Inflow clamping	310 (73.6)	51 (40.2)		0.001	77 (70.6)	40 (36.7)		0.001
Blood loss (ml)*	410 (130–700)	200 (100–400)		0.001#	346 (170–560)	200 (100–400)		0.001#
Conversion	–	19 (15.0)			–	15 (13.8)		
Duration of surgery (min)*	260 (195–360)	237 (180–360)		0.092#	263 (190–400)	240 (170–370)		0.186#
Outcomes								
Transfusion	72 (17.1)	13 (10.2)		0.061	23 (21.1)	8 (7.3)		0.004
Complication	176 (41.8)	73 (57.5)		0.002	57 (52.3)	61 (56.0)		0.587
Severe complication	79 (18.8)	28 (22.0)		0.413	29 (26.6)	25 (22.9)		0.530
Liver failure	37 (8.8)	4 (3.1)		0.034	6 (5.5)	4 (3.7)		0.517
Postoperative death	16 (3.8)	6 (4.7)		0.617	4 (3.7)	6 (5.5)		0.517
Negative margin	324 (77.0)	110 (86.6)		0.019	95 (87.2)	94 (86.2)		0.842
Duration of hospital stay (days)*	13 (9–19)	7 (6–12)		0.001#	14 (9–22)	7 (6–12)		0.001#
Prolonged hospital stay (≥ 12 days)	251 (59.6)	37 (29.1)		0.001	66 (60.6)	32 (29.4)		0.001
Readmission	23 (5.5)	13 (10.2)		0.057	10 (9.2)	13 (11.9)		0.508
Textbook outcome	85 (20.2)	36 (28.3)		0.052	23 (21.1)	33 (30.3)		0.121
Quality of oncological resection								
LND	225 (53.4)	39 (30.7)		0.001	80 (73.4)	37 (33.9)		0.001
Adequate AJCC LND	115 (27.3)	18 (14.2)		0.002	28 (25.7)	16 (14.7)		0.043
AJCC Nx status‡	195 (46.3)	104 (81.9)		0.001	51 (46.8)	88 (80.7)		0.001
R0 + LND	161 (38.2)	35 (27.6)		0.028	70 (64.2)	33 (30.3)		0.001
R0 + adequate AJCC LND	53 (12.6)	14 (11.0)		0.640	20 (18.3)	14 (12.8)		0.263
Adjusted textbook outcome§	44 (10.5)	8 (6.3)		0.162	19 (17.4)	7 (6.5)		0.012
Patients with LND	*n* = 225	*n* = 39			*n* = 80	*n* = 37		
No. of nodes harvested*	3 (1–6)	5 (3–7)		0.019#	3 (2–6)	5 (4–7)		0.030#
Adequate AJCC LND	115 (51.1)	18 (46)		0.567	28 (35)	16 (43)		0.392
N+ status	95 (42.2)	9 (23)		0.024	30 (38)	7 (19)		0.044

Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.). A standardized mean difference (SMD) of less than 0.100 indicates very small differences, between 0.100 and 0.300 indicates small differences, between 0.301 and 0.500 indicates moderate differences, and above 0.500 indicates considerable differences. †SMDs for BMI between open liver resection (OLR) and laparoscopic liver resection (LLR) groups in the whole and matched populations were 0.242 and 0.081 respectively. ‡Patients who had neither positive nodal status nor appropriate lymphadenectomy according to AJCC 8th edition criteria. §Patients who had both lymph node dissection (LND) and textbook outcome. ¶χ^2 test, except #Mann–Whitney *U* test or Kruskal–Wallis test.

Table 2 Multivariable logistic regression analysis of factors associated with lymph node dissection

	Odds ratio	P
Laparoscopic liver resection	0.37 (0.20, 0.69)	0.002
BMI (per 5-kg/m^2 increase)	0.59 (0.33, 1.04)	0.069
ASA grade ≥ III	0.32 (0.15, 0.65)	0.002
Tumour size (per 10-mm increase)	1.11 (1.01, 1.22)	0.024
Major resection	3.07 (1.59, 5.91)	0.001
Severe fibrosis	0.22 (0.08, 0.56)	0.002

Values in parentheses are 95 per cent confidence intervals. Variables included in analysis: study period (3 intervals defined according to 2 year cut-offs: 2005 and 2011), ASA grade at leat III, BMI (analysed in 5-kg/m^2 strata), age (analysed in 10-year strata), male sex, severe fibrosis, laparoscopic approach, planned major resection, portal vein embolization, number of patients included by centre, number of tumours, tumour size (analysed in 10-mm strata), and liver resection difficulty level.

Table 3 Multivariable logistic regression analysis of factors associated with textbook outcome

	Odds ratio	P
Study period	1.75 (1.08, 2.82)	0.022
Liver resection difficulty level (per 1-grade increase)	0.52 (0.34, 0.79)	0.003
BMI (per 5-kg/m^2 increase)	0.73 (0.52, 1.04)	0.079
Severe fibrosis	0.41 (0.16, 1.04)	0.061

Values in parentheses are 95 per cent confidence intervals. Variables included in analysis: study period (3 intervals defined according to 2 year cut-offs: 2005 and 2011), ASA grade at least III, BMI (analysed in 5-kg/m^2 strata), age (analysed in 10-year strata), male sex, severe fibrosis, laparoscopic approach, planned major resection, portal vein embolization, number of patients with intrahepatic cholangiocarcinoma included by centre, number of tumours, tumour size (analysed in 10-mm strata), liver resection difficulty level, and lymph node dissection.

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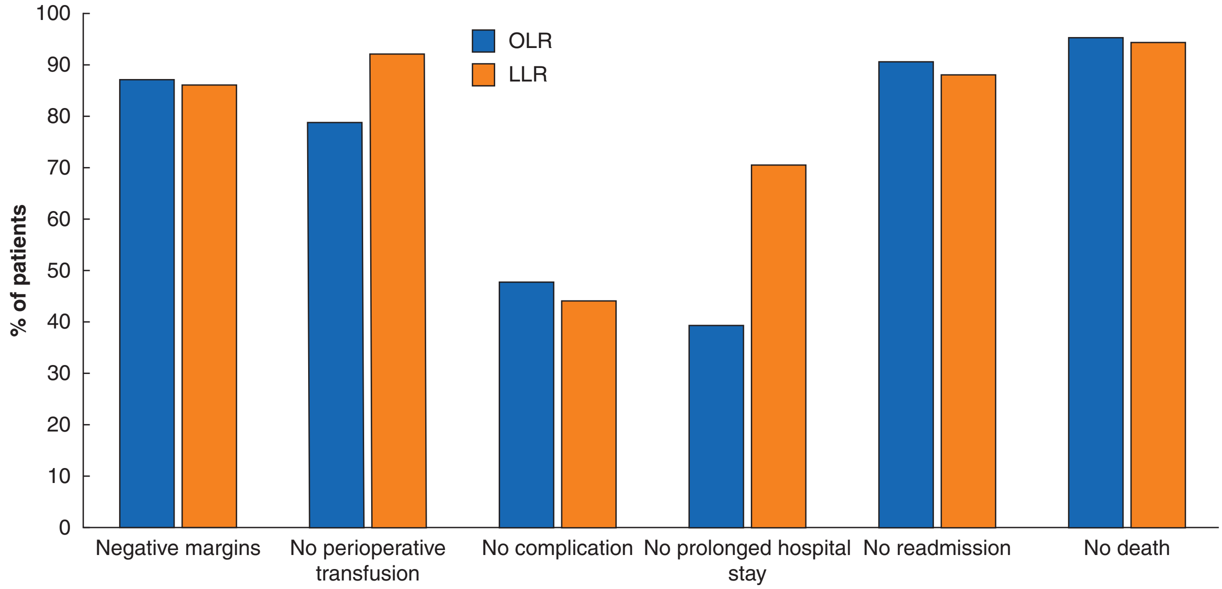

Fig. 2 Distribution of textbook-outcome criteria according to surgical approach

OLR, open liver resection; LLR, laparoscopic liver resection.

Table 4 Cox regression analyses of prognostic factors associated with disease-free and overall survival

	Hazard ratio	P
Disease-free survival		
Age (per 10-year increase)	0.89 (0.80, 0.99)	0.044
Male sex	1.33 (0.99, 1.78)	0.062
Adjusted textbook outcome	0.60 (0.33, 1.09)	0.093
Tumour size (per 10-mm increase)	1.06 (1.03, 1.10)	0.001
Nodal status		
Nx	1.00 (reference)	
N0	0.12 (0.77, 1.63)	0.569
N+	2.02 (1.24, 3.29)	0.005
Overall survival		
Tumour size (per 10-mm increase)	1.14 (1.09, 1.20)	0.001
Nodal status		
Nx	1.00 (reference)	
N0	0.47 (0.26, 0.83)	0.009
N+	1.47 (0.76, 2.86)	0.258

Values in parentheses are 95 per cent confidence intervals. Variables included in analysis: ASA grade at least III, age (analysed in 10-year strata), male sex, severe fibrosis, laparoscopic approach, number of tumours, tumour size (analysed in 10-mm strata), adjusted textbook outcome, and nodal status.

significant differences, but is probably underpowered. Centralization of hepatobiliary surgery has been heavily debated[37,38]. The present study has shown how difficult it is to prove the advantages of treatment of relatively rare, but technically demanding, hepatobiliary tumours. More experience and adoption of new tools and/or techniques, such as robotic surgery, which could improve the feasibility of minimally invasive LND, may increase the quality of minimally invasive treatments[39].

Limitations of this study included its retrospective design and prolonged time period. Selection bias was likely. Data were merged from two different surveys. Patients who had OLR or LLR were retrieved from the same French HPB surgical teams to reduce variation in perioperative evaluation and management regardless of the surgical approach. The learning curve and surgeon's expertise required to perform optimal laparoscopic LND were beyond the scope of the study.

Collaborators

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Supplementary material

Supplementary material is available at *BJS* online.

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