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ORIGINAL ARTICLE

Retrospective Study

Short-term and middle-term evaluation of laparoscopic hepatectomies compared with open hepatectomies: A propensity score matching analysis

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Abstract

AIM

To compare short-term results between laparoscopic hepatectomy and open hepatectomy using a propensity score matching.

METHODS

A patient in the laparoscopic liver resection (LLR) group was randomly matched with another patient in the open liver resection (OLR) group using a 1:1 allocated ratio with the nearest estimated propensity score. Patients of the LLR group without matches were excluded. Matching criteria included age, gender, body mass index, American Society of Anesthesiologists score, potential co-morbidities, hepatopathies, size and number of nodules, preoperative chemotherapy, minor or major liver re-sections. Intraoperative and postoperative data were compared in both groups.

RESULTS

From January 2012 to January 2015, a total of 241 hepa-tectomies were consecutively performed, of which 169 in the OLR group (70.1%) and 72 in the LLR group (29.9%). The conversion rate was 9.7% (n = 7). The mortality rate was 4.2% in the OLR group and 0% in the LLR group. Prior to and after propensity score matching, there was a statistically significant difference favorable to the LLR group regarding shorter operative times (185 min *vs* 247.5 min; P = 0.002), less blood loss (100 mL *vs* 300 mL; P = 0.002), a shorter hospital stay (7 d *vs* 9 d; P = 0.004), and a significantly lower rate of medical complications (4.3% *vs* 26.4%; P < 0.001).

CONCLUSION

Laparoscopic liver resections seem to yield better short-term and mid-term results as compared to open hepatectomies and could well be considered a privileged approach and become the gold standard in carefully selected patients.

Key words: Laparoscopic hepatectomy; Morbidity and mortality; Hepatocellular carcinoma; Liver resection; Colorectal metastases; Open hepatectomy; Propensity score matching

Core tip: This is a retrospective study to compare short-term results between laparoscopic hepatectomy and open hepatectomy using a propensity score matching. Each patient in the laparoscopic liver resection group was randomly matched with another patient in the open liver resection group using a 1:1 allocated ratio with the nearest estimated propensity score. Prior to and after propensity score matching, results were in favour of laparoscopic liver resection. Laparoscopic liver resections seem to yield better short-term and mid-term results as compared to open approach and could well be considered a privileged approach and become the gold standard in carefully selected patients.

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INTRODUCTION

Since the development of laparoscopic cholecystectomy in 1987, the laparoscopic approach extended to several abdominal procedures. However, it took a very long time for laparoscopic liver surgery to expand.

The first non-anatomical liver resection was described by Reich *et al*[1] in 1991 and the first anatomical hepa-tectomy was described by Azagra *et al*[2] in 1996. Historically, laparoscopy was used to evaluate hepatic lesions before an open hepatectomy[3,4] or to evaluate the carcinomatosis or peritoneal spread before the surgery and to treat cystic lesions by means of fenestrations[5,6]. Surgical techniques were progressively developed to propose resections of benign[2], then malignant lesions (hepatocellular carcinomas and hepatic metastases)[7,8].

The main reasons accountable for this lack of enthu-siasm for laparoscopic hepatectomies, in addition to the technical complexity of interventions, were the lack of appropriate instrumentation, the risk of gas embolism, the risks of uncontrolled bleeding, the fear of not being able to follow oncological principles with a subsequent risk of tumoral dissemination. However, some surgical teams decided to look into the possibilities of laparo-scopic hepatic resections.

Indications for laparoscopic hepatectomies were defined during the first international consensus con-ference held in Louisville, United States[9] in 2008 and revised in Morioka[10] in 2014. This approach was used for patients selected with the following criteria: Location and size of lesions, liver function, and the experience of the surgical team. Although it was demonstrated that the laparoscopic approach elicits several advantages in the short- and mid-term (less postoperative pain, quicker restoration of bowel habits, less respiratory and parietal morbidity, improved quality of life, and reduced hospital stay)[11,12], laparoscopic liver surgery remains currently limited to simple and peripheral resections, and few ex-tensive and complex resections were reported[13].

In the literature, such series include few patients and most monocentric series are retrospective ones with potential selection biases.

The objective of our study was to evaluate the short-term and mid-term results of laparoscopic hepa-tectomies as compared to open hepatectomies using a propensity score matching in order to rule out selection biases.

MATERIALS AND METHODS

From January 2012 to January 2015, data of all patients who consecutively underwent hepatectomy in two Uni-versity hospital settings were collected prospectively.

All patients who required liver surgery whatever the pathology (metastasis, hepatocellular carcinoma, adenoma, neuroendocrine tumor, cholangiocarcinoma, *etc.*) were included. The laparoscopic approach did not modify the operative indications established for open surgery. Indications for laparoscopic hepatectomies were determined according to the latest recommendations[9,10]. Exclusion criteria for the laparoscopic approach included the following: A poorly defined lesion or a lesion proximal to main vessels, decompensated cirrhosis or severe heart or respiratory failure[14]. The following variables were analyzed: Type of liver resections (segmentectomies, bisegmentectomies, wedge resections, *etc.*), use of radiofrequency, number of resected segments, operative time, number of clampings, duration and type of clamping, rate of conversion, blood loss, number of transfusions, length of hospital stay, rate of R0 resection margins. All postoperative complications were indexed, namely respiratory (atelectasis, pneumopathy), cardiovascular (cardiac rhythm disorders, ischemia, cardiac decompression, hypertension), renal (acute renal failure, pyelonephritis, cystitis), parietal infections, deep collections, bleeding, biliary fistulas, liver failure, ascites. Liver segmentation was defined according to the Couinaud classification[15]. Liver resections were defined according to the Brisbane classification in 2000[16], using the following definitions: Hepatectomy was defined as major when 3 or more segments were removed. Other hepatectomies, which were limited, were performed on 2 segments or less (standard segmentectomy, bisegmentectomy or subsegmentectomy). Postoperative mortality and morbidity was defined as death or complications which occurred in the first 90 postoperative days and were graded according to the Clavien-Dindo classification[17,18].

Complications were indexed as medical complications, including respiratory complications (atelectasis, pneumopathy), cardiovascular complications (including cardiac rhythm disorders, ischemia, cardiac decompression, hypertension), renal complications (acute renal failure, pyelonephritis, cystitis liver failure, ascites, and as surgical complications including parietal infections, deep collections, biliary fistulas, bleeding, eviscerations, parietal collections and acute digestive ischemia.

Preoperative evaluation

A complete patient evaluation included computed tomography-scan and/or magnetic resonance imaging acquired in 3 phases with a volumetric rendering. Patient personal files were discussed in a multidisciplinary meeting. Resectability was defined by the absence of extrahepatic invasion, the absence of ascites, and a normal liver function. All hepatic resections were performed by expert surgeons skilled in both laparoscopic and open hepatobiliary surgery.

Propensity score matching

All demographic and preoperative data of patients operated on using the open liver resection (OLR) group or the laparoscopic liver resection (LLR) group were compared using a univariate analysis in order to evaluate the comparability of both groups. A propensity score matching was calculated to take into account and limit selection biases as well as confusion between the two groups. This method allows comparing the effects of the two types of intervention (open *vs* laparoscopy) taking into account the variables which influence the choice of the procedure type. The propensity score was assessed using logistic regression including the following variables: Age, gender, co-morbidity, American Society of Anesthesiologists (ASA) score, the use of neoadjuvant therapy, body mass index, total number of nodules, and type of resection. The choice of such variables was based on the results of the univariate analysis and/or the known influence of specific factors on the selection of the intervention type. A 1:1 balance ratio was used for propensity score matching, based on the nearest matching PS method[19-21]. After the matching process, both groups were compared regarding their initial characteristics in order to re-evaluate the comparability of both groups. Finally, matched groups could be compared regarding the different variables of interest in the study.

Statistical analysis

Asymmetrical quantitative variables were presented as medians combined with the first and third quartiles after their distribution had been evaluated. Qualitative variables were presented as numbers and percentages. Comparison of the quantitative variables was performed using a Mann-Whitney test. Comparison of qualitative variables was performed using Pearson's χ^2 test or Fisher's exact test depending on numbers. A *P* value < 0.05 was considered as significant. Analyses were performed using the 3.2.0 version R software (R Core Team, R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Population and short-term results prior to matching

Between January 2012 and January 2015, a total of 241 consecutive hepatectomies were performed, including 169 hepatectomies using laparotomy (70.1%) and 72 laparoscopic ones (29.9%), including 8 which were performed by means of the da Vinci™ robotic surgical system (*da Vinci Si*™ System; Intuitive Surgical, Inc., Sunnyvale, CA, United States).

As for patient characteristics, both groups were comparable, except for gender ratio (*P* = 0.042), the existence of a co-morbidity (67.5% of patients in the OLR group and 54.2% of patients in the LLR group, *P* = 0.0499), the existence of a hepatopathy including hepatic steatosis and cirrhotic livers (13% in the OLR group *vs* 36.1% in the LLR group, *P* < 0.001), and preoperative chemotherapy (59.8% in the OLR group *vs* 36.1% in the LLR group, *P* < 0.001) (Table 1). In addition, there were statistically more lesions in the OLR group as compared to the LLR group 3.0 (1.0-5.0) *vs* 1.0 (1.0-2.0); *P* < 0.001) and more major hepatectomies in the OLR group as compared to the LLR group (40.8% *vs* 12.5%, *P* <

Table 1 Demographic data and preoperative variables before and after propensity score matching *n* (%)

	OLR (*n* = 169)	LLR (*n* = 72)	*P* value	OLR (*n* = 72)	LLR (*n* = 72)	*P* value
Gender (M:F)	106:63	35:37	0.042	37:35	35:37	0.739
Age (yr), median (IQR)	65 (58-71)	61 (49-71)	0.091	62 (52-67)	61 (49-71)	0.794
BMI (kg/m^2), median (IQR)						
< 30	141 (83.74)	58 (80.6)	0.590	58 (80.6)	59 (81.9)	0.831
> 30	28 (16.6)	14 (19.4)		14 (19.4)	13 (18.1)	
Co-morbidities	114 (67.5)	39 (54.2)	0.0499	43 (59.7)	39 (54.2)	0.501
Dyslipidemia	53 (31.4)	16 (22.2)	0.151	20 (27.8)	16 (22.2)	0.441
Diabetes	27 (16.0)	12 (16.7)	0.894	10 (13.9)	12 (16.7)	0.643
Hypertension	60 (35.5)	28 (38.9)	0.617	24 (33.3)	28 (38.9)	0.488
Deep venous thrombosis/pulmonary embolism	20 (11.8)	6 (8.3)	0.423	6 (8.3)	6 (8.3)	1
Arteriopathy	8 (4.7)	3 (4.2)	1	1 (1.4)	3 (4.2)	0.620
Renal failure	7 (4.1)	1 (1.4)	0.442	1 (1.4)	1 (1.4)	1
Hepatopathy	22 (13.0)	26 (36.1)	< 0.001	14 (19.4)	26 (36.1)	0.026
Cirrhosis	18 (10.7)	21 (29.2)	0.002	10 (13.9)	21 (29.2)	0.067
Steatosis	11 (6.5)	4 (5.6)		3 (4.2)	4 (5.6)	
Sains	140 (82.8)	47 (65.3)		59 (81.9)	47 (65.3)	
Cardiopathy	35 (20.7)	9 (12.5)	0.131	10 (13.9)	9 (12.5)	0.806
Arrhythmia-atrial fibrillation	9 (5.3)	3 (4.2)	1	2 (2.8)	3 (4.2)	1
COPD	13 (7.7)	11 (15.3)	0.072	2 (2.8)	11 (15.3)	0.02
ASA score (I / II / III) (*n*)	36/82/51	26/28/18	0.055	21/34/17	26/28/18	0.565
ASA1 + 2	118 (69.8)	54 (75.0)	0.416	55 (76.4)	54 (75.0)	1
ASA3 + 4	51 (30.2)	18 (25.0)	0.416	17 (23.6)	18 (25.0)	1
Preoperative chemotherapy	101 (59.8)	26 (36.1)	< 0.001	30 (41.7)	26 (36.1)	0.494
Number of nodules, median (IQR)	3.0 (1.0-5.0)	1.0 (1.0-1.0)	< 0.001	1.5 (1.0-2.0)	1.0 (1.0-1.0)	< 0.001
Nodule max. size (mm), mean (IQR)	30.0 (20.0-45.0)	26.5 (20.0-44.3)	0.352	26.5 (20.0-44.3)	30.0 (20.0-55.3)	0.138
Resection type						
Major resection	69 (40.8)	9 (12.5)	< 0.001	15 (20.8)	9 (12.5)	0.180
Minor resection	100 (59.2)	63 (87.5)		57 (79.2)	63 (87.5)	
Benign lesions						
Adenoma	3 (1.8)	9 (12.5)	0.001	3 (4.2)	9 (12.5)	0.129
Nodular hyperplasia	2 (1.2)	3 (4.2)	0.159	2 (2.8)	3 (4.2)	1
Hydatid cysts	5 (3.0)	2 (2.8)	1	3 (4.2)	2 (2.8)	1
Angioma	1 (0.6)	0 (0.0)	1	0 (0.0)	0 (0.0)	1
Other pathologies (Caroli disease, sclerosing cholangitis, traumatic, *etc.*)	2 (1.2)	2 (2.8)	0.585	2 (2.8)	2 (2.8)	1
Malignant tumors						
Hepatocellular carcinoma	25 (14.8)	24 (33.3)	0.001	11 (15.3)	24 (33.3)	0.012
Colorectal metastases	101 (59.8)	18 (25.0)	< 0.001	38 (52.8)	18 (25.0)	< 0.001
Cholangiocarcinoma	11 (6.5)	5 (6.9)	1	4 (5.6)	5 (6.9)	1
Gallbladder cancer	1 (0.6)	0 (0.0)	1	0 (0.0)	0 (0.0)	1
Klatskin tumor	2 (1.2)	1 (1.4)	1	2 (2.8)	1 (1.4)	1
Neuroendocrine tumors	7 (4.1)	1 (1.4)	0.442	5 (6.9)	1 (1.4)	0.209
Other types of metastasis	25 (14.8)	24 (33.3)	0.001	11 (15.3)	24 (33.3)	0.012
Preoperative blood test, median (IQR)						
Albumin (g/dL)	40.0 (38.0-43.0)	41.0 (39.0-44.0)	0.293	40.5 (38.0-44.0)	41.0 (39.0-44.3)	0.465

OLR: Open liver resection; LLR: Laparoscopic liver resection; ASA: American Society of Anesthesiologists; COPD: Chronic obstructive pulmonary disease.

0.001). There was a significant difference concerning pathologies with 9 adenoma resections in the LLR group (12.8%), *vs* 3 in the OLR group (1.8%) (*P* = 0.001), 24 hepatocarcinomas in the LLR group (33.3%) *vs* 25 in the OLR group (14.8%), (*P* = 0.001), and 101 colorectal metastasis resections in the OLR group (59.8%) *vs* 18 in the LLR group (25%), *P* < 0.001 (Table 1).

Details of the procedures performed are outlined in Table 2. It can be observed that fewer segments were resected in the LLR group (median of 1 *vs* 2; *P* < 0.001) and that there were more segmentectomies performed in the LLR group (40.3% *vs* 7.1%; *P* < 0.001), fewer bisegmentectomies (13.9% *vs* 27.2%, *P* = 0.025), fewer right hepatectomies (4.2% *vs* 15.4%, *P* = 0.014) and fewer associations with destruction by radiofrequency (12.5% *vs* 32%, *P* = 0.002) as compared to the OLR group. There was a statistically significant difference in favor of LLR concerning operative time, blood loss, and length of hospital stay. In addition, there were significantly fewer medical complications in the LLR group (4.2% *vs* 2.8%, *P* < 0.001), taking all types into account (Table 2).

The conversion rate was 9.7% (*n* = 7), the reason for that being the presence of several pedicular adenopathies, which required an extensive dissection in one patient, and there were difficulties of access in 6 other patients. The mortality rate was 4.2% in the OLR group and 0% in the LLR group. The reason for death

Table 2 Operative and postoperative data before and after propensity score matching *n* (%)

	OLR (*n* = 169)	LLR (*n* = 72)	*P* value	OLR (*n* = 72)	LLR (*n* = 72)	*P* value
Resection type						
Bisegmentectomy	46 (27.2)	10 (13.9)	0.025	30 (41.7)	10 (13.9)	< 0.001
Segmentectomy	12 (7.1)	29 (40.3)	< 0.001	8 (11.1)	29 (40.3)	< 0.001
Wedge resection	49 (29.0)	24 (33.3)	0.502	20 (27.8)	24 (33.3)	0.469
Left hepatectomy	23 (13.6)	5 (6.9)	0.188	8 (11.1)	5 (6.9)	0.383
Right hepatectomy	26 (15.4)	3 (4.2)	0.014	6 (8.3)	3 (4.2)	0.494
Enlarged right hepatectomy	15 (8.9)	1 (1.4)	0.044	2 (2.8)	1 (1.4)	1
Combined resection and radiofrequency	54 (32.0)	9 (12.5)	0.002	13 (18.1)	9 (12.5)	0.354
Number of resected segments, median (IQR)	2.0 (0.0-4.0)	1.0 (0.0-1.3)	< 0.001	2.0 (0.0-2.0)	1.0 (0.0-1.3)	0.004
Operation length (min), median (IQR)	250 (190-330)	185 (150-254)	< 0.001	247.5 (187.5-332.5)	185.0 (150.0-253.8)	0.002
Pedicular clamping	110 (65.1)	40 (55.6)	0.162	43 (59.7)	40 (55.6)	0.613
Intermittent	96 (56.8)	34 (47.2)	0.354	36 (50.0)	34 (47.2)	0.739
Permanent	14 (8.3)	6 (8.3)		7 (9.7)	6 (8.3)	0.771
No clamping	59 (34.9)	32 (44.4)		29 (40.3)	32 (44.4)	0.613
Clamping duration (min), median (IQR)	22.0 (0.0-38.0)	15.0 (0.0-35.0)	0.174	25.0 (0.0-36.5)	15.0 (0.0-35.0)	0.411
Blood loss (mL), median (IQR)	300 (30-500)	100 (30-356)	0.003	300.0 (30.0-562.5)	100.0 (30.0-356.3)	0.002
Transfusion (*n*), median (IQR)	41 (24.3)	12 (16.7)	0.193	16 (22.2)	12 (16.7)	0.400
Length of hospital stay (d), median (IQR)	10.0 (7.0-14.0)	7.0 (5.8-10.0)	< 0.001	9.0 (7.0-12.0)	7.0 (5.8-10.0)	0.004
R0 resection margin	139 (82.3)	63 (87.5)	0.311	62 (86.1)	63 (87.5)	0.806
Conversion rate	NA	7 (9.7)	0.065	NA	7 (9.7)	0.326
Postoperative complications ≥ 1						
Respiratory	30 (17.8)	6 (8.3)	0.060	18 (25.0)	6 (8.3)	0.007
Atelectasis	21 (12.4)	4 (5.6)	0.109	11 (15.3)	4 (5.6)	0.056
Pneumopathy	10 (5.9)	2 (2.8)	0.518	7 (9.7)	2 (2.8)	0.166
Renal	7 (4.1)	0 (0.0)	0.107	5 (6.9)	0 (0.0)	0.058
Acute renal failure	6 (3.6)	0 (0.0)	0.183	5 (6.9)	0 (0.0)	0.058
Cystitis/pyelonephritis	1 (0.6)	0 (0.0)	1	0 (0.0)	0 (0.0)	1
Cardiovascular	7 (4.1)	4 (5.6)	0.737	2 (2.8)	4 (5.6)	0.681
Wall infection	8 (4.7)	2 (2.8)	0.728	6 (8.3)	2 (2.8)	0.275
Deep collection	19 (11.2)	6 (8.3)	0.498	8 (11.1)	6 (8.3)	0.574
Hemorrhage	3 (1.8)	0 (0.0)	0.556	2 (2.8)	0 (0.0)	0.497
Liver failure	7 (4.1)	1 (1.4)	0.442	4 (5.6)	1 (1.4)	0.366
Ascites	5 (3.0)	2 (2.8)	1	5 (6.9)	2 (2.8)	0.441
Biliary fistula	10 (5.9)	2 (2.8)	0.518	1 (1.4)	2 (2.8)	1
Medical complications	47 (27.8)	3 (4.3)	< 0.001	19 (26.4)	3 (4.3)	< 0.001
Surgical complications	7 (4.1)	2 (2.8)	0.729	4 (5.6)	2 (2.8)	0.681
Ⅰ-Ⅱ	47 (27.8)	21 (29.2)	0.690	21 (29.2)	21 (29.2)	0.447
Ⅲ-Ⅳ	33 (19.5)	12 (16.7)		13 (18.1)	12 (16.7)	
Ⅴ	4 (2.4)	0 (0.0)		3 (4.2)	0 (0.0)	
Postoperative mortality 30 d	2 (1.2)	0 (0.0)	1	2 (1.2)	0 (0.0)	0.080
Postoperative mortality 60 d	3 (1.8)	0 (0.0)	0.556	0 (0.0)	0 (0.0)	1
Postoperative mortality 90 d	5 (3.0)	0 (0.0)	0.326	0 (0.0)	0 (0.0)	1

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

was the occurrence of multivisceral failure after a right hepatectomy in 3 ASA 3 patients including 2 who were treated for a cholangiocarcinoma and one for liver metastases of a colorectal cancer which received 3 cycles of neoadjuvant FOLFOX therapy.

Population and short-term results after matching and PS

After using the propensity score, all 72 patients of the LLR group were matched to 72 patients of the OLR group. Both groups were comparable as far as patient characteristics were concerned, except for liver diseases which were more important in the LLR group (36.1% *vs* 19.4%, *P* = 0.026), the type of segment resected (*P* < 0.05), and the pathology, with more hepatocellular carcinomas in the LLR group (33.3% *vs* 15.3%, *P* = 0.012) and fewer colorectal metastases (25% *vs* 52.8% in the OLR group, *P* < 0.001), (Table 1). More bisegmentectomies were performed in the OLR group (41.7% *vs* 13.9%, *P* < 0.001) but more segmentectomies in the LLR group (40.3% *vs* 11.1%, *P* < 0.001).

There was still a significant difference in terms of operative time (*P* = 0.002), a shorter hospital stay (*P* = 0.004) in the LLR group, less blood loss (*P* = 0.002), and fewer medical complications (4.3% *vs* 26.4%, *P* < 0.001) in the LLR group. Other values from both groups were comparable (Table 2).

DISCUSSION

The objective of this study was to compare short-term results of hepatectomies performed using a laparoscopic and an open approach, using the propensity score in order to reduce the selection bias. After matching, it has more open resection for liver metastases of a colorectal cancer that the laparoscopic approach. Indeed in colorectal cancer, metastases are often multiple and difficult to be able to remove by laparoscopic approach. Among the population, there was a selection of indications with more limited and minor resections in the laparoscopic group with fewer resected lesions. After a matching and a propensity score were applied to the essential factors which influence morbi-mortality, a significant decrease in blood loss could be observed, as well as the length of hospital stay, operative time, and postoperative medical complications in the laparoscopic group.

Despite an increase in the number of centers which use laparoscopic hepatobiliary surgery, the use of this approach is not very widespread (5% to 30% of liver resections)[22-27]. Only a few centers report a strong activity representing 50% to 80%[28-30] of liver resections. Over a period of 3 years, we report 72 laparoscopic hepatectomies, out of 241 hepatectomies in total, which means that 29.9% of hepatectomies were performed laparoscopically. Our indications for laparoscopic hepatectomy are the same as for open surgery. Most often, we would decide to choose a laparoscopic approach due to the location and the size of the tumor[9,10]. As shown in our series, laparoscopic is most often used for anterolateral resections (segments 2 to 6). Wedge resections, segmentectomies, and left lobectomies remain the best laparoscopic indications[22,30,31]. Major hepatectomies, especially right hepatectomies, were mainly performed using an open approach due to technical difficulties[32-36]. Resection of lesions located in segments Ⅶ, Ⅷ, Ⅰva and Ⅰ is still not properly documented due to exposure difficulties and proximity with the inferior vena cava and suprahepatic veins. Superior posterior segments can be approached using transdiaphragmatic ports[37,38], or using a transthoracic route[39]. In addition, laparoscopic resection is not recommended for lesions greater than 5 cm in diameter, due to manipulation difficulties with a risk of tumoral rupture and of obtaining insufficient resection margins[22,26,29]. The hepatic pedicle is systematically controlled at the beginning of the intervention in order to perform a pedicular clamping if required (55.6% of cases in our series). We report 6 permanent clampings but this corresponds to very superficial resections. In most cases, we privileged intermittent clamping, as this allows for a better liver tolerance, especially in cirrhotic patients[40-42], as well as a better short- and long-term prognosis[43]. We used intermittent clamping using a laparoscopic approach systematically. Additionally, laparoscopic clamping, which is associated with pneumoperitoneum pressure, allows to decrease bleeding and almost completely eliminates the use of continuous aspiration, which is not feasible.

Average clamping time was 15 min with the LLR *vs* 22 min with the OLR (*P* = 0.174). Intermittent clamping was 20 min with reperfusion phases of 10 min in all patients, except for cirrhotic patients, in which clamping would not exceed 15 min.

In addition, we do not report any gas embolism in our series, a rare occurrence which has, however, previously been described in laparoscopic surgery[22,27,28]. It has been demonstrated that in order to decrease this risk, the use of carbon dioxide (a highly soluble gas) should be privileged, as well as low insufflations pressures[44]. We did not use Argon although it allows for a good hemostasis, because it increases the risk of gas embolism in liver surgery[45].

After PS, our study clearly demonstrated the benefits of the laparoscopic approach. There was a decrease in intraoperative bleeding (100 mL *vs* 300 mL, *P* = 0.002), a reduction in the length of hospital stay[11] with a median of 7 d *vs* 9 d (*P* = 0.004) and even a shorter operative time (185 min *vs* 247.5 min, *P* = 0.002). The same goes for postoperative outcomes which appear to be simpler with fewer medical complications, especially respiratory ones (4.3% *vs* 26.4%, *P* < 0.001), also described in the series by Fuks *et al*[46]. As for surgical complications, laparoscopy does not provide any real benefits. Some authors have reported similar results[47-49], like Cannon *et al*[50] (23% *vs* 50%, *P* = 0.004), Simillis in his meta-analysis[51]. In the laparoscopic group, no deaths have been recorded; the same goes for unusual complications, and less than 20% of patients were transfused during hospitalization.

The conversion rate described in the literature ranges from 5% to 15%[22-24,30]. The 2 main reasons for conversion are: Firstly, a technical problem due to a difficult exposure, a risk of tumoral rupture dissemination for fragile lesions or a doubt concerning the sufficient resection margin. The second reason is uncontrolled bleeding. In our series, we report a conversion rate of 9.7%, the main reason for it being exposure difficulties, which make resection difficult.

The results were obtained in our series as well as in series published by surgeons with experience in liver surgery and laparoscopic surgery, and consequently these results can only be extrapolated with caution in all centers.

In conclusion, the development of liver surgery using a laparoscopic approach has been a gradual process, and some liver resections currently seem feasible and safe in patients selected in centers in which surgeons have experience in both hepatic surgery and laparoscopic surgery. This study compared the complications mainly for minor resections after matching; although bicentric study with small groups, the laparoscopic liver resections seem to produce the same results as the open approach in the short- and middle-term. It could be considered as an alternative to open surgery and become the gold standard for carefully selected patients. However, complementary studies seem necessary, especially for long-term oncological results and for major hepatectomies, in order for the laparoscopic approach to become a widely used alternative to hepatectomies using laparotomy.

COMMENTS

Background

Laparoscopic surgery is a consolidate technique who is diffusing rapidly also in some subspeciality who initially were contraindicated.

Research frontiers

The aim of this paper is to evaluate the impact of short and mid-term results of laparoscopy in liver surgery.

Innovations and breakthroughs

Minimally invasive approach represents the standard of care for most digestive cancer and it has to be confirmed for liver malignancies.

Applications

The extended indication for liver malignancies are even more frequent and need to be confirmed by short, middle and long term results.

Terminology

Minimally invasive and laparoscopic approach, liver resection, and better postoperative outcome are the main subjects of the paper.

Peer-review

This article has some important information to promote introduction of laparoscopy in the hepatobiliary and pancreatic field.

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