

Laparoscopic Liver Resection—Understanding its Role in Current Practice

The Henri Mondor Hospital Experience

Richard Bryant, MD, Alexis Laurent, MD, PhD, Claude Tayar, MD, and Daniel Cherqui, MD

Objective: To report our complete experience with laparoscopic liver resection (LLR) to understand what role it may play in the broader context of liver surgery.

Background: The goal of LLR is to extend the benefits of the laparoscopic approach without compromising the fundamental principles of open liver surgery. LLR, however, presents unique technical challenges and its evaluation is made difficult by the restricted indications for this approach, the few centers world-wide experienced in the technique, and the heterogeneity of procedures and pathologies involved.

Methods: Retrospective analysis of a prospectively maintained database of liver resections from a unit with a comprehensive liver program, including resection and transplantation.

Results: There were 166 laparoscopic liver resections between May 23, 1996 and December 31, 2007, including 100 (60%) for malignant pathology (64 HCC, 3 cholangiocarcinoma, 33 hepatic metastases) and 66 for benign pathology (adenoma, 23; FNH, 19; cystic, 17; other, 7). Numbers of resections for benign indications remained stable over time whereas those for malignant indications increased. There were 31 major resections, 56 left lateral sectionectomies, 28 segmentectomies, and 51 tumorectomies. There was 0% mortality and 15.1% morbidity. Median blood loss was 200 mL, 9 patients (5.4%) required transfusion, and median operating time was 180 minutes. Left lateral sectionectomies demonstrated reduced bleeding (median, 175 vs. 300 mL, $P = 0.0015$) and faster operating time (median, 170 vs. 180 minutes, $P = 0.0265$). In the second half of the experience, there was reduced bleeding (median, 200 vs. 300 mL, $P = 0.0022$) and a lower conversion rate (2.4% vs. 16.9%, $P = 0.0015$).

Conclusions: Good patient selection and refined surgical technique are the keys to successful LLR. The indications for resection of asymptomatic benign lesions should not be increased because the laparoscopic approach is available. Hepatocellular carcinomas (HCCs) are more likely to be suitable to a laparoscopic approach than colorectal liver metastases. Left lateral sectionectomy and limited resection of solitary peripheral lesions are particularly suitable while hemihepatectomies remain challenging procedures. LLR requires an ongoing robust audit to identify any emerging problems.

(*Ann Surg* 2009;250: 103–111)

After the initial laparoscopic cholecystectomies, first performed in the 1980s,¹ progress in techniques and equipment have allowed the laparoscopic approach to be extended to increasingly complex procedures. The advantages of the laparoscopic approach in abdominal surgery have been shown in various proce-

dures, including appendicectomy,² cholecystectomy,³ splenectomy,⁴ and colectomy.^{5,6} The safety of laparoscopic resections in malignancy has been demonstrated.^{7,8}

The goal of laparoscopic liver resection (LLR) is to extend these benefits of the laparoscopic approach without compromising the fundamental principles of open liver surgery. LLR, however, presents unique technical challenges with respect to mobilization of the heavy organ, transection of the parenchyma with its potential for significant bleeding, and maintaining surgical orientation in the absence of anatomic markers to ensure a satisfactory oncologic clearance.

LLR was initially reported in 1995 by Rau et al,⁹ Cuesta et al,¹⁰ and Hashizume et al.¹¹ Anatomic resections in the form of left lateral sectionectomy were reported in 1996 by Azagra et al¹² and Kaneko et al,¹³ formal hemihepatectomies were reported in 1998 by Hüscher et al,¹⁴ and this unit at the Henri Mondor Hospital reported the first significant series of 30 patients¹⁵ in 2000. The largest series were recently reported by Koffron et al¹⁶ and Buell et al.¹⁷ The assessment of this technique has been based on series^{15,18–43} as well as retrospective comparative studies.^{16,44–53} Well-designed prospective comparative studies are required to validate the technique but are difficult to perform, as the technique is largely restricted to specialized centers and the numbers are necessarily small due to the strict indications. Studies, therefore, need to be well planned and targeted to provide meaningful results.

The aim of this study is to report our complete experience with LLR, from a unit with a comprehensive liver program including resection and transplantation, to understand what role it may play in the broader context of liver surgery, and what type of data to expect when planning future targeted studies.

STUDY METHOD AND SURGICAL TECHNIQUE

Patient Selection

All patients being considered for liver resection are discussed at a multidisciplinary meeting including surgeons, hepatologists, oncologists, radiologists, and pathologists. Cases of hepatocellular carcinomas (HCC) in transplantable patients are also discussed at the transplant meeting. All patients undergo good quality imaging of the liver with triple-phase CT scan and/or MRI using appropriate contrast agents. PET scans are used when indicated, principally in cases of hepatic metastases. The indication for resection is confirmed for suitably staged malignant indications, for symptomatic or complicated benign lesions, and for indeterminate lesions in which the benign character cannot be confirmed on noninvasive imaging or percutaneous biopsy. With the indication for resection confirmed in a multidisciplinary fashion, the patients are then assessed on their suitability for a laparoscopic approach based on the size, number, and location of lesions, the type of resection required, and the patient's comorbidities and surgical history. Lesions 5 cm or less in diameter located in the peripheral segments of the liver are considered for segmental or nonanatomic resections. Larger lesions are acceptable if pedunculated or located in the left lateral section. A

From the Service de Chirurgie Digestive et Hépatobiliaire, Hôpital Henri Mondor (APHP)—Université Paris 12, Créteil, France.

R. B. and A. L. contributed equally to this work.

Reprints: Daniel Cherqui, MD, Hôpital Henri Mondor, 51, Avenue De Lattre de Tassigny, 94010 Créteil, France. E-mail: daniel.cherqui@hmn.aphp.fr.

Copyright © 2009 by Lippincott Williams & Wilkins

ISSN: 0003-4932/09/25001-0103

DOI: 10.1097/SLA.0b013e3181ad6660

laparoscopic approach may be suitable for multiple lesions where they can be resected with a single anatomic hepatectomy with a clear margin but not where multiple complicated or bilobar procedures are required. Patients requiring a hemihepatectomy are considered suitable for a laparoscopic approach where the lesions are well clear of the plane of transection and major structures (the pedicles, the hepatic veins, and the inferior vena cava), and are not too bulky. Patients with lesions in segments 7 and/or 8 are considered for a laparoscopic approach if a right hemihepatectomy is required, usually due to proximity to the right hepatic vein in a healthy liver. If a nonanatomic resection is indicated then they are only considered for a laparoscopic approach if the lesion is particularly superficial. When a laparoscopic approach was decided upon, the patients were informed of the innovative nature of the procedure and consent was obtained.

Surgical Technique

Resections are defined according to the Brisbane classification⁵⁴ and include hemihepatectomies, left lateral sectionectomies, segmentectomies, and nonanatomic resections.

The technique of LLR has been previously described.^{15,23,25,26} In brief, resections are usually performed in the supine position with the surgeon standing between the legs and 1 assistant on each side. The left lateral decubitus position is used for resections of segments 6 and 7, which enables better exposure of the right posterior section of the liver. An open cutdown technique is used to establish the pneumoperitoneum. The camera port is in the midline above the umbilicus, with two 12 mm working ports, 1 on each side of the midline, and 2 5 mm ports, 1 on each side laterally beneath the costal margin.

An initial laparoscopic examination and laparoscopic ultrasound examination of the liver are performed routinely. A tape is routinely placed around the hepatic pedicle in preparation for a Pringle maneuver if it is required. Pedicles are approached intraparenchymally in minor resections while preliminary extrahepatic hilar inflow division is used in hemihepatectomies. Parenchymal transection is performed with a combination of the Harmonic scalpel (Ultracision, Ethicon Endo-Surgery) for superficial layers of the liver and the ultrasonic dissector (Dissectron or CUSA, Integra) for deeper transection. Major structures are divided with stapling devices (EndoGIA, Covidien) and minor vessels are divided between clips. The gall bladder is removed where indicated, but after division of the cystic duct and artery, it may be left attached to the liver until later in the procedure to act as a handle to maneuver the liver. The gall bladder and the round ligament thus become the 2 "handles of the liver."

Segmentectomies consist of large resections along the theoretical segmental borders. Nonanatomic resections consist of tumor resections or wedge resections with an intended 1- to 2-cm margin, depending on the pathology and the location. Transection uses a combination of harmonic scalpel, clips, and staplers depending on the size of the vascular and biliary structures encountered. Radiofrequency precoagulation⁵⁵ (Laparoscopic Habib 4X, Angiodynamics, Queensbury) is also used in selected cases.

Left lateral sectionectomy begins with division of the falciform ligament, left coronary ligament, and lesser omentum to mobilize the left lobe. The parenchyma is divided using the harmonic scalpel so as to expose the upper surface of the segment 2 and 3 pedicles intrahepatically. The pedicles are then divided with an EndoGIA vascular stapler—with traction on the round ligament up and to the right; the lower jaw of the stapler sits comfortably in the groove for the ligament of Arantius to facilitate this maneuver. The parenchymal transection is then completed with the harmonic scalpel to expose the left hepatic vein intrahepatically, which is divided with a stapler.

For a left hemihepatectomy, the left liver is mobilized as above. The left hepatic artery and left portal vein are dissected and divided extrahepatically, demonstrating the line of demarcation. The parenchymal transection is then begun, initially with the harmonic scalpel and then with the ultrasonic dissector once deeper into the liver, opening the liver to allow a good exposure of the left pedicle and sufficient space to introduce a stapling device to divide the left bile duct. The parenchymal transection is then completed, exposing the left hepatic vein intrahepatically, which is divided with the stapling device to complete the transection.

A right hemihepatectomy can be performed either with an anterior or a traditional approach. An anterior approach begins with an extrahepatic dissection and division of the right hepatic artery and right portal vein. The parenchymal transection is then begun, using both harmonic scalpel and ultrasonic dissector, followed by an intrahepatic division of the right bile duct. Sometimes there is insufficient space to introduce the stapling device to divide the right portal vein, and so in these cases the right portal vein is clamped to demonstrate the line of demarcation and the vein can then be divided with the stapling device once the liver has been opened. The parenchymal transection is then completed down to the anterior surface of the vena cava. The minor hepatic veins are then divided between clips, followed by the right hepatic vein and then the hepatocaval ligament with stapling devices. The final step is mobilization of the liver and division of the right coronary ligament. In the traditional approach, there is the same extrahepatic division of the right hepatic artery and right portal vein, followed by full mobilization of the right liver and division of the hepatocaval ligament followed by the right hepatic vein with stapling devices before transection of the parenchyma.

A Pringle maneuver is reserved in the event of bleeding and uses an intermittent protocol.^{56,57} Hand ports are used selectively in right-sided resections and are indicated where mobilization is difficult because of a posterior tumor in the right lobe for a nonanatomic resection or a bulky right lobe for a right hemihepatectomy. These indications are usually predictable preoperatively and the use of the hand port is therefore planned in most cases, but if unexpected difficulties in mobilization of the right liver are encountered a hand port is added early in the procedure. Hand ports are introduced via a muscle-splitting incision in the right iliac fossa or right flank if the patient is in the left lateral position.

The specimen is removed intact in a bag, either via the hand-port incision, a previous appendicectomy scar or a Pfannenstiel incision. The incision is then closed to allow re-establishment of the

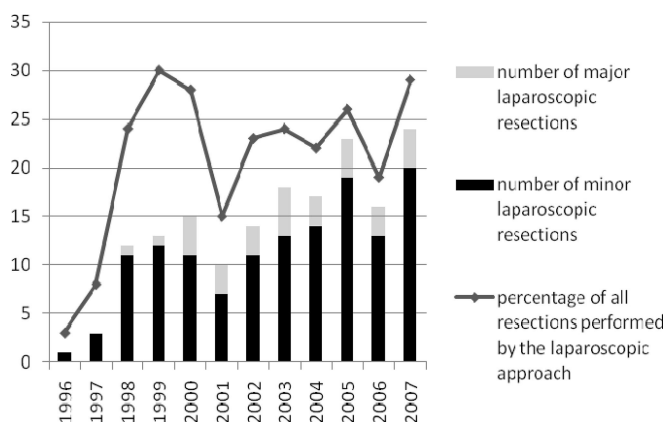


FIGURE 1. Numbers of major and minor resections per year. Percentage of all resections performed by the laparoscopic approach per year.

TABLE 1. Patient Demographics and Indications

Demographics		
Total number	166	
M:F	79:87	
Age, mean (range)	54.7 (15–83)	
BMI, mean (range)	25.1 (13.7–48.9)	
BMI >30	25 (15%)	
Chronic liver disease	64 (38.6%)	
Pathology		
Malignant	100	
Primary liver	67	
HCC*	64	
Cholangiocarcinoma	3	
Metastases	33	
Colorectal†	22	
Breast	7	
Other‡	4	
Benign	66	
Benign tumor	48	
Adenoma	23	
FNH§	19	
Hemangioma¶	4	
Other	2	
Benign cystic	17	
Hydatid**	8	
Caroli disease††	3	
Complicated biliary cyst‡‡	3	
Polycystic disease§§	3	
Benign other	1	
Hepatolithiasis	1	
No. lesions per patient		
1 lesion	148	
2 lesions	14	
3 lesions	2	
4 lesions	1	
6 lesions	1	
Lesions location (192 lesions in 166 patients)		
Segment 1	0	
Segment 2	35	
Segment 3	44	
Segment 4	22	
Segment 5	24	
Segment 6	47	
Segment 7	11	
Segment 8	9	
Lesion size		
Median diameter		
Benign (n = 66)	50	P < 0.0001
Malignant (n = 100)	30	
Major (n = 31)	30	NS
Minor (n = 135)	35	
Lesions >80 mm		
Benign (n = 66)	9 (13.6%)	P = 0.0312
Malignant (n = 100)	4 (4%)	
Major (n = 31)	2 (6.5%)	NS
Minor (n = 135)	11 (8.1%)	

*Sixty with chronic liver disease, 4 with normal liver.
†Primary tumor—rectum in 7, left colon in 11, right colon in 4.
‡Melanoma, uterine cervix, sarcoma, maxillary sinus tumor.
§Symptomatic or suspected adenoma on imaging or percutaneous biopsy.
¶Atypical imaging not permitting preoperative diagnosis in 3, pedunculated symptomatic lesion in 1.
||Angiomyolipoma, inflammatory pseudotumor.
**Pericystectomy or formal resection of intact cyst.
††Patients with localized Caroli disease.
‡‡Resection of intact cyst for complicated cysts or suspected cystadenomas.
§§Patients with polycystic disease who underwent left lateral sectionectomy for symptomatic disease predominantly in this part of the liver.
BMI indicates body mass index; NS, nonsignificant.

pneumoperitoneum to confirm hemostasis. Closed suction drains are used for right hemihepatectomies and are usually omitted for other resections.

Data Collection and Analysis

Since 1996, a thorough prospective database (Filemaker Pro) has been maintained for all liver resections performed in the unit. A major resection is defined as the resection of 3 or more contiguous segments, according to Couinaud.⁵⁸ A conversion is when the procedure is completed via a laparotomy. Morbidity was classified according to Clavien classification.⁵⁹ Statistics were analyzed using StatsDirect (<http://www.statsdirect.com>, England: StatsDirect Ltd. 2008), using the Mann-Whitney *U* test, Fisher exact test, simple linear regression, and the follow-up life table test. Statistical significance was taken at *P* < 0.05.

RESULTS

A total of 166 laparoscopic liver resections have been performed in 166 patients from May 23, 1996, until December 31, 2007. This represented 22% of the 754 liver resections performed during the same period. The experience was split in 2 halves for analysis. The first 83 cases were performed before November 25, 2003. After the first 2 years of the series, the proportion of resections performed laparoscopically has remained relatively constant (Fig. 1). This series includes only true hepatic resections and does not include procedures such as deroofting of hepatic cysts. Patient demographics and characteristics are listed in Table 1.

The indications for LLR are listed in Table 1. A total of 100 patients (60%) underwent resection for malignant pathology, including 64 for HCC, 3 for cholangiocarcinoma, and 33 for hepatic metastases. Sixty four patients suffered chronic liver disease, with most undergoing minor resections for HCC. There were 47 with established cirrhosis and 17 with fibrosis. Five patients with chronic liver disease underwent a major resection. Among metastases, colorectal primaries accounted for 22 cases while noncolorectals accounted for 11, breast being the most common.

A total of 66 patients (40%) underwent resection for benign pathology. Of them, 48 patients had benign tumors, including mainly adenomas and focal nodular hyperplasia (FNH). Seventeen patients underwent resection for cystic disease, with the most frequent indication being hydatid disease. Benign lesions tended to be larger than malignant lesions (Table 1). The number of patients who underwent LLR for benign disease did not increase during the study period, in contrast to the number of patients with malignant disease which increased dramatically (Fig. 2).

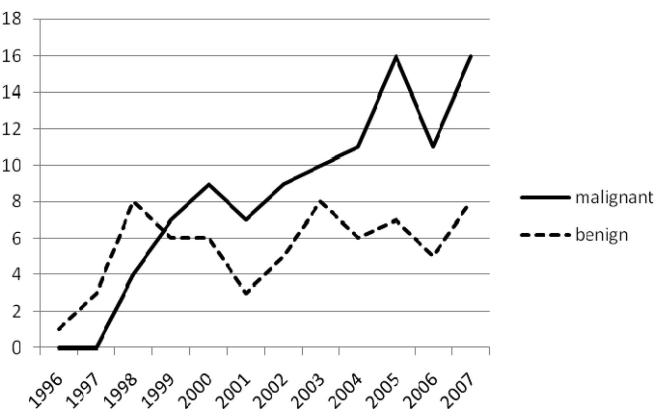


FIGURE 2. Numbers of benign and malignant cases resected laparoscopically per year.

TABLE 2. Types of Resection by Pathology

Type of Resection	Pathology				Totals
	HCC	CLM	Other Malignancy	Benign	
Limited resection (<3 segments)	58	13	9	55	135*
Left lateral sectionectomy	22	6	4	24	56
Segmentectomy [†] /tumorectomy [‡]	36	7	5	31	79
Major resection (≥3 segments)	6	9	5	11	31*
Right hepatectomy	2	8	4	5	19
Left hepatectomy	3	1	1	6	11
Central hepatectomy	1	0	0	0	1
Total	64	22	14	66	166

*Hand assistance 8 of 31 (25.8%) versus 8 of 135 (5.9%) $P = 0.0032$.

[†]Segmentectomy 28 (1 in segment 3, 1 in segment 4, 5 in segment 4b, 6 in segment 5, and 15 in segment 6).

[‡]Tumorectomy 51 (3 in segment 2, 10 in segment 3, 6 in segment 4, 14 in segment 5, 14 in segment 6, 2 in segment 7, and 2 in segment 8).

CLM indicates colorectal liver metastases.

There were 192 lesions in 166 patients (Table 1). A total of 148 patients (89%) had a single lesion. The majority of lesions were located in segments 2 to 6. Nineteen patients had lesions located in segments 7 and/or 8, and of these 14 underwent a right hepatectomy.

The types of resection are summarized in Table 2. There were 31 major resections, including 19 right hepatectomies, 11 left hepatectomies, and 1 central hepatectomy (which was converted to open), and 135 minor resections, including 56 left lateral sectionectomies, 28 segmentectomies, and 51 nonanatomic resections. Hand assistance was used in 16 cases, including 8 majors (25.8%) (all right hepatectomies) and 8 minors (5.9%) (7 resections in segment 6 and 1 in segment 7) ($P = 0.0032$). All of the cases using hand assistance occurred in the second half of the experience.

The suitability to a laparoscopic approach varied according to the pathology and the type of resection. Among all 754 cases where a liver resection was indicated during the study period, the proportion suitable to a laparoscopic approach, according to selected pathologies and procedures, is listed in Table 3.

There were 16 conversions to laparotomy (9.6%) (Table 4), including 8 majors (25.8%) and 8 minors (5.9%) ($P = 0.0032$). In 8 cases the main indication for conversion was bleeding, in 5 cases it

was concern about achieving an adequate oncologic clearance, and in 3 cases it was failure to progress. Eight of the conversions occurred in cirrhotic patients ($P = 0.06$). Only 2 of the 16 conversions occurred in the second half of the experience ($P = 0.0015$).

The median operating time was 180 minutes (range: 30–480 minutes). Left lateral sectionectomies were faster than nonanatomic minor resections (median, 170 vs. 180 minutes, $P = 0.0265$), which were faster than hemihepatectomies (median, 180 vs. 285 minutes, $P < 0.0001$). Converted cases took longer than nonconverted cases (median, 240 vs. 180 minutes, $P = 0.0005$). Operating time was less in the second half of the experience (median, 180 vs. 200 minutes, $P = 0.0008$).

Overall blood loss was low (Table 5) with a mean of 329 mL (standard deviation: 363 mL) and a median of 200 mL (range: 0–2000 mL) and only 9 patients required transfusion (5.4%). Blood loss was greater in major resections and in those cases requiring conversion, hand assistance or clamping, but was not greater in chronic liver disease. Blood loss was less in left lateral sectionectomies and in the second half of the experience. Transfusion was more likely in those cases requiring conversion. Blood loss correlated with operating time by simple linear regression ($P < 0.0001$), and remained so when conversions were excluded ($P < 0.0001$).

TABLE 3. Proportion of Resections Selected for a Laparoscopic Approach Among 754 Liver Resections

Suitability by procedure	
Limited resection (<3 segments)	
Left lateral sectionectomy	77%
Segmentectomy/tumorectomy	51%
Major resection (≥3 segments)	
Formal left hepatectomy	18%
Formal right hepatectomy	11%
Overall	22%
Suitability by pathology	
Benign	
Adenoma	72%
FNH	63%
Hydatid	50%
Malignant	
HCC	27%
Colorectal liver metastasis	9%
Breast metastases	41%

TABLE 4. Conversion to Laparotomy

Conversions		<i>P</i>
Total (n = 166)	16 (9.6%)	
Bleeding	8	
Oncologic reasons	5	
Failure to progress	3	
Major (n = 31)	8 (25.8%)	0.0032
Minor (n = 135)	8 (5.9%)	
Hand assistance (n = 16)	1 (6.3%)	NS
Without hand assistance (n = 150)	15 (10.0%)	
First half of experience (n = 83)	14 (16.9%)	0.0015
Second half of experience (n = 83)	2 (2.4%)	
Chronic liver disease (n = 64)	8 (12.5%)	NS
Normal liver (n = 102)	8 (7.8%)	
Clamping (n = 88)	14 (15.9%)	0.0033
No clamping (n = 78)	2 (2.6%)	

NS indicates nonsignificant.

In 88 cases pedicular clamping was used. Blood loss was greater where clamping was used (median, 300 vs. 200 mL, $P < 0.0001$). Clamping was used in 14 of 16 conversions versus 74 of 150 nonconversions ($P = 0.0033$) and 41 of 64 with chronic liver disease versus 47 of 102 normal livers ($P = 0.0251$).

In 2 cases, there was a suspicion of gas embolism with an episode of sudden mild and transient desaturation with reduced ETCO_2 but without further clinical consequence. There was 1 diaphragmatic injury requiring aspiration of the pneumothorax.

For the 100 patients with malignant pathology the median margin was 11.5 mm, with a mean of 15.3 mm and a range of 0 to 58 mm. A total of 5 patients had a margin <1 mm. There was no difference in the margin between the first and second halves of the experience.

Postoperative complications occurred in 25 patients (15.1%). There were 8 complications specific to liver resection, including six grade 1 complications (jaundice, 4; ascites, 2), one grade 3 (bile leak requiring percutaneous drainage), and one grade 4 (hemoperitoneum requiring laparotomy 12 hours after surgery). There were 3 abdominal wall complications including two grade 1 (wound abscess and hematoma, one each) and one grade 4 (1 early incisional hernia on a 12-mm port requiring reoperation for incarcerated bowel). In

addition, 2 patients developed a late incisional hernia and required subsequent repair. There were three grade 1 pulmonary complications and one grade 4 in a patient who developed a decompensation of chronic obstructive pulmonary disease and required 7 days of mechanical ventilation. There were 8 miscellaneous general grade 1 complications. In summary, there were nineteen grade 1 complications, one grade 3, and three grade 4 (the 2 late hernias were not graded).

The median hospital length of stay was 6 days (range: 2–76 days) with a mean of 7.9 days and standard deviation of 8.2 days. Hospital length of stay was longer for those with cirrhosis (median, 7 vs. 6 days, $P = 0.0002$), for those patients requiring conversion (median, 10.5 vs. 6 days, $P < 0.0001$) and for major resections (median, 9 vs. 6 days, $P < 0.0001$) but was less for left lateral sectionectomies compared with other resections (median, 6 vs. 7 days, $P = 0.0036$). Blood loss correlated with hospital length of stay by simple linear regression ($P = 0.0031$) and this remained so when conversions were excluded from the analysis ($P = 0.0028$).

Eighteen patients (10.8%) underwent subsequent liver surgery. We observed that there were clearly fewer adhesions after an initial laparoscopic resection in comparison to our experience with previous open resections. One patient who underwent LLR for polycystic liver disease underwent subsequent laparoscopic cyst fenestration for recurrent symptoms. The other 17 cases were performed by laparotomy. Liver transplantation was performed in 12 patients, all with HCC in the setting of cirrhosis, 3 as a bridge procedure (with the patient being listed at the time the decision for resection was taken), and 9 as a salvage procedure (with the patient listed at the time that recurrent disease becomes apparent). Two patients with HCC, 1 in cirrhosis, and 1 in a normal liver, subsequently underwent an open right hepatectomy for recurrent disease after nonanatomic resections on the right liver. Three patients with colorectal liver metastases underwent repeat resection for recurrent disease. In 1 case this was a margin recurrence after metastasectomy for a lesion in segment 5 necessitating a central hepatectomy. The other 2 cases were a right hepatectomy after a metastasectomy from segment 6 and metastasectomies from the left liver after a laparoscopic right hepatectomy.

Of 100 patients with a malignant pathology, follow-up information was available for 93, with a median follow-up of 26 months (Table 6). For patients with HCC, the 3-year overall and disease-free survival was 70% and 46%, respectively, and the 5-year overall and disease-free survival was 65% and 34%, respectively. For patients with colorectal liver metastases, the 3-year overall and disease-free survival was 79% and 71%, respectively, and the 5-year overall and disease-free survival was 64% and 47%.

DISCUSSION

Since 1996, 22% of liver resections have been performed laparoscopically. Overtime, the number of laparoscopic resections

TABLE 5. Results

	Blood Loss	P
Median blood loss (mL)		
Overall	200	
Major resections	300	0.0022
Minor resections	200	
Conversion	625	<0.0001
No conversion	200	
Hand assistance	300	0.011
No hand assistance	200	
Hand assistance	300	0.0309
Conversion	625	
Left lateral sectionectomy (LLS)	175	0.0015
Other resections	300	
Hemihpatectomies	300	NS
Minor resections excluding LLS	225	
Clamping	300	<0.0001
No clamping	105	
First half of experience	300	0.0022
Second half of experience	200	
Chronic liver disease	250	NS
Normal liver	200	
>500 mL blood loss (n)		
Overall	24 (14.5%)	
Major (n = 31)	8 (25.8%)	NS
Minor (n = 135)	16 (11.9%)	
Conversion (n = 16)	9 (56.3%)	<0.0001
No conversion (n = 150)	15 (10%)	
Transfusion required (n)		
Overall	9 (5.4%)	
Major (n = 31)	3 (9.7%)	NS
Minor (n = 135)	6 (4.4%)	
Conversion (n = 16)	5 (31.3%)	0.0005
No conversion (n = 150)	4 (2.7%)	

NS indicates nonsignificant.

TABLE 6. Laparoscopic Liver Resection: Survival for Selected Malignancies

	HCC (n = 63)	CLM (n = 22)
Overall survival		
3 yr	70% (53%–81%)	79% (38%–94%)
5 yr	65% (47%–78%)	64% (24%–87%)
Disease-free survival		
3 yr	46% (28%–63%)	71% (34%–90%)
5 yr	34% (15%–44%)	47% (15%–74%)

CLM indicates colorectal liver metastases.

for malignancy has increased while the overall proportion of resections approached laparoscopically has remained relatively constant. This reflects the increased complexity of cases referred to the unit, including many cases that are not suitable for a laparoscopic approach.

Suitability for a laparoscopic approach is determined by the size, number, and location of lesions. The majority of patients (89%) had single lesions. Overall the median size of the lesions was 35 mm, and only 13 patients had lesions greater than 80 mm in diameter. Benign lesions tended to be larger, as some large symptomatic benign lesions do present in favorable, sometimes even pedunculated, locations.

The number of resections for benign disease did not increase during the study period. This reflects that the indications for resection of benign tumors are very limited. It is important that the indications for resection of benign lesions do not change just because a laparoscopic approach is possible. However, benign lesions are more likely to be suitable to a laparoscopic approach than malignant lesions. This reflects the fact that they are often single and when large are sometimes relatively pedunculated. Additionally, when the lesion is known to be benign, the margin is not an important issue, and preservation of the abdominal wall and good cosmesis are more relevant than in malignant lesions. Of the benign lesions the majority were adenomas, which require resection because of their potential for bleeding or malignant transformation.⁶⁰ By contrast, FNH, a more frequent condition, has a benign course and does not require resection.⁶⁰ FNH can be diagnosed on imaging in the majority of cases, and resected FNH in this series were either for symptomatic lesions, or those that could not be distinguished preoperatively from adenoma, with the diagnosis only confirmed on histology of the resected specimen. Of note, only a very small minority of all FNH seen in our hospital undergo resection. Only 4 hemangiomas underwent laparoscopic resection, including 3 with an atypical appearance on imaging not permitting a preoperative diagnosis and 1 symptomatic pedunculated lesion. Hemangiomas rarely pose diagnostic problems on imaging and they do not require resection except in the rare cases of symptomatic or complicated giant hemangiomas, which are not candidates for a laparoscopic approach. It is extremely uncommon for hemangiomas seen in our hospital to undergo resection. A few cysts underwent liver resection because of complications or suspected cystadenoma. These procedures were resections without opening the cyst—cyst deroofings were not classified as liver resections and therefore are not reported here. A few selected cases of polycystic liver disease and hydatid cyst may be good candidates for LLR.

The majority of laparoscopic resections done for malignancy were for HCC (63%), almost all being minor resections in the setting of chronic liver disease. There were only 4 cases of HCC in a normal liver resected laparoscopically, reflecting both that this pathology is uncommon and that, as the patients are not undergoing screening, it usually presents as a large tumor less suitable to a laparoscopic approach. HCC was more likely to be resected laparoscopically than hepatic metastases, reflecting the indications for resection in each case. HCC in chronic liver disease that are considered suitable for resection are often small lesions identified by screening and are resectable with minor resections so as to preserve adequate parenchyma to prevent postoperative liver failure. It is often therefore suitable to consider a laparoscopic approach. Many of these cases fit also into the Milan criteria⁶¹ for transplant, which is taken into account when the decision for resection is made. Of note, 12 patients went on to undergo liver transplantation after previous LLR.

Only 9% of resections done for colorectal liver metastases were performed laparoscopically. This reflects the broad indications for liver resection in this disease. The potential for cure has been

well demonstrated^{62–64} and the normal underlying liver allows extensive resections without postoperative hepatic failure. The disease, at least in our experience, often presents with large lesions, multiple lesions and bilobar disease requiring complicated resections that are not suitable for a laparoscopic approach.

Highly selected noncolorectal metastases may be good candidates for a laparoscopic approach. However, these accounted for only 11 cases, breast being the most frequent indication, reflecting the stringent criteria for resection of noncolorectal metastases due to the uncertain benefits of liver resection, which is only considered in rare cases with few lesions where the clinical course suggests favorable biology.

The majority of left lateral sectionectomies (77%) were performed laparoscopically. This reflects the particular suitability of this resection to the laparoscopic approach. There were only 2 conversions (3.6%) and the procedures were faster and there was less bleeding compared with the other types of resection. The left lateral section is readily accessible due to its location and is easily maneuverable. The pedicles to segments 2 and 3 are readily identifiable intrahepatically and, taking advantage of appropriate traction on the round ligament, can be safely divided without risking other structures. The plane of transection is an anatomic plane with few bridging structures and readily identifiable by the external anatomy. The intrahepatic division of the left hepatic vein to complete the resection is facilitated by the fact that the vein at this point is running almost perpendicular to the operating instruments and can be safely divided without risking injury to the inferior vena cava lying behind it and to the right.

Only 18% of left hemihepatectomies and 11% of right hemihepatectomies were performed laparoscopically. In addition to the fact that laparoscopic hemihepatectomies are more technically demanding, the indications for hemihepatectomy, including large, multiple and/or ill-located lesions, are also unfavourable to a laparoscopic approach. Operating time in hemihepatectomies was significantly longer, and they were more likely to use hand assistance (for right hepatectomy only) or to require conversion, although there was only 1 conversion during a major resection in the second half of experience. A left hemihepatectomy retains the advantages of a maneuverable lobe and easier access to the longer extrahepatic course of the left hepatic pedicle. However, the middle hepatic vein runs in the line of transection with hemostasis, thus being more technically demanding. Laparoscopic right hepatectomy requires particular expertise in both hepatic and laparoscopic surgery. The right hemiliver is more difficult to access and mobilize due to its weight and volume. The area of the hepatocaval ligament requires special care. The right hepatic pedicular structures run a shorter extrahepatic course. Division of the right hepatic vein is done in close proximity to the inferior vena cava, whether it is by either an anterior or a traditional approach. Our standard approach to a right hepatectomy, both open and laparoscopic, is now an anterior approach because of its reported advantages.⁶⁵

Segmental and nonanatomic resections are more suitable for a laparoscopic approach when in the peripheral “laparoscopic” segments 2 to 6. Segments 7 and 8 are more difficult to access as the approach angle of the instruments is limited by the costal margin. The major problems then become ensuring an adequate oncologic margin and difficult-to-control bleeding from venous tributaries in the depth of the tumorectomy. Only 19 patients had lesions in segments 7 and/or 8, and of these the majority¹⁴ underwent a right hemihepatectomy—Cho et al⁶⁶ also found a greater proportion of major resections for posteriorly located lesions. A laparoscopic approach to a limited resection for a single lesion in segment 7 or 8 would only be suitable where the lesion was particularly small and superficial. A single larger lesion must, therefore, be considered for

either an open limited resection or a laparoscopic right hemihepatectomy—the choice of technique must therefore weigh up the potential benefits of the laparoscopic approach versus those of parenchymal preservation, and the appropriate balance between these 2 priorities must be considered on an individual patient basis.

From a technical point of view the various steps of LLR are of unequal difficulty. State of the art equipment and instruments are mandatory. Liver exploration and operative ultrasound are easily performed. The loss of manual palpation is somewhat compensated by a better vision and if felt necessary it can be an exceptional indication for hand assistance. Mobilization of the left lobe is usually very easy while that of the right lobe may be more difficult and may occasionally require hand assistance. Extrahepatic dissection of the portal vein and hepatic artery usually does not pose significant problems and is in fact enhanced by the better vision of laparoscopy. Liver transection is the most critical issue (as it is in open surgery). Several techniques using various devices have been proposed and these may all be effective if appropriately used. We elected to use the harmonic scalpel for superficial transection (ie, 2–3 cm in depth) and the ultrasonic dissector for deeper transection, which allows identification of larger vessels which can be secured individually. The latter is used routinely in hemihepatectomies. Unlike others,^{16,17} we have not used staplers for parenchymal transection and restrict their use to division of large portal pedicles or hepatic veins. Large locked clips are useful for mid-sized structures. Finally, radiofrequency precoagulation may be useful to increase margins during some marginal limited resections.

This study showed significant improvement in the second half of the experience with significant reduction of operating time, need for conversion and blood loss. The importance of limiting bleeding and transfusion in liver resections has been well recognized.^{67–72} A careful technique to avoid bleeding is paramount. It should be emphasized that bleeding was generally minimal during LLR with a median overall blood loss of 200 mL and a significant proportion of patients where blood loss was unmeasurable. Our experience of problems with bleeding has not been one of sudden dramatic bleeding that requires precipitous conversion to laparotomy, but of slow, persistent bleeding that obscures the view, complicates the procedure, and can steadily accumulate to a significant level, requiring transfusion. However, significant vascular injuries may occur and require immediate hemostasis, emphasizing the need for mastering advanced laparoscopic techniques, such as vascular control and suturing. Gas embolism was suspected in 2 cases, but there were no significant clinical consequences.

Overall bleeding was low with a median of 200 mL, a 5.4% transfusion rate and only 14.5% losing more than 500 mL. However, this study demonstrates that blood loss is a useful surrogate marker for the difficulty of the resection and the mastering of the technique. Bleeding was the main cause of conversion. Blood loss correlated with operating time, reflecting that difficult cases tend to have more bleeding, and blood loss can complicate and slow a procedure. Blood loss also correlated with hospital length of stay, again reflecting the more difficult cases.

Blood loss was less in left lateral sectionectomies, but with these excluded there was no difference in blood loss between hemihepatectomies and minor resections. There was no statistical difference in bleeding for patients with chronic liver disease. There was no correlation between tumor size and blood loss. Blood loss was less in the second half of the series, reflecting greater experience with the technique.

We use pedicular clamping selectively where there is bleeding. Understandably therefore, blood loss was greater in those cases where pedicular clamping was used. Pedicular clamping is well tolerated during laparoscopic resections, as we have previously

shown.^{56,57} Its use is recommended when bleeding occurs, and it is a safe measure to place a tape around the porta at the beginning of the procedure to be used where necessary. It is more frequently required in cirrhotic patients and in minor resections rather than hemihepatectomies where earlier devascularization of the lobe is used. As the time of transection is usually longer during laparoscopic, as compared with open resection, intermittent clamping is particularly recommended. Clamping was required less frequently in the second part of the study reflecting better management in parenchymal transection.

Blood loss was significantly less in cases using hand assistance than in cases requiring conversion, and only 1 case of hand assistance required conversion, suggesting that hand assistance is a useful tool to reduce bleeding and avoid conversion in difficult cases, rather than being 1 step of an inevitable process towards conversion. We liberally use hand assistance in difficult minor right-sided resections in segments 6 and 7 and more selectively for right hemihepatectomies. In the latter, hand assistance is useful for mobilization where there is a large right lobe. We have never used hand assistance for left-sided resections. When indicated, hand assistance should be introduced early in the procedure.

Mortality and morbidity rates were 0% and 15%, respectively. These results demonstrate that this is a safe technique among these carefully selected patients. There were only 2 complications that might be directly attributable to hepatic surgical technique—1 bile leak and 1 hemorrhage. There were 6 cases of transient post-operative liver insufficiency with jaundice or ascites, reflecting the large group of resections in chronic liver disease. However, as we have shown before, morbidity of liver resection in cirrhotics was reduced by the laparoscopic approach as compared with open surgery, particularly the incidence of significant ascites.^{26,48} The abdominal wall complications were mainly related to conversions and the remaining complications were general medical complications of a surgical intervention. This complication rate is acceptable when compared with other published series.^{16,27,64,73–75}

There was 1 case of a margin recurrence after resection of a colorectal liver metastasis, reinforcing the requirement not to compromise clear margins to achieve a laparoscopic resection. Particular care with the margin should be taken during limited resections in anterior segments (segments 4 and 5) where the posterior margin may be more difficult to assess. This is where the use of precoagulation (ie, Habib 4X) could be of particular interest.

The results for 3- and 5-year overall and disease-free survival for HCC and colorectal liver metastases compare well against published open series.^{62–64,69,73,74,76–78} Direct comparison, however, is difficult. The resections for colorectal liver metastases are performed on a selected population with tumor characteristics suitable for a laparoscopic resection that may also reflect favorable biology. Newer surgical techniques are also performed in an environment of improved chemotherapy that may prolong survival and of improved imaging techniques, so that patients are better staged. HCC resections in cirrhosis are also done taking into consideration the possibilities for transplantation, which will significantly influence long-term survival. In this context, we found that a major advantage of initial laparoscopic hepatectomy was the facilitation of subsequent reoperations, especially transplantation, as compared with earlier laparotomy.⁷⁹

To date, LLR has mainly been reported in case series, with a few retrospective comparative studies. Prospective randomized trials would be ideal, but are difficult to design. As we have shown above there is significant heterogeneity between different pathologies and different procedures in terms of their relative suitability for a laparoscopic approach. A trial would need to be either pathology or procedure specific, so that the results could be interpreted. It would

be difficult in such a specific study to achieve adequate power to show significant differences, considering the low rate of sentinel events such as perioperative mortality or local recurrence, the limited number of cases suitable to be randomized to an open versus laparoscopic approach, and the limited number of centers worldwide experienced in the technique. Until such a trial becomes feasible, continued prospective evaluation is required.

CONCLUSION

Good patient selection and refined surgical technique are the keys to successful LLR, which should find a significant place in the management of liver tumors. The advantages are those of minimally invasive surgery and the facilitation of reoperations. Left lateral sectionectomy and limited resection of solitary peripheral lesions are particularly suitable to a laparoscopic approach and have shown excellent results. Hemihepatectomies are feasible but remain challenging procedures. Small HCCs are more likely to be amenable to laparoscopic resection than colorectal metastases or cholangiocarcinomas. The indications for resection of asymptomatic benign lesions should not be increased because a laparoscopic approach is possible. As randomized trials will be difficult to conduct, LLR requires an ongoing robust audit to identify any emerging problems.

REFERENCES

- Reynolds W. The first laparoscopic cholecystectomy. *JSLA*. 2001;5:89–94.
- Bennett J, Boddy A, Rhodes M. Choice of approach for appendicectomy: a meta-analysis of open versus laparoscopic appendicectomy. *Surg Laparosc Endosc Percutan Tech*. 2007;17:245–255.
- Keus F, de Jong JAF, Gooszen HG, et al. Laparoscopic versus open cholecystectomy for patients with symptomatic cholelithiasis. *Cochrane Database Syst Rev*. 2006;CD006231.
- Winslow ER, Brunt LM. Perioperative outcomes of laparoscopic versus open splenectomy: a meta-analysis with an emphasis on complications. *Surgery*. 2003;134:647–653, discussion 654–655.
- Tjandra JJ, Chan MKY. Systematic review on the short-term outcome of laparoscopic resection for colon and rectosigmoid cancer. *Colorectal Dis*. 2006;8:375–388.
- Reza MM, Blasco JA, Andradas E, et al. Systematic review of laparoscopic versus open surgery for colorectal cancer. *Br J Surg*. 2006;93:921–928.
- Jayne DG, Guillou PJ, Thorpe H, et al; UK MRC CLASICC Trial Group. Randomized trial of laparoscopic-assisted resection of colorectal carcinoma: 3-year results of the UK MRC CLASICC Trial Group. *J Clin Oncol*. 2007;25:3061–3068.
- Fleshman J, Sargent DJ, Green E, et al; The Clinical Outcomes of Surgical Therapy Study Group. Laparoscopic colectomy for cancer is not inferior to open surgery based on 5-year data from the COST Study Group trial. *Ann Surg*. 2007;246:655–662, discussion 662–664.
- Rau HG, Meyer G, Cohnert TU, et al. Laparoscopic liver resection with the water-jet dissector. *Surg Endosc*. 1995;9:1009–1012.
- Cuesta MA, Meijer S, Paul MA, et al. Limited laparoscopic liver resection of benign tumors guided by laparoscopic ultrasonography: report of two cases. *Surg Laparosc Endosc*. 1995;5:396–401.
- Hashizume M, Takenaka K, Yanaga K, et al. Laparoscopic hepatic resection for hepatocellular carcinoma. *Surg Endosc*. 1995;9:1289–1291.
- Azagra JS, Goergen M, Gilbert E, et al. Laparoscopic anatomical (hepatic) left lateral segmentectomy-technical aspects. *Surg Endosc*. 1996;10:758–761.
- Kaneko H, Takagi S, Shiba T. Laparoscopic partial hepatectomy and left lateral segmentectomy: technique and results of a clinical series. *Surgery*. 1996;120:468–475.
- Hüscher CG, Irici MM, Chiodini S. Laparoscopic liver resections. *Semin Laparosc Surg*. 1998;5:204–210.
- Cherqui D, Husson E, Hammoud R, et al. Laparoscopic liver resections: a feasibility study in 30 patients. *Ann Surg*. 2000;232:753–762.
- Koffron AJ, Auffenberg G, Kung R, et al. Evaluation of 300 minimally invasive liver resections at a single institution: less is more. *Ann Surg*. 2007;246:385–392, discussion 392–394.
- Buell JF, Thomas MT, Rudich S, et al. Experience with more than 500 minimally invasive hepatic procedures. *Ann Surg*. 2008;248:475–486.
- Ardito F, Tayar C, Laurent A, et al. Laparoscopic liver resection for benign disease. *Arch Surg*. 2007;142:1188–1193, discussion 1193.
- Bachellier P, Ayav A, Pai M, et al. Laparoscopic liver resection assisted with radiofrequency. *Am J Surg*. 2007;193:427–430.
- Belli G, Fantini C, D'Agostino A, et al. Laparoscopic left lateral hepatic lobectomy: a safer and faster technique. *J Hepatobiliary Pancreat Surg*. 2006;13:149–154.
- Berends FJ, Meijer S, Prevoo W, et al. Technical considerations in laparoscopic liver surgery. *Surg Endosc*. 2001;15:794–798.
- Champault A, Dagher I, Vons C, et al. Laparoscopic hepatic resection for hepatocellular carcinoma: retrospective study of 12 patients. *Gastroenterol Clin Biol*. 2005;29:969–973.
- Chang S, Laurent A, Tayar C, et al. Laparoscopy as a routine approach for left lateral sectionectomy. *Br J Surg*. 2007;94:58–63.
- Chen H, Juan C, Ker C. Laparoscopic liver surgery for patients with hepatocellular carcinoma. *Ann Surg Oncol*. 2008;15:800–806.
- Cherqui D, Soubrane O, Husson E, et al. Laparoscopic living donor hepatectomy for liver transplantation in children. *Lancet*. 2002;359:392–396.
- Cherqui D, Laurent A, Tayar C, et al. Laparoscopic liver resection for peripheral hepatocellular carcinoma in patients with chronic liver disease: midterm results and perspectives. *Ann Surg*. 2006;243:499–506.
- Dagher I, Proske JM, Carloni A, et al. Laparoscopic liver resection: results for 70 patients. *Surg Endosc*. 2007;21:619–624.
- Dagher I, Lainas P, Carloni A, et al. Laparoscopic liver resection for hepatocellular carcinoma. *Surg Endosc*. 2008;22:372–378.
- Descottes B, Lachachi F, Sodji M, et al. Early experience with laparoscopic approach for solid liver tumors: initial 16 cases. *Ann Surg*. 2000;232:641–645.
- Descottes B, Glineur D, Lachachi F, et al. Laparoscopic liver resection of benign liver tumors. *Surg Endosc*. 2003;17:23–30.
- Dulucq JL, Wintringer P, Stabilini C, et al. Laparoscopic liver resections: a single center experience. *Surg Endosc*. 2005;19:886–891.
- Gayet B, Cavaliere D, Vibert E, et al. Totally laparoscopic right hepatectomy. *Am J Surg*. 2007;194:685–689.
- Gigot J, Glineur D, Santiago Azagra J, et al. Laparoscopic liver resection for malignant liver tumors: preliminary results of a multicenter European study. *Ann Surg*. 2002;236:90–97.
- Inagaki H, Kurokawa T, Nonami T, et al. Hand-assisted laparoscopic left lateral segmentectomy of the liver for hepatocellular carcinoma with cirrhosis. *J Hepatobiliary Pancreat Surg*. 2003;10:295–298.
- Kaneko H. Laparoscopic hepatectomy: indications and outcomes. *J Hepatobiliary Pancreat Surg*. 2005;12:438–443.
- Koffron AJ, Kung R, Baker T, et al. Laparoscopic-assisted right lobe donor hepatectomy. *Am J Transplant*. 2006;6:2522–2525.
- Mala T, Edwin B, Rosseland AR, et al. Laparoscopic liver resection: experience of 53 procedures at a single center. *J Hepatobiliary Pancreat Surg*. 2005;12:298–303.
- O'Rourke N, Fielding G. Laparoscopic right hepatectomy: surgical technique. *J Gastrointest Surg*. 2004;8:213–216.
- Poultides G, Brown M, Orlando R. Hand-assisted laparoscopic management of liver tumors. *Surg Endosc*. 2007;21:1275–1279.
- Shimada M, Hashizume M, Maehara S, et al. Laparoscopic hepatectomy for hepatocellular carcinoma. *Surg Endosc*. 2001;15:541–544.
- Soubrane O, Cherqui D, Scatton O, et al. Laparoscopic left lateral sectionectomy in living donors: safety and reproducibility of the technique in a single center. *Ann Surg*. 2006;244:815–820.
- Tang CN, Tsui KK, Ha JP, et al. A single-centre experience of 40 laparoscopic liver resections. *Hong Kong Med J*. 2006;12:419–425.
- Vibert E, Perniceni T, Levard H, et al. Laparoscopic liver resection. *Br J Surg*. 2006;93:67–72.
- Belli G, Fantini C, D'Agostino A, et al. Laparoscopic versus open liver resection for hepatocellular carcinoma in patients with histologically proven cirrhosis: short- and middle-term results. *Surg Endosc*. 2007;21:2004–2011.
- Cai X, Wang Y, Yu H, et al. Laparoscopic hepatectomy for hepatolithiasis: a feasibility and safety study in 29 patients. *Surg Endosc*. 2007;21:1074–1078.
- Farges O, Jagot P, Kirstetter P, et al. Prospective assessment of the safety and benefit of laparoscopic liver resections. *J Hepatobiliary Pancreat Surg*. 2002;9:242–248.
- Kaneko H, Takagi S, Otsuka Y, et al. Laparoscopic liver resection of hepatocellular carcinoma. *Am J Surg*. 2005;189:190–194.

48. Laurent A, Cherqui D, Lesurtel M, et al. Laparoscopic liver resection for subcapsular hepatocellular carcinoma complicating chronic liver disease. *Arch Surg*. 2003;138:763–769, discussion 769.
49. Lee KF, Cheung YS, Chong CN, et al. Laparoscopic versus open hepatectomy for liver tumours: a case control study. *Hong Kong Med J*. 2007;13:442–448.
50. Lesurtel M, Cherqui D, Laurent A, et al. Laparoscopic versus open left lateral hepatic lobectomy: a case-control study. *J Am Coll Surg*. 2003;196:236–242.
51. Mala T, Edwin B, Gladhaug I, et al. A comparative study of the short-term outcome following open and laparoscopic liver resection of colorectal metastases. *Surg Endosc*. 2002;16:1059–1063.
52. Morino M, Morra I, Rosso E, et al. Laparoscopic versus open hepatic resection: a comparative study. *Surg Endosc*. 2003;17:1914–1918.
53. Troisi R, Montalti R, Smeets P, et al. The value of laparoscopic liver surgery for solid benign hepatic tumors. *Surg Endosc*. 2008;22:38–44.
54. Strasberg SM. Nomenclature of hepatic anatomy and resections: a review of the Brisbane 2000 system. *J Hepatobiliary Pancreat Surg*. 2005;12:351–355.
55. Pai M, Navarra G, Ayav A, et al. Laparoscopic Habibtrade mark 4X: a bipolar radiofrequency device for bloodless laparoscopic liver resection. *HPB (Oxford)*. 2008;10:261–264.
56. Decailliot F, Streich B, Heurtematte Y, et al. Hemodynamic effects of portal triad clamping with and without pneumoperitoneum: an echocardiographic study. *Anesth Analg*. 2005;100:617–622.
57. Decailliot F, Cherqui D, Leroux B, et al. Effects of portal triad clamping on haemodynamic conditions during laparoscopic liver resection. *Br J Anaesth*. 2001;87:493–496.
58. Couinaud C. *Le foie: Études Anatomiques et Chirurgicales*. Paris, France: Masson; 1957.
59. Dindo D, Demartines N, Clavien P. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240:205–213.
60. Cherqui D, Rahmouni A, Charlotte F, et al. Management of focal nodular hyperplasia and hepatocellular adenoma in young women: a series of 41 patients with clinical, radiological, and pathological correlations. *Hepatology*. 1995;22:1674–1681.
61. Mazzaferro V, Regalia E, Doci R, et al. Liver transplantation for the treatment of small hepatocellular carcinomas in patients with cirrhosis. *N Engl J Med*. 1996;334:693–699.
62. Scheele J, Stangl R, Altendorf-Hofmann A. Hepatic metastases from colorectal carcinoma: impact of surgical resection on the natural history. *Br J Surg*. 1990;77:1241–1246.
63. Fong Y, Fortner J, Sun RL, et al. Clinical score for predicting recurrence after hepatic resection for metastatic colorectal cancer: analysis of 1001 consecutive cases. *Ann Surg*. 1999;230:309–318, discussion 318–321.
64. Rees M, Tekkis PP, Welsh FKS, et al. Evaluation of long-term survival after hepatic resection for metastatic colorectal cancer: a multifactorial model of 929 patients. *Ann Surg*. 2008;247:125–135.
65. Liu CL, Fan ST, Cheung ST, et al. Anterior approach versus conventional approach right hepatic resection for large hepatocellular carcinoma: a prospective randomized controlled study. *Ann Surg*. 2006;244:194–203.
66. Cho JY, Han H, Yoon Y, et al. Feasibility of laparoscopic liver resection for tumors located in the posterosuperior segments of the liver, with a special reference to overcoming current limitations on tumor location. *Surgery*. 2008;144:32–38.
67. Stephenson KR, Steinberg SM, Hughes KS, et al. Perioperative blood transfusions are associated with decreased time to recurrence and decreased survival after resection of colorectal liver metastases. *Ann Surg*. 1988;208:679–687.
68. Rosen CB, Nagorney DM, Taswell HF, et al. Perioperative blood transfusion and determinants of survival after liver resection for metastatic colorectal carcinoma. *Ann Surg*. 1992;216:493–504, discussion 504–505.
69. Poon RT, Fan ST, Lo CM, et al. Improving survival results after resection of hepatocellular carcinoma: a prospective study of 377 patients over 10 years. *Ann Surg*. 2001;234:63–70.
70. Hanazaki K, Kajikawa S, Shimozawa N, et al. Perioperative blood transfusion and survival following curative hepatic resection for hepatocellular carcinoma. *Hepatogastroenterology*. 2005;52:524–529.
71. Cherqui D, Alon R, Lauzet JY, et al. Limitation of blood transfusions during hepatectomies: study of 150 consecutive hepatic resections on healthy and pathological livers. *Gastroenterol Clin Biol*. 1996;20:132–138.
72. Asahara T, Katayama K, Itamoto T, et al. Perioperative blood transfusion as a prognostic indicator in patients with hepatocellular carcinoma. *World J Surg*. 1999;23:676–680.
73. Cha CH, Ruo L, Fong Y, et al. Resection of hepatocellular carcinoma in patients otherwise eligible for transplantation. *Ann Surg*. 2003;238:315–321, discussion 321–323.
74. Belghiti J, Regimbeau JM, Durand F, et al. Resection of hepatocellular carcinoma: a European experience on 328 cases. *Hepatogastroenterology*. 2002;49:41–46.
75. Belghiti J, Hiramatsu K, Benoist S, et al. Seven hundred forty-seven hepatectomies in the 1990s: an update to evaluate the actual risk of liver resection. *J Am Coll Surg*. 2000;191:38–46.
76. Malik HZ, Prasad KR, Halazun KJ, et al. Preoperative prognostic score for predicting survival after hepatic resection for colorectal liver metastases. *Ann Surg*. 2007;246:806–814.
77. Capussotti L, Muratore A, Amisano M, et al. Liver resection for hepatocellular carcinoma on cirrhosis: analysis of mortality, morbidity and survival—a European single center experience. *Eur J Surg Oncol*. 2005;31:986–993.
78. Bismuth H, Chiche L, Adam R, et al. Liver resection versus transplantation for hepatocellular carcinoma in cirrhotic patients. *Ann Surg*. 1993;218:145–151.
79. Laurent A, Tayar C, Andreoletti M, et al. Laparoscopic liver resection facilitates salvage liver transplantation for hepatocellular carcinoma. *J Hepatobiliary Pancreat Surg*. 2009;16:310–314.