CIRUGÍA ESPAÑOLA

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Original article

Laparoscopic Liver Resection: Lessons Learned After 132 Resections☆

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ARTICLE INFO

Article history:
Received 15 October 2012
Accepted 22 November 2012
Available online 9 December 2013

Keywords:
Liver surgery
Benign liver tumours
Hepatic metastases
Hepatocarcinoma
Laparoscopic liver surgery

ABSTRACT

Introduction: After 20 years of experience in laparoscopic liver surgery there is still no clear definition of the best approach (totally laparoscopic [TLS] or hand-assisted [HAS]), the indications for surgery, position, instrumentation, immediate and long-term postoperative results, etc.

Aim: To report our experience in laparoscopic liver resections (LLRs).

Patients and method: Over a period of 10 years we performed 132 LLRs in 129 patients: 112 malignant tumours (90 hepatic metastases; 22 primary malignant tumours) and 20 benign lesions (18 benign tumours; 2 hydatid cysts). Twenty-eight cases received TLS and 104 had HAS. Surgical technique: 6 right hepatectomies (2 as the second stage of a two-stage liver resection); 6 left hepatectomies; 9 resections of 3 segments; 42 resections of 2 segments; 64 resections of one segment; and 5 cases of local resections.

Results: There was no perioperative mortality, and morbidity was 3%. With TLS the resection was completed in 23/28 cases, whereas with HAS it was completed in all 104 cases. Transfusion: 4.5%; operating time: 150 min; and mean length of stay: 3.5 days. The 1-, 3- and 5-year survival rates for the primary malignant tumours were 100, 86 and 62%, and for colorectal metastases 92, 82 and 52%, respectively.

Conclusion: LLR via both TLS and HAS in selected cases are similar to the results of open surgery (similar 5-year morbidity, mortality and survival rates) but with the advantages of minimally invasive surgery.

Resección hepática por laparoscopia: lecciones aprendidas tras 132 resecciones

Palabras clave:
Cirugía hepática

RESUMEN

Introducción: Tras 20 años de experiencia en cirugía hepática laparoscópica, aún no están bien definidos el mejor abordaje (totalmente laparoscópico [CTL] o asistido con la mano

☆ Please cite this article as: Robles Campos R, Marín Hernández C, Lopez-Conesa A, Olivares Ripoll V, Paredes Quiles M, Parrilla Paricio P. Resección hepática por laparoscopia: lecciones aprendidas tras 132 resecciones. Cir Esp. 2013;91:524–533.

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2173-5077/$ – see front matter

Tumores hepáticos benignos
Metástasis hepáticas
Hepatocarcinoma
Cirugía hepática laparoscópica

[CLA]), indicaciones quirúrgicas, posición, instrumentación, resultados postoperatorios inmediatos y a largo plazo, etc.

Objetivo: Presentar nuestra experiencia en resecciones hepáticas laparoscópicas (RHL).

Pacientes y método: En 10 años hemos realizado 132 RHL en 129 pacientes: 112 tumores malignos (90 metástasis hepáticas; 22 tumores malignos primarios) y 20 lesiones benignas (18 tumores benignos; 2 quistes hidatídicos). Veintiocho casos se realizaron por CTL y 104 por CLA. Técnica quirúrgica: 6 hepatectomías derechas (2 como segundo tiempo de una resección hepática en 2 tiempos); 6 hepatectomías izquierdas; 9 resecciones de 3 segmentos; 42 resecciones de 2 segmentos; 64 resecciones de un segmento y 5 casos de resecciones locales.

Resultados: No existió mortalidad perioperatoria. Morbilidad: 3%. Con CTL se completó la resección en 23/28 casos, mientras que con CLA se completó en los 104 casos. Transfusión 4,5%; tiempo quirúrgico 150 min y estancia media de 3,5 días. La supervivencia a 1, 3 y 5 años de los tumores malignos primarios fue del 100, 86 y 62%, mientras que la supervivencia de las metástasis colorrectales fue del 92, 82 y 52%, respectivamente.

Conclusión: La RHL, tanto por CTL como por CLA, en casos seleccionados, reproduce los resultados de la cirugía abierta (morbimortalidad y supervivencia a 5 años similares), con las ventajas de la cirugía mínimamente invasiva.

Introduction

The current indications for laparoscopic liver surgery (LLS), tumours less than 5 cm located in the left anatomic lobe of the liver or in the anterior segment, were outlined in 2000,[1] and these indications were re-established in the Louisville meeting[2] in 2009. More complex laparoscopic liver resections (LLR) (e.g., posterior-superior segments, central tumours, proximity to large vessels, and major resections) should be performed in centres with experience in such procedures.[3–7] The 2 fundamental approaches for LLR are total laparoscopic surgery (TLS)[1,4,6] and assisted laparoscopic surgery (ALS),[4,5,7,8] and a variety of factors, including the surgeon, pathology, lesion size, and the location of lesions, dictate procedure selection.

This article presents our experience with LLS using 2 laparoscopic approaches, TLS and ALS, and it presents the indications, advantages and disadvantages of both techniques. We also present the post-operative outcomes of our LLR series, which is the largest published series in our country.

Patients and Methods

We performed 683 liver resections between January 2003 and April 2012; 132 (19.3%) of these resections were LLR performed in 129 patients (2 LLR were performed in one patient, and resection was performed in 2 stages in 2 patients). LLR was performed in 5.5% of cases in 2003 (3/54 cases) and 23.3% of cases in 2011 (21/90 cases). The median patient age was 62 years (range 23–85), and 54 patients were women (42%).

The indication for LLR in 112 cases (85%) was a malignant tumour (Table 1): 90 liver metastases and 22 primary liver tumours. The remaining 20 resections (15%) were benign lesions: 18 benign tumours and 2 hydatid cysts.

We resected 203 liver lesions, and 42 of these cases exhibited 2 or more lesions (32%) with an average tumour

Table 1 – Indications and Surgical Technique (n=132).

Indications	
A. Malignant tumours	112 (84.8%)
A.1. Liver metastases	90
CLM	84
GIST	2
PNET	2
Breast	1
«tail gut» ADC	1
A.2. Primary malignant tumours	22
HCC cirrhosis	15
HCC healthy liver	5
Leiomyosarcoma	1
peripheral CC	1
B. Benign lesions	20 (15.2%)
Hemangiomas	9
Adenomas	4
FNH	3
Hydatid cysts	2
DSCTN	1
Cystoadenoma	1
Indications hemangiomas	
Tumour growth	4
Tumour rupture	3
Diagnostic suspicion	1
Associated with cholelithiasis in S V	1
Indications adenomas	
All with tumour size>5 cm	
Indications FNH	
Diagnostic suspicion and size>6 cm	
Indications in CLM	
In 45 cases metachronous	
In 35 cases synchronous (colon resection and delayed resection of LM in 34 cases, resection in one stage by removing sigma R0 by laparoscopy and bisegmentectomy VI+VIb)	
Indications in LM without colorectal cancer	
The indication was based on excised tumour	
Indications in hepatocellular carcinoma	
Lesions that required resection of 2 or more segments, peripheral (chemoembolisation of the segments to be resected)	

Table 1 (*Continued*)

Surgical technique	
RH	6
LH	6
Resections 3 segments	9
1 resection III+VII+IVB	
1 resection III+V-VI	
1 resection III+VI+VIII	
2 resections IVb+V+VII	
4 LLS + resections of other segments	
Resections of 2 segments	42
21 LLS	
11 RLS (VI-VII)	
5 V-VI	
2 IVb-V	
1 VII+III	
1 VIII+III	
1 III+V	
Resections of one segment	64
27 segmentectomies	VI
6 segmentectomies	III
7 segmentectomies	V
6 segmentectomies	VIII
6 segmentectomies	VII
6 segmentectomies	II
4 segmentectomies	IVB
1 segmentectomy	IV
1 segmentectomy	I
Local resections	5
2 hemangiomas	
1 LM between segments IVa y IVb	
1 FNH	
1 adenoma	
Manoeuvres added	
1 resection of sigma	
2 partial gastric resections	
2 partial diaphragm resections	
2 body and tail pancreatectomies plus splenectomy (TMNEP)	
1 ovarian resection	
1 hysterectomy	
1 hilar lymphoidectomy CLM	

ADC: adenocarcinoma; CC: cholangiocarcinoma; HCC: hepatocellular carcinoma; GIST: gastrointestinal stroma tumour; RH: Right hepatectomy; LH: Left hepatectomy; FNH: focal nodular hyperplasia; CLM: colorectal liver metastasis; DSCTN: desmoplastic spindle cell tumour in nests; PNET: Pancreatic neuroendocrine tumour; RLS: right lateral segmentectomy; LLS: left lateral segmentectomy.

size of 4.8 cm (range 1–20 cm). Lesions were localised in the right posterior-superior segments of the liver (VII and VIII) in 34 of these cases (26%). LLR was performed for the first time for the treatment of multiple bilobar colorectal liver metastases (CLM) in 4 cases: 2 cases underwent percutaneous portal vein embolisation 1 week before a right hepatectomy was completed via laparoscopy, and CLM was performed via laparotomy in the other 2 cases.

We employed TLS and ALS according to the following criteria:

- *TLS (28 cases)*: TLS was indicated in 13 benign tumours, 11 hepatocellular carcinomas in cirrhotic livers, 3 hepatocellular carcinomas in healthy livers and 1 peripheral cholangiocarcinoma. The patient was placed in a supine position, and the surgeon stood between the patient's legs with 2 assistants. Three trocars were placed following a concave line to the lesion (one trocar is 12 mm when an endovascular stapler is used) (Fig. 1A) to generate a pneumoperitoneum of 12 mmHg. Another 3 optional trocars could be placed if necessary: in the epigastrium for liver retraction, in the right subcostal area to mobilise the right lobe and in the left flank to introduce the clamp used to perform the Pringle manoeuvre (described by our unit).[9,10] We used an optic of 0° and a flexible laparoscopic ultrasound 5.5–7.5 MHz, Philips©. Sectioning of the parenchyma was performed using a harmonic scalpel (Ethicon©), and the intrahepatic vessels were dissected with clips or hemolocks. The hepatic hilum was occluded using a LigaSure Atlas® (Covidien©). We transected the hepatic artery and portal vein in the portal pedicles with ligatures or hemolocks in right and left lobe dissections, and the biliary tract was transected with staples. The suprahepatic veins were dissected and transected with staples. Hemostasis of the liver surface was performed using Tissuelink® (Primm©), and bile leaks were sutured. Hemostatic material was placed on the liver surface (TachoSil®-Nycomed©), and non-aspiration drainage was placed when necessary. The resected specimens are placed in a bag and removed through a Pfannenstiel incision.
- *ALS (104 cases)*: ALS was indicated in 90 cases of liver metastases (LM) of correct staging: 6 for large tumours (2 benign and 4 malignant primary tumours between 7 and 20 cm); 6 for tumours in the right posterior segment (5 large benign tumours of 5 cm and one hepatocellular carcinoma); and 2 cases converted from TLS to ALS. We employed the technique originally described and published by our unit[9,10] (Fig. 1B), which is briefly described here. A transverse incision was made in the right flank from the mid-axillary line to the anterior axillary line, where a handport was placed (GelPort®; Applied Medical©). A full manual examination of the liver and abdominal cavity was performed, and an abdominal ultrasound (Entos®, CT8, Philips©) exploration was performed introduced through the handport. The remainder of the procedure was similar to the procedure for TLS. The resected liver specimen was placed in a bag and removed via the handport.

We performed 21 major resections (16%): 6 right hepatectomies, 6 left hepatectomies and 9 resections of 3 segments (Table 1). Intraoperative radiofrequency ablation was used in 7 patients (2 for the treatment of cirrhotic nodules, 2 to treat CLM of 1 cm size, and 3 to ensure that the surgical margin was clear after the resection of CLM). Additional procedures following LLR were performed in 10 patients (Table 1). The anaesthetic and central venous pressures (CVP) are identical to the parameters of open surgery (CVP below 4).

We calculated the overall survival and disease-free rates at 1, 3 and 5 years using the Kaplan–Meier method. Comparisons of means between groups were performed using the Student *t*-test or the Behrens–Fisher test, depending on the homogeneity of variances between samples, or the non-parametric Mann–Whitney test. We compared percentages between groups with analysis of contingency tables using the Chi-square test or Fisher exact test when case frequencies were low.

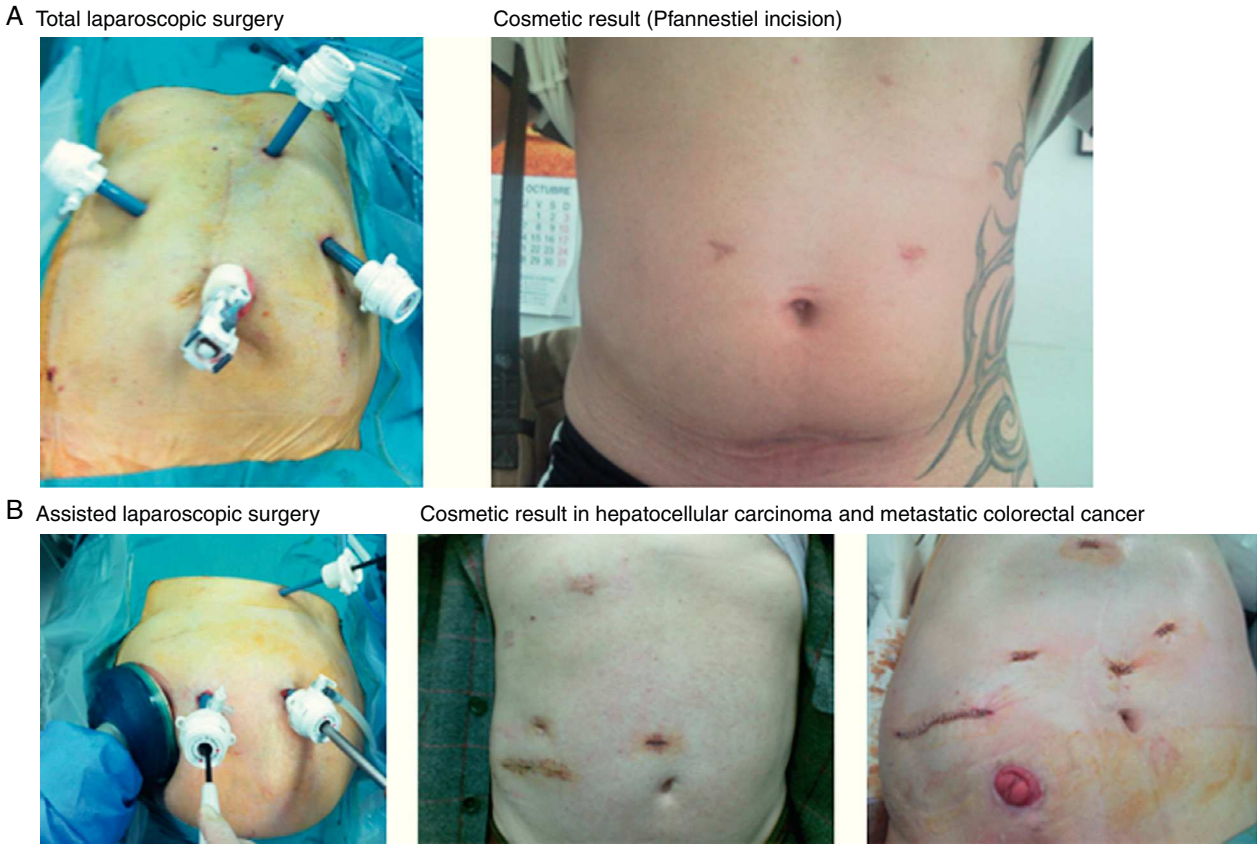


Fig. 1 – Trocar placement in total laparoscopic surgery (TLS) and in assisted laparoscopic surgery (ALS) with aesthetic results. (A) TLS and the cosmetic result (Pfannestiel incision). (B) ALS, cosmetic result in hepatocellular carcinoma and metastatic colorectal cancer.

Table 2 – Results of Laparoscopic Liver Surgery According to the Surgical Indication: Liver Metastases, Primary Malignant Tumours and Benign Tumours.

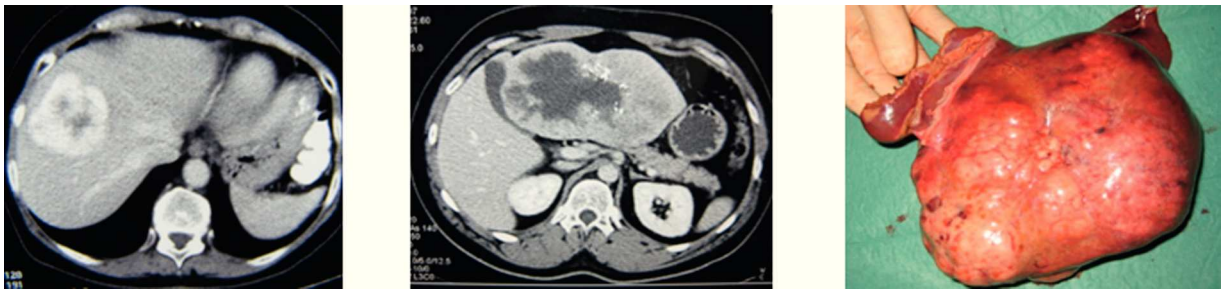
Parameters	Liver metastases (n=90)	Primary malignant tumours (n=22)	Benign tumours (n=20)
Median age (range)	63 (42–85)	65 (39–83)	39 (23–51)
Sex (F) (%)	30 (33.3)	8 (36)	16 (80)
Comorbidity (%)	40 (44.4)	9 (41)	1 (5)
Cirrhotic liver (%)	3 (3.3%)	15 (68%)	0
Number of nodules	159 (1.8%)	24 (1.1%)	20 (1%)
1 nodule (%)	49 (54.4)	21 (95.4)	20 (100)
2 nodules (%)	25 (27.7)	1 (4.6)	0
3 or more nodules (%)	16 (17.7)	0	0
Median tumour size (cm)	3.3 (1–10)	4 (1.5–12)	9 (3–20)
Conversion (%)	2 (2.2)	0	1 (5)
Major resections (%)	18 (20)	1 (4.5)	2 (10)
TLS/ALS (%)	0/90 (100)	15/7 (31)	13/7 (35)
Blood loss (ml)	205 (50–900)	120 (50–600)	120 (100–600)
Transfusions (%)	4 (4.4)	1 (4.5)	1 (5)
Pringle (%)	31 (34.4)	5 (22)	8 (40)
Hemi-hepatic (%)	9 (10)	1 (4.5)	2 (10)
Surgical time, in minutes (range)	177 (60–360)	112 (60–240)	150 (60–300)
Morbidity (%)	3 (3.3)	0	1 (5)
Hospital stay, in days (range)	4.3 (2–30)	3 (2–12)	4.2 (2–20)
Survival rate at 1, 3 and 5 years (%)	92, 82 and 52	100, 86 and 62	100, 100 and 100

ALS: assisted laparoscopic surgery; TLS: Total laparoscopic surgery; F: female.

A Benign tumours

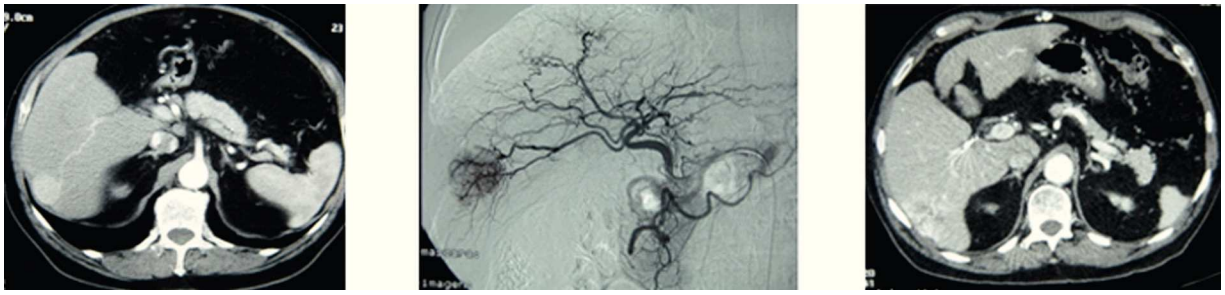
Atypical hemangioma

Desmoplastic spindle cell tumour in nests (HI surgical specimen)



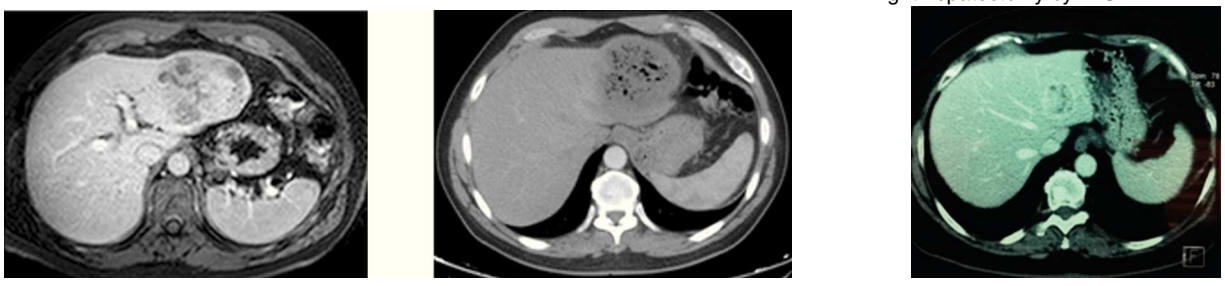
B Primary malignant tumours

B1 Hepatocellular carcinoma in cirrhosis with chemical embolisation



B3 Intrahepatic cholangiocarcinoma that required right hepatectomy by TLS

B2 Hepatocellular carcinoma in healthy liver with pre-operative chemical embolisation



C Liver metastases

C1 Neuroendocrine tumour of the body and tail of the pancreas with liver metastasis in segment VIII

C2 CLM with 2 lesions in the right lobe that required right hepatectomy by ALS

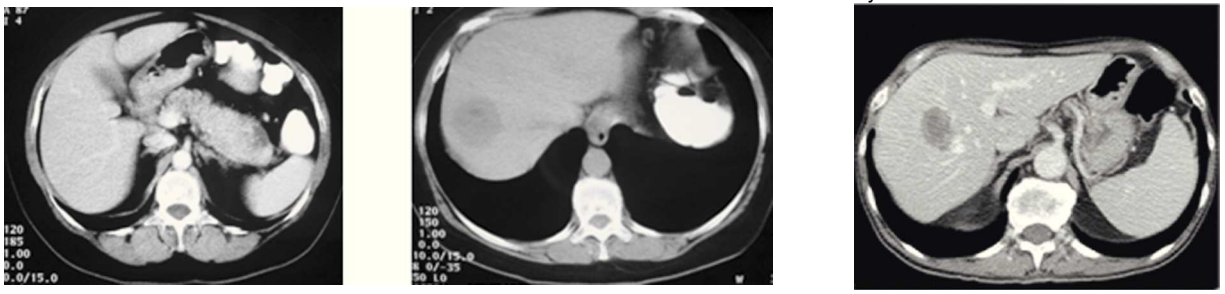


Fig. 2 – Images of some tumours in our series. (A) Benign tumours. (1) Atypical hemangioma. (2 and 3) Desmoplastic spindle cell tumour in nests (HI surgical specimen). (B) Primary malignant tumours. (1) Hepatocellular carcinoma in cirrhosis with chemical embolisation (2) Hepatocellular carcinoma in healthy liver with pre-operative chemical embolisation (3) Intrahepatic cholangiocarcinoma that required right hepatectomy by TLS. (C) Liver metastases. (1) Neuroendocrine tumour of the body and tail of the pancreas with liver metastasis in segment VIII. (2) CLM with 2 lesions in the right lobe that required right hepatectomy by ALS.

Results

No intra- or post-operative deaths occurred. Complications occurred in 4 cases (3%) (2 cases with collections requiring radiological-guided drainage: 1 case of a biliary fistula and 1 case of sepsis due to an infected collection, both cases required reoperation). Transfusions were required in 4.5% of cases (6 patients), and the median operative time was 150 min (range 60–360 min). The average hospital stay was 3.5 days (range 2–30 days). The Pringle manoeuvre was used in 44 cases (33.3%) with a median time of 16 min (range 6–21 min): hemi-hepatic occlusion was performed in 12 cases, 2 cases underwent selective hepatic artery and right portal vein occlusion, and the remaining 74 resections were performed without vascular occlusion.

Three TLS cases were converted to laparotomy (2.3%): 1 case of haemorrhage of a liver adenoma 8 cm in size in segment VII and 2 cases of CLM due to blocking adhesions with an accidental perforation of a small bowel loop. TLS resection was completed in 23 of 28 cases (82%): besides the 3 cases converted to laparotomy, 2 cases were converted to ALS. ALS laparoscopic resection was completed in 104 cases.

ALS was used to resect CLM that were first staged using ultrasound, visualisation of the abdominal cavity and palpation within a prospective comparative study between both staging methods. Eighty-four LR were performed for CLM: 77 were staged (liver resection was performed in 2 stages in 2 patients, and 2 patients who were conversions from TLS to laparotomy and 3 resections in cirrhotic livers were excluded). The addition of palpation detected more disease than ultrasound examination alone in 8 patients (10%) and a peritoneal implant was detected in one of these cases.

Age and comorbidity for benign tumours (Table 2) (Fig. 2A, 2) were lower than in the LM and primary malignant tumours (Fig. 2B, 1, 2 and 3), and tumour size and the percentage of women was higher ($P<.05$). Blood loss, operating time and the number of nodules were higher in LM (Fig. 2C, 1, 2) than in other indications (16 patients had 3 or more lesions), and surgical margins invaded further into the parenchyma in 3 patients. Overall survival and disease-free survival at 1, 3 and 5 years of CLM were 92, 82 and 52% and 85, 60 and 32%, respectively. The number of cirrhotic livers in primary malignant tumours was higher, and there were fewer major resections than in the other 2 groups. Blood loss, the use of the Pringle manoeuvre, operative time, hospital length of stay and morbidity were lower in the other 2 groups. Overall survival and disease-free rates at 1, 3 and 5 years was 100, 86 and 62% and 94, 80 and 50%, respectively.

More cirrhotic livers were observed in the final 66 resections (Table 3) than in the first 66 resections, and no patients were converted to laparotomy. We have conducted more major hepatic resections with a decrease in blood loss, transfusions, Pringle manoeuvres, operating time and hospital stay with increased experience.

Discussion

We initiated LLS of cystic liver lesions in 1993[11] within the context of our overall experience in general laparoscopic surgery.[12–15] We began LLR in January 2003 after we acquired experience in open liver surgery (177 resections). Three LLR series have been published in Spain, and all of these studies include less than 100 cases.[16–18] One national multicentric study examined 104 LLR of solid lesions in 15 centres.[19] Recent institutional studies have included more than 100 LLR (Table 4),[20–38] and recent reviews of almost 3000 patients[39–50] have attempted to verify the safety (morbidity) and curative efficacy compared to open surgery.

Many authors, especially in Europe,[1,6,16,17,26–30,35,36] prefer TLS and reserve ALS for conversion. However, 42 of

Table 3 – Results Obtained by Comparing the First 61 Resections With the Second 62 Resections.

Parameters	Resections 1–66	Resections 67–132	P
Median age, years (range)	59 (24–78)	64 (32–85)	NS
Sex (F) (%)	28 (42.4)	26 (39.3)	NS
Comorbidity (%)	24 (36)	26 (39.3)	NS
Liver cirrhosis (%)	3 (5)	15 (23)	.05
Liver metastases (%)	47 (71)	43 (65)	NS
Primary malignant tumours (%)	7 (11)	15 (23)	
Benign tumours (%)	12 (18)	8 (12)	
Number of nodules	106 (1.6%)	97 (1.5%)	NS
Median tumour size (range)	4.2 (1–20)	4.25 (1–17)	NS
Conversion (%)	3 (4.5)	0	.05
Major resections (%)	7 (11)	14 (21)	.05
TLS/ALS (%)	8/58 (88)	20/46 (69.6)	NS
Blood loss in ml (range)	200 (50–900)	120 (50–600)	NS
Transfusion (%)	4 (6)	2 (3)	.05
Pringle (n=43) (%)	28 (42)	16 (24)	.05
Hemi-hepatic (n=11) (%)	4 (6)	8 (12)	NS
Surgical time in minutes (range)	171 (60–360)	138 (60–240)	NS
Morbidity (%)	2 (3)	2 (3.3)	NS
Hospital stay in days (range)	6 (2–30)	3 (2–25)	.05

ALS: assisted laparoscopic surgery; TLS: Total laparoscopic surgery; F: female.

Table 4 – Series With Over 100 Laparoscopic Liver Resections (Excluding Meta-analyses, Reviews and Multicentric Studies).

Author	Number of patients	Surgical indications	Approach	Major resections	Conversion	Transfusion	Pringle	Morbidity	Mortality	Stay
Koffron et al.[20]	300	Cysts 70; TB 107; TM 103; donor 20	TLS 241; ALS 32; hybrid 27	119: HI 47; HD 64; RT 8	from TLS to ALS in 6% (20)	2 in 300	No	9.3	0	1.9
Chen et al.[21]	116	HCC	TLS	4: total LH	6 (5.2%)	8 cases		7 cases	0	6
Topal et al.[22]	102	TB 32; TM 77	TLS	21: RH 14; LH 4; tri-segmentectomies 3	7 cases	Loses: 100 (5–4000)	11 cases	6 (5.5%)		6
Cho et al.[23]	128	TB 50; TM 78	TLS	36: RH 13; LH 23	4 (3.1%)	20 cases	No	9 cases	1	11
Buell et al.[24]	306 (253 patients)	Cysts 40; BT 107; MT 106	TLS ALS	62: RH 33; LH 24; RT 5	2 cases	7%		16%	4 (1.6%)	2.9
Han et al.[25]	170	Hepatolithiasis 58; BT 15; MT 97	TLS	21: RH 12; LH 9	6 (5.4%)	Loses: 506 (10-1800)	No	17 (15.2%)	0	9.5
Bryant et al.[26]	166	Cysts 17; BT 49; MT 100	TLS 150; ALS in 16	31: RH 19; LH 11; hepat central 1	16 (9.6%)	9 (5.4%)	88 cases	25 (15.1%)	0	6
Wakabayashi et al.[27]	176	BT: 12; MT 157; donor 7	TLS 131; ALS 45	24: RH 12; LH 11; TD 2	1.7%	9 (5.1%)	No	8 (4.5%)	0	NA
Castaing et al.[29]	215 (60)	CLM n=60	TLS	26: RH 22; extended resections 2; hepatec central 1; left lobectomy + segmentectomy	6 (10%)	15%	17%	27%	1.7%	10
Vigano et al.[28]	174	TB 67; TM 107	TLS 156; ALS: 18 (10%)	35: RH 23	17 (9.8%)	9 (5.1%)	91 (52%)	25 (13.7%)	0	7
Nguyen et al.[31]	314	Cysts 24.2%; T. solid 75.8%: BT: 54.6% y and MT: 45.4%	TLS 56%; ALS 37%; hybrid 3.5%	47: RH 21; LH 26	33 (7.7%)	51 (14.6%)	No	CCR 4%; HCC 6%	0	3 days
Kazaryan et al.[30]	135	CLM	TLS	6: RH 5; LH 1	5 (4.2%)	16 (14%)	No	16 (14%)	1 of 122	3
Troisi et al.[32]	110 (LLS 37 cases)	De los 37 LLS (BT 17; MT 19; donor 1)	TLS	All LLS	0	0	No	3 (8.1%)	0	6
Cannon et al.[33]	300	BT 168; MT 132	ALS 211 (70.3%)	133 (44.3%)	4 cases	21 (7%)	11%	5 (1.7%)	32 (10.7%) in LR major	NA
Costi et al.[35]	100	benign T.: 28; malig T: 33; live donor: 39	TLS	13: RH 4; LH 4; Resections 3; segmentectomy 5	17 cases	1 case	15 cases	21	0	9 days
Abu-Hilal et al.[36]	215 (133 malignant tumours)	CLM: 83; HCC: 18; NET: 17; LM no CRC: 11; lymphoma: 2; CCC intrah: 2	TLS	42 R. major 1 (32%): RH 34; LH 6; trisegmentectomies 2	7 cases to laporotomy; 4 to ALS	300 ml (10–3000)	No	16 (13%)	1 (0.8%)	4 days
Ker et al.[34]	116	HCC	TLS	4: LH 4	6 (5.2%)	8 (6.9%)	No	7 (6%)	0	6 days
Yoon et al.[37]	225 (107 HCC)	HCC	TLS	11: RH7; LH 3; central 1	5 (4.7%)	31 (29%)	No	18 (16.8%)	0	9.3
Kwon et al.[38]	111 (61 TM)	MT: 34 HCC; 3 CCI; 24 LM	TLS	4: RH 2; LH 2	2 (3%) to laparotomy	11 (18%)	No	9 (14%)	0	9 days

CCC: cholangiocarcinoma; ALS: assisted laparoscopic surgery; HCC: hepatocellular carcinoma; RH: right hepatectomy; LH: left hepatectomy; CLM: colorectal liver metastases; NO not obtainable; LLS: left lateral sectionectomy; BT: benign tumours; RT: right trisectomectomy; MT: malignant tumours; NET: neuroendocrine tumours.

103 resections (40.4%) in a review of LLR by CLM were performed using ALS, and it was more frequently used in American centres (85%) than European (15%).[31,42] The Louisville meeting concluded that ALS is quick, safe and most likely more effective than TLS for LM, and it highlighted the high rate of TLS use in the U.S.[2,41] and Japan.[38] A problem of TLS in CLM is the possibility of failure to detect occult lesions using laparoscopic ultrasound examination. This problem has been demonstrated in several studies in which the addition of liver palpation in staging detected liver disease and/or inadvertent peritoneal lesions in 10%–20% of cases when converting to laparotomy or ALS.[8,51–53] Our results in CLM demonstrate under-staging in 10% of cases, which suggests that palpation is essential for proper staging.[53]

TLS is the indicated approach in primary malignant tumours because they are often unique surgeries, and palpation is ineffective for the adequate staging of hepatocellular carcinoma in cirrhotic livers. Staging must be performed with ultrasound alone in these cases (in our series, there were 15 out of 22 cases by TLS). TLS of hepatocellular carcinoma in cirrhosis may reduce postoperative ascites due to the preservation of the collateral circulation.[16,17,21,28,34,37] We use pre-operative chemical embolisation of the segments to be resected[54] to decrease the amount of haemorrhage and the need for the Pringle manoeuvre. This technique may also ensure the surgical margin because most of the chemically embolised nodules exhibited greater than 90% necrosis.

Benign tumours are a good indication for LLS because these patients are young and present with solitary tumours (Table 2) and the cosmetic result is important. TLS is the ideal approach because the resected liver is extracted through a Pfannenstiel incision, and this approach was performed in 13 of 20 of our patients. ALS may be an alternative start for large tumours and/or localisation in posterior segments of the right lobe[5,8,10,18,20,21,31] or after conversion from TLS. TLS has not changed the indication of benign tumours in our unit, and this procedure was used for 6% of all solid tumours that were resected until January 2003 and 7.5% since that date. However, benign tumours account for 20%–50% of the indications in some series.[19,20,26]

The size and localisation of lesions are important for the selection of patients for LLS.[4,5,10,16–18,20,23,24,31] In our series, 36 patients (25%) had tumours larger than 5 cm. Additionally, the difficulties are even greater if these large lesions are located in posterior segments (as occurred in 9 of the 34 patients with tumours in that location), and some surgeons advocate placing the patient in the lateral decubitus position.[1,16,17,28,33] However, ALS in supine patients has expanded the initially recommended indications for some authors, especially American and Asian authors, and for us.[5,10,18,20,24,31,33] This position allows us to more easily address posterior right lobe lesions and perform a higher percentage of hepatic resections and hemi-hepatectomies. Our unit performed this resection in 16% of cases. The use of the hand reproduces the advantages of open surgery, including liver mobilisation, vascular pedicle control and compression, for some American[20,24,31,33] and Japanese authors.[38,39]

The conversion of TLS to laparotomy oscillates between 0% and 20%.[10,16–18,20–38] Our conversion rate is 2.3%, and this rate is related to the approach employed. Therefore, TLS became laparotomy in 3 of the 28 cases, and there was no conversion to ALS. An alternative to conversion to laparotomy from TLS is conversion to ALS, which is a manoeuvre that we and some other authors (0.3% conversion)[20,41,42] have used.

The margin of invasion in malignant tumours is a cause for conversion.[24,26,30,33,40] The margin with TLS, is accounted for by the performing of repeated scans,[1,6,16,17,26,28] and the margin in ALS is accounted for by using palpation and ultrasound examination.[5,8,10,20,24,41] Some authors have used radiofrequency ablation of the surgical resection bed when the margin is invaded to prevent conversion,[24,41,42] and we employed this approach in 3 of our patients. Adhesions in patients with CLM is another cause of conversion,[30,41,42] which occurred in 2 of our cases who also exhibited associated bowel lesions. The most frequent cause for conversion is haemorrhage,[1,10,16,17,19,30,36,47] which can occur during the sectioning of the parenchyma or the dissection of the portal vessels, inferior vena cava (IVC) and hepatic segment veins. Manual compression is lost with TLS and requires the bleeding to be controlled mainly with the Pringle manoeuvre. Direct compression in ALS reduces blood loss and provides greater security against possible vascular lesions. Vascular injury is difficult to control, and it often requires conversion. However, some surgeons have sutured lesions of the IVC and hepatic segment veins.[6] We control haemorrhage in ALS of IVC lesions, injuries to the right hepatic artery, a portal vein injury and a torn right middle hepatic segment vein by laparoscopic suturing. We suggest that the above techniques and left lateral segmentectomy can be performed safely without vascular occlusion, but the Pringle manoeuvre provides greater security for right posterior segments.

Vascular control of the hepatic segment veins is a complex manoeuvre. Middle and left vascular pedicle dissection can be performed more easily in left hepatectomy because of the space that exists with the IVC, which allows vascular staple transection. We performed this manoeuvre in 5 of the 6 patients. We have performed the control of the right hepatic segment veins, which is a very complicated manoeuvre,[6] on 4 occasions.

In conclusion, LLR, either by TLS or ALS, shares all the advantages of minimally invasive surgery (e.g., better and faster postoperative recovery, better cosmesis and less postoperative analgesic requirements) with rates of complications and survival in malignant tumours that are similar to the results reported for open surgery.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

REFERENCES

1. Cherqui D, Husson E, Hammoud R, Malassagne B, Stephan F, Bensaid S, et al. Laparoscopic liver resections: a feasibility in 30 patients. Ann Surg. 2000;232:753–62.
2. Buell JF, Cherqui D, Geller DA, O'Rourke N, Iannitti D, Dagher I, et al. The international position on laparoscopic liver

surgery. The Louisville stament, 2008. Ann Surg. 2009;250:825–30.
3. O'Rourke N, Fielding G. Laparoscopic right hepatectomy: surgical technique. J Gastroint Surg. 2004;8:213–6.
4. Buell JF, Koffron AJ, Thomas MJ, Rudich S, Abecassis M, Woodle ES. Laparoscopic liver resection. J Am Coll Surg. 2005;200:472–80.
5. Huang M, Lee W, Wang W, Wei P, Chen R. Hand-assisted laparoscopic hepatectomy for solid tumor in the posterior portion of the right lobe: initial experience. Ann Surg. 2003;238:674–9.
6. Dagher I, O'Rourke N, Geller DA, Cherqui D, Belli G, Gamblin TC, et al. Laparoscopic major hepatectomy: an evolution in standard of care. Ann Surg. 2009;250:856–60.
7. Robles R, Marín C, Abellán B, López-Conesa A, Ramírez P, Parrilla P. Hepatectomía derecha e izquierda por laparoscopia asistida. Descripción de un abordaje original. Cir Esp. 2006;80:326–30.
8. Antonetti M, Killelea B, Orlando R. Hand-assisted laparoscopic liver surgery. Arch Surg. 2002;137:407–12.
9. Robles R, Abellán B, Marín C, Fernández JA, Ramírez P, Morales MD, et al. Resección de tumores hepáticos sólidos por laparoscopia. Presentación de nuestra experiencia. Cir Esp. 2005;78:238–45.
10. Robles R, Marín C, Abellán B, López A, Pastor P, Parrilla P. A new approach to hand-assisted laparoscopic liver surgery. Surg Endosc. 2008;22:2357–64.
11. Luján JA, Parrilla P, Robles R, García-Ayllón J. Laparoscopic treatment of a liver hydatid cyst. Br J Surg. 1993;80:907–8.
12. Luján JA, Robles R, Parrilla P, Soria V, García Ayllón J. Laparoscopic versus open appendicectomy: a prospective assessment. Br J Surg. 1994;81:133–5.
13. Robles R, Parrilla P, Luján JA, Torralba JA, Ramírez P, Sánchez Bueno F. Laparoscopic treatment of biliary peritonitis after T tube removal in patients undergoing orthotopic liver transplantation. Br J Surg. 1997;84:1244.
14. Lujan JA, Parrilla P, Robles R, Marin P, Torralba JA, Garcia-Ayllon J. Laparoscopic cholecystectomy vs open cholecystectomy in the treatment of acute cholecystitis: a prospective study. Arch Surg. 1998;133:173–5.
15. Robles R, Piñero A, Luján J, Fernández JA, Torralba JA, Acosta F, et al. Thoracoscopic partial pericardiectomy in the diagnosis and management of pericarcial effusion. Surg Endosc. 1997;11:253–6.
16. Rotellar F, Bueno A, Benito A, Martí-Cruchaga P, Zozaya G, Pedano N, et al. Resección de lesiones hepáticas sólidas por cirugía totalmente laparoscópica: análisis de 71 casos en una serie institucional. Cir Esp. 2012;90:569–75.
17. Herrero Fonollosa E, Cugat Andorra E, García-Domingo MI, Rivero Deniz J, Camps Lasa J, Rodríguez Campos A, et al. Sectionectomía lateral izquierda laparoscópica: presentación de nuestra técnica. Cir Esp. 2011;89:650–6.
18. Ramos Fernández M, Loinaz Segurola C, Fernández Cebrián JM, Vega López ML. Laparoscopic and hand-assissted liver resection: preliminary results at a mid-sized hospital. Hepatogastroenterology. 2011;58:492–6.
19. Cugat E, Pérez-Romero N, Rotellar F, Súarez MA, Gastaca M, Artigas V, et al. Laparoscopic liver surgery: 8 years of multicenter Spanish register. J Hepatobiliary Pancreat Surg. 2010;17:262–8.
20. Koffron AJ, Auffenberg G, Kung R, Abecassis M. Evaluation of 300 minimally invasive liver resections at a single institution. Ann Surg. 2007;246:385–94.
21. Chen HY, Juan CC, Ker CG. Laparoscopic liver surgery for patients with hepatocellular carcinoma. Ann Surg Oncol. 2008;15:800–6.
22. Topal B, Fieuws S, Aerts R, Vandeweyer H, Penninckx F. Laparoscopic vs open liver resection of hepatic neoplasm: comparative analysis of short-term results. Surg Endosc. 2008;22:2208–13.
23. Cho JY, Han HS, Yoon YS, Shin SH. Experiences of laparoscopic liver resection including lesions in the posterosuperior segments of the liver. Surg Endosc. 2008;22:2344–9.
24. Buell JF, Thomas MT, Rudich S, Marvin M, Nagubandi R, Ravindra KV, et al. Experience with more than 500 minimally invasive hepatic procedures. Ann Surg. 2008;248:475–86.
25. Han HS, Cho JY, Yoon YS. Techniques for performing laparoscopic liver resection in various hepatic locations. J Hepatobiliary Pancreat Surg. 2009;16:427–32.
26. Bryant R, Laurent A, Tayar C, Cherqui D. Laparoscopic liver resection-understanding its role in current practice: the Henri Mondor Hospital experience. Ann Surg. 2009;250:103–11.
27. Wakabayashi G, Nitta H, Takashara T, Shimazu M, Kitajima M, Sasaki A. Standardization of basic skills for laparoscopic liver surgery towards laparoscopic donor hepatectomy. J Hepatobiliary Pancreat Surg. 2009;16:439–44.
28. Vigano L, Laurent A, Tayar C, Tomatis M, Ponti A, Cherqui D. The learning curve in laparoscopic liver resection: improved feasibility and reproducibility. Ann Surg. 2009;250:772–82.
29. Castaing D, Vibert E, Ricca L, Azoulay D, Adam R, Gayet B. Oncologic results of laparoscopic versus open hepatectomy for colorectal liver metastases in two specialized centers. Ann Surg. 2009;250:849–55.
30. Kazaryan AM, Marangos IP, Rosock BI, Rosseland AR, Villanger O, Fosse BI, et al. Laparoscopic resection of colorectal liver metastases: surgical and long-term oncologic outcome. Ann Surg. 2010;252:1005–12.
31. Nguyen KT, Marsh JW, Tsung A, Steel JJ, Gamblin TC, Geller DA. Comparative benefits of laparoscopic vs open hepatic resection: a critical appraisal. Arch Surg. 2011;146:348–56.
32. Troisi RI, Huysse JV, Berrevoet F, Vandenvossche B, Sáinz-Barriga M, Vinci A, et al. Evolution of laparoscopic left lateral sectionectomy without the Pringle maneuver: through resection of benign and malignant tumors to living liver donation. Surg Endosc. 2011;25:79–87.
33. Cannon RM, Brock GN, Marvin MR, Buell JF. Laparoscopic liver resection: an examination of our first 300 patients. J Am Coll Surg. 2011;213:501–7.
34. Ker CG, Chen JS, Kuo KK, Chuang SC, Wang SJ, Chang WC, et al. Liver surgery for hepatocellular carcinoma: laparoscopic versus open approach. Int J Hepatol. 2011;2011:596792.
35. Costi R, Scatton O, Haddad L, Randone B, Andraus W, Massault PP, et al. Lessons learned from the first 100 laparoscopic liver resections: not delaying conversion may allow reduced blood loss and operative time. J Laparoendosc Adv Surg Tech A. 2012;22:425–31.
36. Abu-Hilal M, di Fabio F, Abu Salameh M, Pearce NW. Oncological efficiency analysis of laparoscopic liver resection for primary and metastatic cancer: a single-center UK experience. Arch Surg. 2012;147:42–8.
37. Yoon YS, Han HS, Cho JY, Yoon CJ, Kim JH. Laparoscopic approach for treatment of multiple hepatocellular carcinomas. Surg Endosc. 2012;26:3133–40.
38. Kwon IS, Yun SS, Lee DS, Kim HJ. Laparoscopic liver resection for malignant liver tumor, why not more? J Korean Surg Soc. 2012;83:30–5.
39. Tsuchiya M, Otsuka Y, Tamura A, Nitta H, Sasaki A, Wakabayashi G, et al. Status of endoscopic liver surgery in Japan: a questionnaire survey conducted by the Japanese endoscopic liver surgery study group. J Hepatobiliary Pancreat Surg. 2009;16:405–9.
40. Simillis C, Constantinides VA, Tekkis PP, Darzi A, Lovegrove R, Jiao L, et al. Laparoscopic versus open hepatic resections

for benign and malignant neoplasms – a meta-analysis. Surgery. 2007;141:203–11.
41. Nguyen KT, Gamblin TC, Geller DA. World review of laparoscopic liver resection-2,804 patients. Ann Surg. 2009;250:831–41.
42. Nguyen TN, Laurent A, Dagher I, Geller DA, Steel J, Thomas MT, et al. Minimally invasive liver resection for metastatic colorectal cancer. A multi-institutional report of safety, feasibility, and early outcomes. Ann Surg. 2009;250:842–8.
43. Dagher I, Belli G, Fantini C, Laurent A, Tayar C, Lainas P, et al. Laparoscopic hepatectomy for hepatocellular carcinoma: a European experience. J Am Coll Surg. 2010;211:16–23.
44. Chung CD, Lau LL, Ko KL, Wong AC, Wong S, Chan AC, et al. Laparoscopic liver resection for hepatocellular carcinoma. Asian J Surg. 2010;33:168–72.
45. Zhou YM, Shao WY, Zhao YF, Xu DH, Li B. Meta-analysis of laparoscopic versus open resection for hepatocellular carcinoma. Dig Dis Sci. 2011;56:1937–43.
46. Mirnezami R, Mirnezami AH, Chandrakumaran K, Abu-Hilal M, Pearce NW, Primrose JN, et al. Short- and long-term outcomes after laparoscopic and open hepatic resection: systematic review and meta-analysis. HPB (Oxford). 2011;13:295–308.
47. Park JS, Han HS, Hwang DW, Yoon YS, Cho JY, Koh YS, et al. Current status of laparoscopic liver resection in Korea. J Korean Med Sci. 2012;27:767–71.
48. Li N, Wu YR, Wu B, Lu MQ. Surgical and oncologic outcomes following laparoscopic versus open liver resection for hepatocellular carcinoma: a meta-analysis. Hepatol Res. 2012;42:51–9.
49. Rao A, Rao G, Ahmed I. Laparoscopic versus open liver resection for malignant liver disease. A systematic review. Surgeon. 2012;10:194–201.
50. Stoot JH, Wong-Lung-Hing EM, Limantoro I, Visschers R, Busch OR, van Hillegersberg R, et al. Laparoscopic liver resections in the Netherlands: how far are we? Dig Surg. 2012;29:70–8.
51. Pilkington SA, Rees M, Peppercorn D, John TG. Laparoscopic staging in selected patients with colorectal liver metastases as a prelude to liver resection. HPB (Oxford). 2007;9:58–63.
52. Thaler K, Kanneganti S, Khajanchee Y, Wilson C, Swastrom L, Hanson PD. The evolving role of staging laparoscopy in the treatment of colorectal hepatic metastases. Arch Surg. 2005;140:727–34.
53. Hata S, Imamura H, Aoki T, Hashimoto T, Akahane M, Hasegawa K, et al. Value of visual inspection, bimanual palpation, and intraoperative ultrasonography during hepatic resection for liver metastases of colorectal carcinoma. World J Surg. 2011;35:2779–87.
54. Robles R, Marín C, López-Conesa A, Capel A, Parrilla P. Quimioembolización previa a la resección laparoscópica del hepatocarcinoma precoz en pacientes cirróticos. Cir Esp. 2009;86:303–7.