**Abstract**

Background & Aims: Laparoscopic liver surgery (LLS) is increasingly performed and has become the standard procedure for some indications. However, the role of LLS remains controversial due to the limited number of studies reporting, essentially, the long-term outcomes. The aim of the present study is to analyse the perioperative and long-term outcomes for patients who underwent LLS.

Patients and methods: Clinical, operative, pathological and outcome data from 63 patients who underwent LLS for benign and malignant lesions between January 1993 and August 2015 were collected and analysed retrospectively. Laparoscopic unroofing of liver cysts (LULC) was performed in 25 patients (39.7%) and laparoscopic liver resection (LLR) was performed in 38 patients (60.3%). Amongst the LLR group, 12 patients (19%) had hepatocellular carcinoma, seven (11.1%) had colorectal liver metastases, four (6.3%) had non-colorectal liver metastases, three (4.8%) had hepatocellular adenoma, four (6.3%) had hepatic hemangioma, six (9.5%) had other benign lesions (focal nodular hyperplasia, hydatid cyst, fibrohyaline nodule and solitary necrotic nodule) and two (3.2%) had intermediate-behavior lesions (epithelioid hemangioendoepithelioma and biliary mucinous cystoadenoma).

Results: Overall morbidity was registered in nine patients (14.3%), major morbidity in two (3.2%) – one patient with Dindo-Clavien grade IIIa, including mortality in one patient (Dindo-Clavien grade V). Liver specific morbidity was registered in seven patients (11.1%). In the LLR group, overall mortality was observed eight patients (21%), major morbidity in two (5.2%) and liver specific morbidity in six (15.8%). Chronic liver disease, intraoperative red blood cells transfusion and plasma transfusion were associated with liver specific morbidity ($p<0.05$). The 5- year overall survival (OS) was 67.9% and disease free survival (DFS) was 53.2% for those who had malignant disease. For hepatocellular carcinoma group,

the 5- year overall survival was 74.1% and disease free survival was 51.9%. For the colorectal metastases group, the 5- year overall survival was 53.3% and disease free survival was 62.5%. Conclusion: LLR can be safely performed with low overall morbidity and favourable long-term oncological outcomes. The good results in our series, both short and long-term outcomes in benign and malignant lesions, support the role of laparoscopy in hepatic surgery. As described in the literature, although scarce and supported by low evidence level, results of laparoscopy are comparable to the open technique.

**Keywords:** liver, laparoscopy, liver resection, morbidity, survival

## I. Introduction

Since first described by Gagner in 1992, laparoscopic liver surgery (LLS) has been increasingly performed worldwide and has become the standard practice for some surgical procedures such as left lobectomy, according to the Louisville Statement Consensus Conference (1).

Although LLS was initially restricted to patients with solitary lesions with 5 cm or less, located in segments 2 to 6 (1), indications have been expanding over the last two decades. As with other laparoscopic procedures, the short-term benefits such as less pain, less bleeding and shorter hospital stay have been reported.(2–10) Indeed, the results have improved in terms of less postoperative morbidity and shorter recovery time due to the technological advances, the meticulous knowledge of liver anatomy and advances in laparoscopic skills, aiding in lifting barriers for LLS.

Despite being considered a feasible and safe procedure (11) with reported favourable results, LLR remains controversial (12) and there are still many concerns regarding its role for some indications. Many studies reported favourable results after LLR for hepatocellular

carcinoma (HCC) (13–19) and hepatic metastatic colorectal cancer. (20) Twaij et al (21) described LLR for hepatocellular carcinoma as a safe procedure, especially in patients with cirrhosis, and documented better outcomes when compared to open liver resection. Jianguo et al (20) also described LLR as a safe and feasible treatment for hepatic metastatic colorectal cancer, providing less postoperative morbidity than open liver resection. However, few studies of oncological outcomes in LLR and hepatic metastatic colorectal cancer have been reported and debated (22–24). Therefore, some uncertainty remains regarding the oncological outcomes of LLR. This paper aims to contribute to filling this gap.

The aim of this study is to analyse the perioperative and long-term outcomes for patients who underwent laparoscopic liver resection (LLR) in a single center.

## II. Patients and methods

This study is a retrospective review of clinical, operative data, pathological results and outcome of all patients undergoing laparoscopic liver surgery (LLS) from January 1993 to August 2015 at Serviço de Cirurgia A from Centro Hospitalar e Universitário de Coimbra (Head of Department: Prof. Doutor Francisco Castro e Sousa, Coimbra, Portugal).

The inclusion criteria were laparoscopic liver surgery, including unroofing of liver cysts. In cases of conversion to laparotomy, the patients were not excluded from analysis but the reasons for conversion were noted. Exclusion criteria were: exploratory laparoscopy and conversion to open liver resection due to unexpected intraoperative findings (without attempt at laparoscopic resection); exploratory laparoscopy for staging purposes only; and laparoscopic exploration for diagnostic liver biopsy.

A formal approval of an ethics committee was not required due to the retrospective nature of this study.

## 1. Study population

Sixty-six patients underwent LLS during the study period. Three patients did not match the inclusion criteria and were excluded (Figure 1).

The mean age was 61 ± 11 years (range 36-85). Twenty two (34.9%) were male and forty one (65.1%) female. Nineteen (30.2%) were American Society of Anesthesiologists ASA grade I, twenty one (33.3%) grade II and twenty three (36.5%) grade III.

The most prevalent co-morbidities were hypertension (39.7%), dyslipidemia (28.6%) and diabetes mellitus (12.7%) (Table 1).

Indications for LLS included simple liver cysts in twenty five (39.7%) patients, hepatocellular carcinoma (HCC) in twelve (19%), metastases in eleven (17.4%), namely colorectal cancer liver metastases (CRCLM) in seven (11.1%) and non-colorectal liver metastases (NCRLM) in four (6.3%). Of these, nine patients presented with metachronous and two with synchronous metastases. Two other patients were identified with intermediate behavior lesions (3.2%), one biliary mucinous cystoadenoma and one epithelioid hemangioendothelioma. Three patients were identified with hepatocellular adenoma (4.8%), four with hepatic hemangioma (6.3%), other six with benign lesions (9.5%), three with focal nodular hyperplasia (4.8%), one with hydatid cyst (1.6%), one with fibrohyaline nodule (1.6%) and a last one with solitary necrotic nodule (1.6%) (Table 2). The patients with focal nodular hyperplasia underwent surgery due to suspicion of malignancy on preoperative imaging studies.

The median number of lesions was 1 (range 1 – 13) and the mean diameter of the largest lesion was 61.33 ± 52.1mm (range 8 – 217 mm). The distribution was thirty (47.6%) lesions in left hemi-liver, twenty two (34.9%) in the right hemi-liver and eleven (17.5%) bilobar. The most frequent locations of solid lesions were segment 2 and 6 in ten patients each (26.3%) (Table 2).

Twelve (19%) patients presented with chronic liver disease, namely six (9.5%) alcoholic cirrhosis, one (1.6%) chronic hepatitis B, two (3.2%) hepatitis C, two (3.2%) nonalcoholic steatohepatitis (NASH) and one (1.6%) alcoholic and chronic hepatitis C cirrhosis simultaneously (Table 1). Of these, median MELD score was 8.6 ± 1.6 (range 6 – 11) and eleven (91.7%) Child-Pugh class A and one (8.3%) Class B.

Preoperative systemic chemotherapy was performed in eight (32%) patients of twenty five patients who had malignant diseases. The mean number of cycles was 7 ± 3.8 (range 2 – 12).

The number of LLS (LULC and LLR) per year is shown in figure 2.

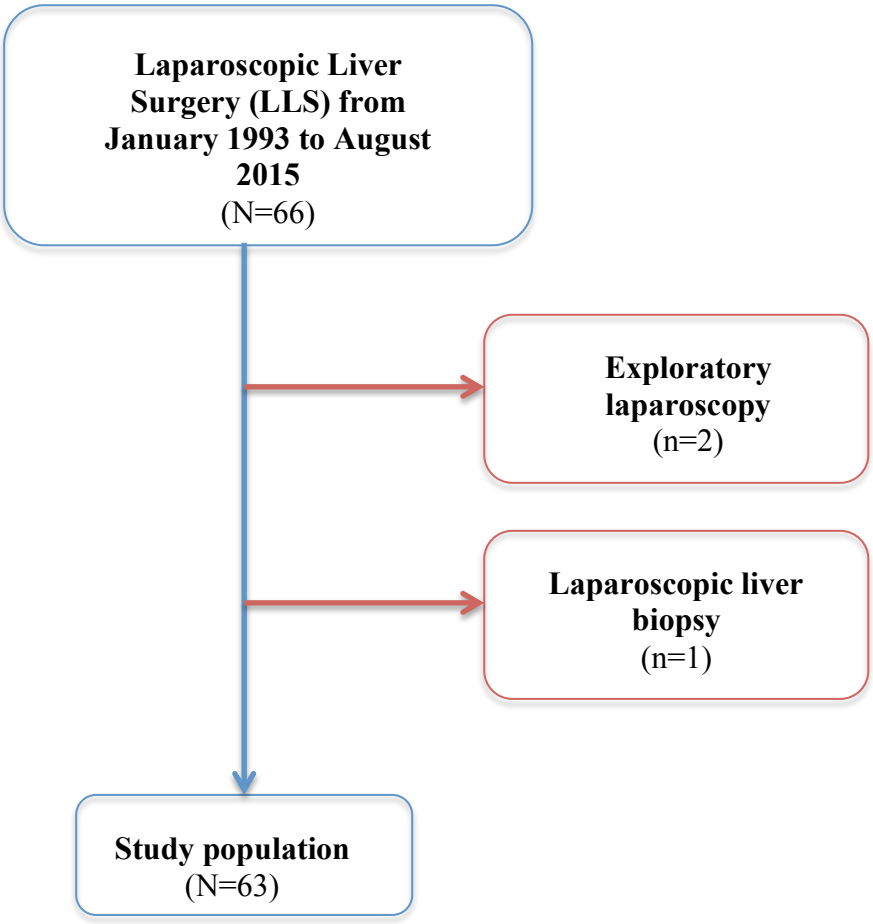
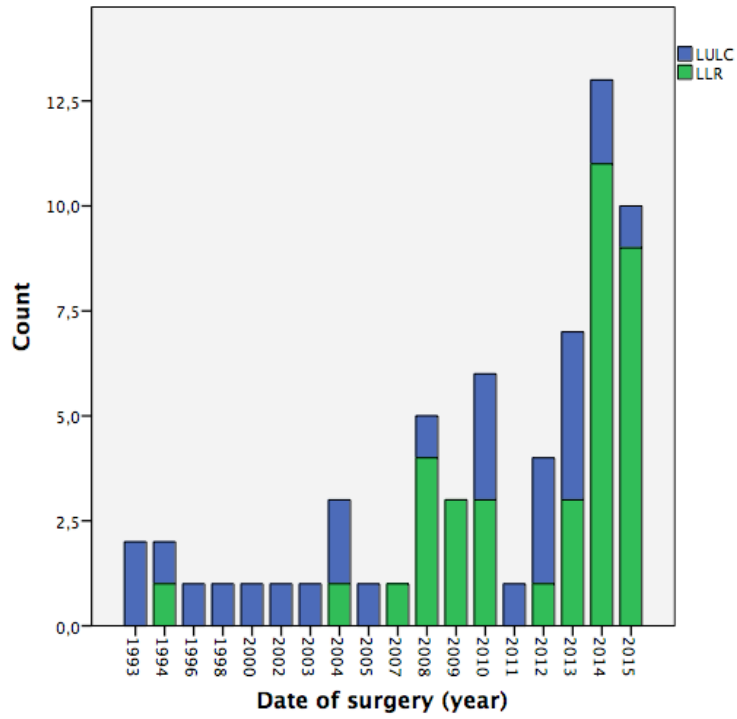



**Figure 1.** Exclusion criteria and study population.

**Figure 2.** Number of LLS per year.




**LULC:** Laparoscopic unroofing of liver cysts; **LLR:** Laparoscopic liver resection

## 2. Operative details

After creation of pneumoperitoneum with a Veress needle, or by open technique, as described by Hasson (25) in cases of previous abdominal surgery, a 12 mm trocar in the supraumbilical position was placed, followed by a 30º scope. Placement of the remaining ports in the upper abdomen was done according to location of pathology. Laparoscopic ultrasound was routinely performed and after exploration of the abdominal cavity for disseminated disease, parenchymal transection was performed with ultrasonic dissector (CUSA™ Ultrasonic Surgical Aspirator, Valleylab, Boulder, CO). Hepatic pedicle clamping was performed, only if deemed necessary by the operating surgeon, in an intermittent clamping strategy, 15 minutes clamping with 5 minutes reperfusion in normal liver and 10 minutes clamping with 5 minutes reperfusion in chronic liver disease, as previously described (Figure 3). (26) LLUC consisted of controlled opening of the cyst, evacuation of contents and

excision of cyst wall to allow ample drainage of fluid. Routine frozen-section pathologic exam of the resected cyst wall was performed in all cases.

Twenty-five patients (39.7%) underwent laparoscopic unroofing of liver cysts and thirty eight (60.3%) underwent liver resection.

Among the resected patients (n=38), one patient (1.6%) underwent major hepatectomy (left hemihepatectomy) and thirty seven (58.7%) underwent minor hepatectomy (Table 3). Fourteen patients (22.2%) underwent segmentectomy, four patients (6.3%) underwent bisegmentectomy, five (7.9%) underwent multiple subsegmentectomies, six (9.5%) underwent left lobectomy and one (1.6%) underwent left hemihepatectomy.

Twenty five patients (39.7%) underwent anatomical liver resection and thirteen (20.6%) underwent non-anatomical liver resections (including subsegmentectomies).

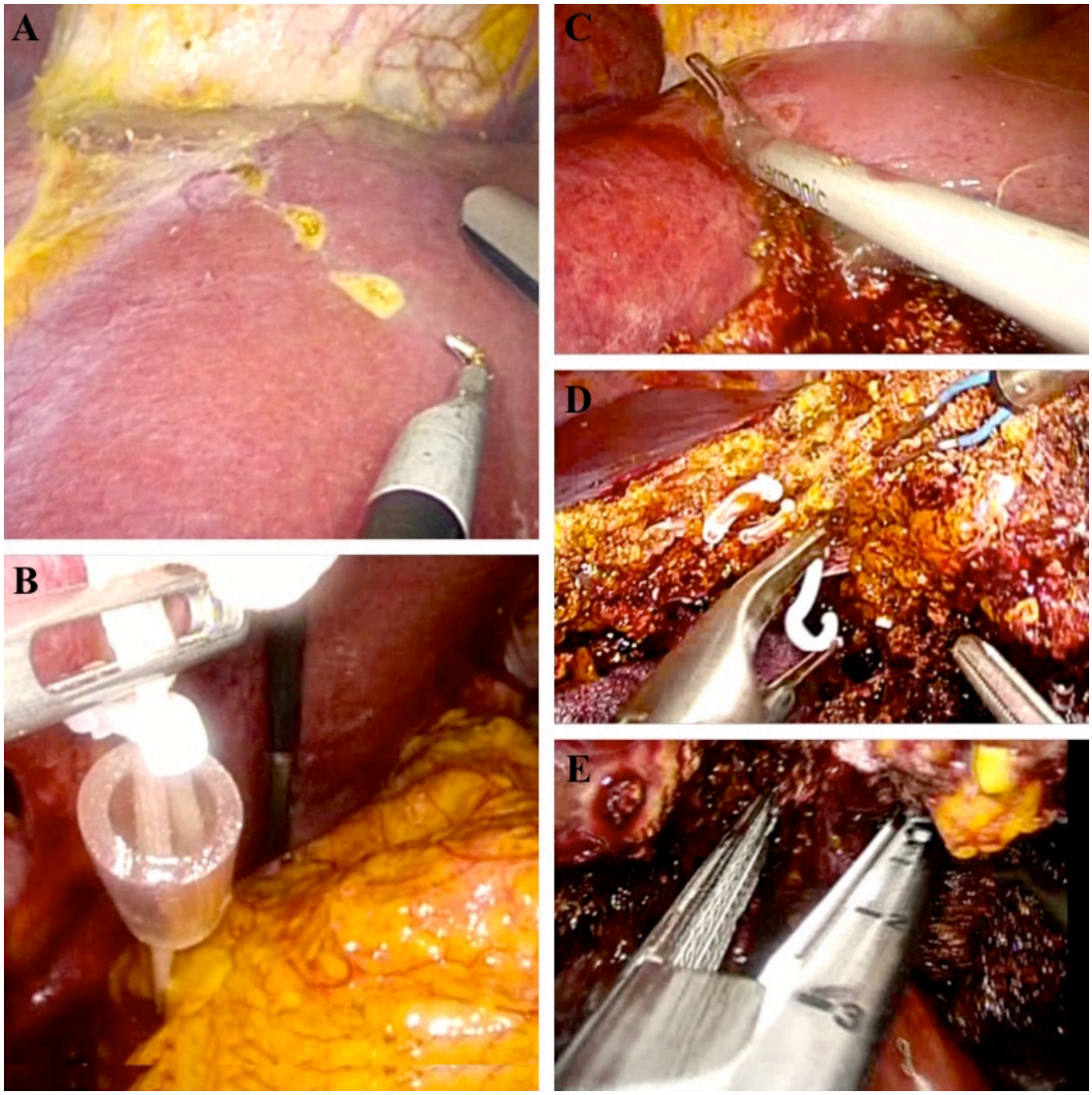
Thirty two patients (50.8%) underwent associated interventions: twenty six (41.3%) cholecystectomies, three (4.8%) colectomies, one (1.6%) splenectomy, one (1.6%) hysterectomy and one (1.6%) tubal ligation. Conversion to open surgery was performed in only one case (1.6%), due to intraoperative hemorrhage.

Ten (15.9%) patients were transfused with packed red blood cells and the mean was 960 ± 386.4 ml (range 400 – 1600). Eleven (17.5%) patients were also transfused with fresh frozen plasma and the mean was 618.18 ± 315.7 ml (range 400 – 1600).

Hepatic pedicle clamping was performed in fifteen (23.8%) patients and the mean time was 40.7 ± 27 minutes (range 11-92).

The mean operative time was 254.4 ± 131.0 minutes (range 60 – 515).

**Figure 3.** Laparoscopic bissegmentectomy (segments 3 and 4): (A) Laparocopic intraoperative ultrasonography and liver marking; (B) Hepatic pedicle clamping (Pringle manoeuver); (C) Parenchymal transection with harmonic scalpel; (D) Hemostasis with non-absorbable clips; (E) Staple transection of glissonian pedicles.



### 3. Outcome

Postoperative morbidity was defined up to the 90$^{th}$ postoperative day according to Dindo-Clavien (27). Major morbidity was defined as Dindo-Clavien score grade greater than II. Liver-specific complications, as biloma, bile leakage, hemorrhage, ascites and posthepatectomy liver failure (PHLF) were defined according to consensus definitions. Additionally, PHLF was specifically graded according to International Study Group of Liver Surgery (ISGLS) consensus.(28)

Patients with malignant diseases were also evaluated in terms of the recurrence rate, overall survival and disease-free survival. Overall survival (OS) was calculated from the date of surgery to the date of death or last follow up. Disease-free survival (DFS) was calculated from the date of surgery to the date of either tumor recurrence, or date of last follow up.

### 4. Pathological data

The histologic margins were collected for the patients who had malignant diseases. Microvascular invasion, satellite nodes and Edmondson-Steiner(29) grade were also recorded in patients with hepatocellular carcinoma.

Of the patients who had malignant diseases, R0 margins (margin $\geq$ 1 millimeter) were found in twenty two (88%) cases while R1 margins (margin < 1 millimeter) were found in three (12%). The mean margin distance was 5.3 mm ± 4.8 (range 0 – 17). Microvascular invasion was found in two 2 cases of hepatocelular carcinoma (16.7%) and there were no satellite nodes.

In twelve patients with hepatocellular carcinoma, the Edmondson-Steiner G1 score was observed in two (16.7%) patients, G2 in seven (58.3%) patients, G3 in two (16.7%) and G4 in one (8.3%) patient.

## 5. Statistical analysis

Statistical analyses were made by SPSS™ software version 22.0. Quantitative data were expressed as mean ± standard deviation (SD) and range. Continuous variables were evaluated using Student's t-test, whereas categorical variables were analyzed performing Chi-square test. Survival probabilities were evaluated with Kaplan-Meyer method and compared with the log- rank test. Statistical significance was defined as $p<0.05$.

**Table 1.** Clinical and demographic characteristics of patients undergoing laparoscopic liver resection.

| Clinical characteristics | All (n=63) | Chronic liver disease (n=12) |
|---|---|---|
| Gender (male/female) | 22/41 | |
| Age *years* (range) | 61 ± 11 (36-85) | |
| Comorbidities | 45 (71.4%) | |
| Hypertension | 25 (39.7%) | |
| Dyslipidemia | 18 (28.6%) | |
| Diabetes | 8 (12.7%) | |
| Chronic liver disease | 12 (19%) | |
| Alchoolic cirrhosis | 6 (9.5%) | |
| HBV | 1 (1.6%) | |
| HCV | 2 (3.2%) | |
| NASH | 2 (3.2%) | |
| Alchool + HBC | 1 (1.6%) | |
| ASA status (I/II/III) | 19/21/23 | |
| Child-Pugh A/B/C | | 11/1/0 |
| MELD (range) | | 8 (6-11) |

**Table 2.** Indications for liver laparoscopic resection.

| LLS indications | Total (%) |
|---|---|
| Simple liver cysts | 25 (39.7%) |
| Hepatocellular carcinoma | 12 (19%) |
| Liver metastases | 11 (17.4%) |
| CRCLM | 7 (11.1%) |
| NCRLM | 4 (6.3 %) |
| Hepatocellular adenoma | 3 (4.8%) |
| Hepatic hemangioma | 4 (6.3%) |
| Benign lesions | 6 (9.5%) |
| Focal nodular hyperplasia | 3 (4.8%) |
| Hydatid cyst | 1 (1.6%) |
| Fibrohyaline nodule | 1 (1.6%) |
| Solitary necrotic nodule | 1 (1.6%) |
| Intermediate behaviour lesions | 2 (3.2%) |
| Billiary mucinous cystoadenoma | 1 (1.6%) |
| Epithelioid hemangioendoepithelioma | 1 (1.6%) |
| **Lesions characteristics** | |
| Number of lesions n (range) | 1.7 ± 1.8 (1 – 13) |
| Lesion size *mm* (range) | 61.3 ± 52.1 (8 - 217) |
| Location (*lobes*) – **Liver cysts** | |
| Right hemi-liver | 7 |
| Left hemi-liver | 8 |
| Bilobar | 15 |
| Location (*segments*) – **Solid lesions** | |
| 2 | 10 |
| 3 | 6 |
| 4 | 6 |
| 5 | 6 |
| 6 | 1 |

**CRCLM:** Colorectal cancer liver metastases; **NCRLM:** Non-colorectal liver metastases.

**Table 3.** Operative details.

| Surgery characteristics | Total (%) |
|---|---|
| **Operative procedure** | |
| Unroofing of liver cyst (LULC) | 25 (39.7%) |
| Liver ressection (LLR) | 38 (60.3%) |
| Anatomic | 25 (39.7%) |
| Nonanatomic | 13(20.6%) |
| Minor hepatectomy | 37 (58.7%) |
| Atypical, nonanatomic | 8 (12.7%) |
| Left lobectomy | 6 (9.5%) |
| Segmentectomy | 14 (22.2%) |
| Bissegmentectomy | 4 (6.3%) |
| Multiple subsegmentectomies | 5 (7.9%) |
| Major hepatectomy | 1 (1.6%) |
| Left hemihepatectomy | 1 (1.6%) |
| **Associated interventions** | 32 (50.8%) |
| Cholecistectomy | 26 (41.3%) |
| Colectomy | 3 (4.8%) |
| Splenectomy | 1 (1.6%) |
| Hysterectomy | 1 (1.6%) |
| Tubal ligation | 1 (1.6%) |
| **Conversion rate** | 1/63 (1.6%) |
| Hemorrhage | 1 |
| **Hepatic pedicle clamping** | 15 (23.8%) |
| Duration *min* (range) | 40.7 ± 27 (11 – 92) |

## III. Results

### 1. Postoperative morbidity

Overall morbidity was registered in nine patients (14.3%). According to the Dindo-Clavien scale, five patients (7.9%) presented a grade I complication, two (3.2%) grade II and one (1.6%) grade IIIa. Postoperative mortality was observed in one case (1.6%), from acute myocardial infarction in the fourth postoperative day (grade V).

For the LULC group (n=25), general morbidity was registered in only one (4%) patient (hemorrhage, Dindo-Clavien grade I). No major morbidity or mortality were registered in this group.

For the LLR group (n=38), general morbidity was registered in eight (21%) patients. According to Dindo-Clavien grading score, four (10.5%) patients presented a grade I complication, two (5.2%) grade II, one (2.6%) grade IIIa and one (2.6%) died (grade V) of acute myocardial infarction on the fourth postoperative day. Major morbidity was registered in two (5.2%) patients. Liver-specific morbidity rate was 15.8% (six patients). Four (16.5%) patients had postoperative liver failure, one (2.6%) patient had biloma treated with percutaneous drainage and one (2.6%) had ascites and liver failure in the postoperative period. One (2.6%) patient had postoperative pneumonia (Dindo –Clavien grade II) (5). Amongst the patients who had PHLF, three were graded class A and two were graded class B according to ISGLS severity grading. All were considered Dindo-Clavien grade II.

On univariate analysis there was a statistical association between liver-specific morbidity and patients with chronic liver disease (Odds Ratio [OR] = 17.14; Confidence Interval [CI] = 1.71 – 172.06; p=0.009) and intraoperative plasma transfusion (OR= 26; CI = 2.45 – 272.82; p=0.003). There was also a statistical association between PHLF and intraoperative plasma transfusion (OR= 16.67; CI = 1.57 – 177.49; p=0.015), chronic liver

disease (OR= 1.71; CI = 1.06 – 2.77; p=0.002) and hepatocellular carcinoma (OR= 1.71; CI = 1.06 – 2.77; p=0.002).

**2. Length of hospital stay**

The median length of hospital stay was 5 (1 - 31) days. The median length stay was 3 (1 – 18) days for patients of LULC group, significantly shorter than the 6 (2 – 31) days for patients who underwent LLR (Mann-Whitney p = 0.001) (Table 4).

**3. Recurrence**

Hepatic recurrence was registered in eight patients (32%) from the 25 who had malignant diseases (n=25). The recurrence rate was 50% (six patients) for the HCC group and 28.6% (two patients) for the CRCLM (Table 5).

At the end of this study, eighteen patients (72%) were alive, four (17%) had tumoral death, one (4%) had non-tumoral death and two (8%) were lost for follow-up. Two patients with HCC (16.7%) and two patients with CRCLM (28.6%) had tumoral death. One patient of the NCRLM group had non-tumoral death.

**4. Overall and disease free survival**

After a median follow up time of 22 months, the median overall survival for patients with malignant disease was 31.56 ± 30.56 (0 – 92) months and the median disease-free survival was 27.92 ± 28.05 (0-92) months, with 1-, 3-, 5- year OS of 94.4%, 79.3%, 67.9% and DFS of 77.4%, 63.8%, 53.2%, respectively (Figure 4).

For hepatocellular carcinoma group, the median OS was 42.50 ± 36.5 (3 - 92) months and median DFS was 36.25 ± 33.19 (3 – 92), with 1-, 3-, 5- year OS of 88.9%, 88.9%, 74.1%

and DFS of 77.8%, 64.8% and 51.9%, respectively. For these patients, the OS and DFS were significantly lower (p=0.005) when microvascular invasion was present (Figure 5, C-D).

For patients who had colorectal liver metastases, OS was 28.86 ± 21.87 (5 – 67) and DFS was 26.43 ± 23.27 (5 – 67), with the 1-, 3-, 5- year OS of 100%, 80%, 53.3% and DFS of 83.3%, 62.5% and 62.5%, respectively. For these patients, the DFS was significantly lower in single lesions (p=0.027) and when neoadjuvant chemotherapy was performed (p=0.025) (Figure 6, C-D).

The median OS and DFS were the same for the patients who had non-colorectal liver metastases, 8.25 ± 14.52 (0-30) months (Table 5).

**Table 4.** Postoperative results.

| Postoperative complications | All (n=63) | LULC (n=25) | LLR (n=38) |
|---|---|---|---|
| **Overall morbidity** | 9 (14.3%) | 1 (4%) | 8 (21%) |
| **Dindo-Clavien classification grade** | | | |
| I | 5 (7.9%) | 1 (4%) | 4 (10.5%) |
| II | 2 (3.2%) | 0 | 2 (5.2%) |
| IIIa | 1 (1.6%) | 0 | 1 (2.6%) |
| IIIb | 0 | 0 | 0 |
| IVa | 0 | 0 | 0 |
| IVb | 0 | 0 | 0 |
| V | 1 (1.6%) | 0 | 1 (2.6%) |
| **Major morbidity** | 2 (3.2%) | 0 | 2 (5.2%) |
| **Liver-specific complications** | 7 (11.1%) | 1 (4%) | 6 (15.8%) |
| Biloma | 1 (1.6%) | 0 | 1 (2.6%) |
| Haemorrhage | 1 (1.6%) | 1 (4%) | 0 |
| PHLF | 4 (6.3%) | 0 | 4 (10.5%) |
| Ascites | 1 (1.6%) | 0 | 1 (2.6%) |
| **Non-hepatic complications** | 2 (3.2%) | 0 | 2 (5.2%) |
| Pneumonia | 1 (1.6%) | 0 | 1 (2.6%) |
| Acute myocardial infarction | 1 (1.6%) | 0 | 1 (2.6%) |
| **Length of hospital stay *days* (range)** | 6.06 ± 5.4 (1 - 31) | 4.44 ± 3.74 (1 – 18) | 7.13 ± 6.07 (2 – 31) |
| **Postoperative mortality** | 1 (1.6%) | 0 | 1 (2.6%) |
| Cause | Acute myocardial infarction | | Acute myocardial infarction |

**PHLF:** Posthepatectomy liver failure.

**Table 5.** Postoperative status in patients with malignant diseases.

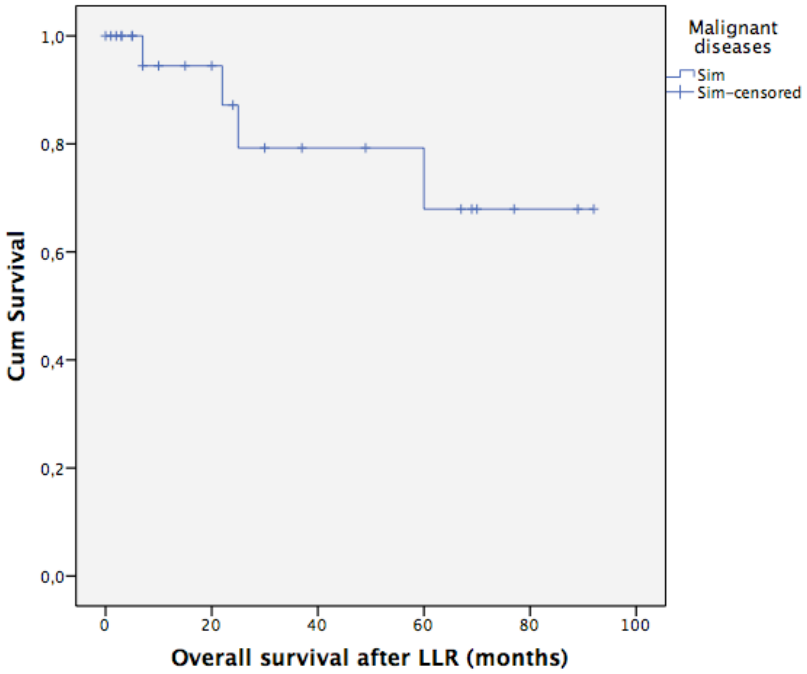
| Postoperative status | Malignant disease (n=25) | HCC (n=12) | CRCLM (n=7) | NCRLM (n=4) |
|---|---|---|---|---|
| **Hepatic recurrence rate** | 8/25 (32%) | 6/12 (50%) | 2/7 (28.6%) | 0 |
| **Postoperative status** | | | | |
| Alive | 18 (72%) | 9 (75%) | 4 (57.1%) | 3 (75%) |
| Tumoral death | 4 (16%) | 2 (16.7%) | 2 (28.6%) | 0 |
| Non-tumoral death | 1 (4%) | 0 | 0 | 1 (25%) |
| Lost for follow-up | 2 (8%) | 1 (8.3%) | 1 (14.3%) | 0 |
| **Disease-free survival *months* (range)** | 27.92 ± 28.05 (0 – 92) | 36.25 ± 33.19 (3 - 92) | 26.43 ± 23.27 (5 - 67) | 8.25 ± 14.52 (0-30) |
| **Overall survival *months* (range)** | 31.56 ± 30.56 (0 – 92) | 42.50 ± 36.5 (3 -92) | 28.86 ± 21.87 (5 – 67) | 8.25 ± 14.52 (0-30) |

**HCC**: Hepatocellular carcinoma; **CRCLM**: Colorectal cancer liver metastases; **NCRLM**: Non-colorectal liver metastases.

**Figure 4** Kaplan-Meier curves of overall (A) and disease free survival (B) after laparoscopic liver resection for malignant diseases.

**LLR**: Laparoscopic liver resection.

**A**




**B**

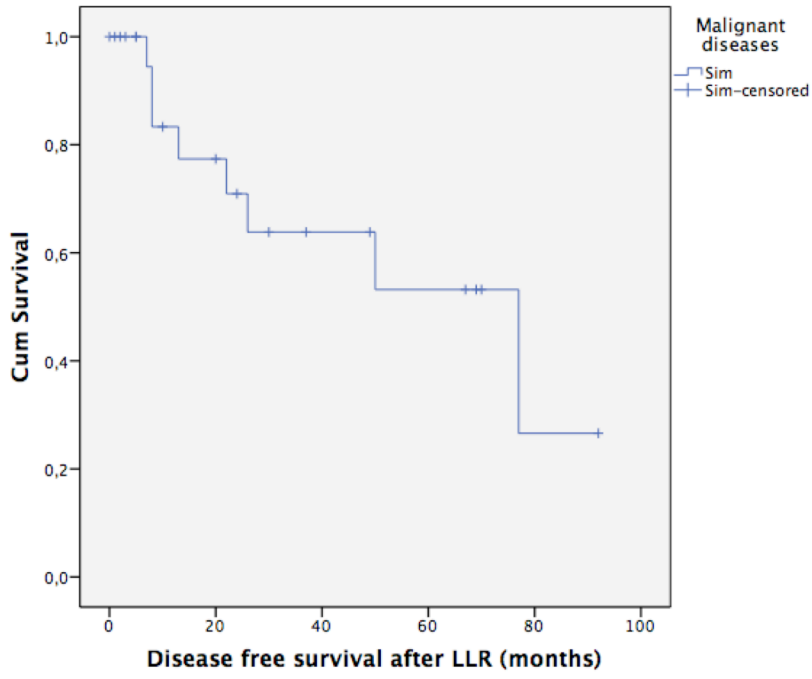
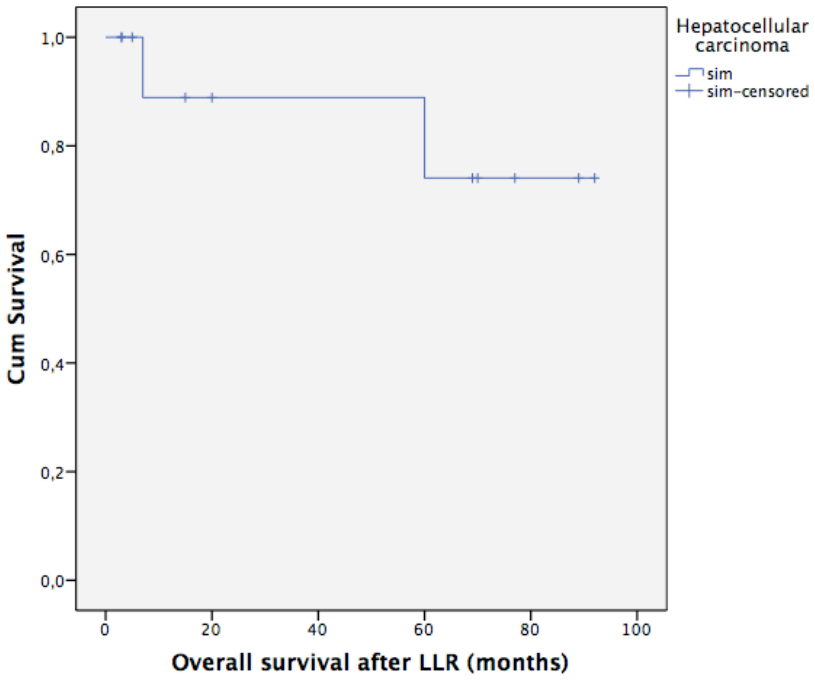


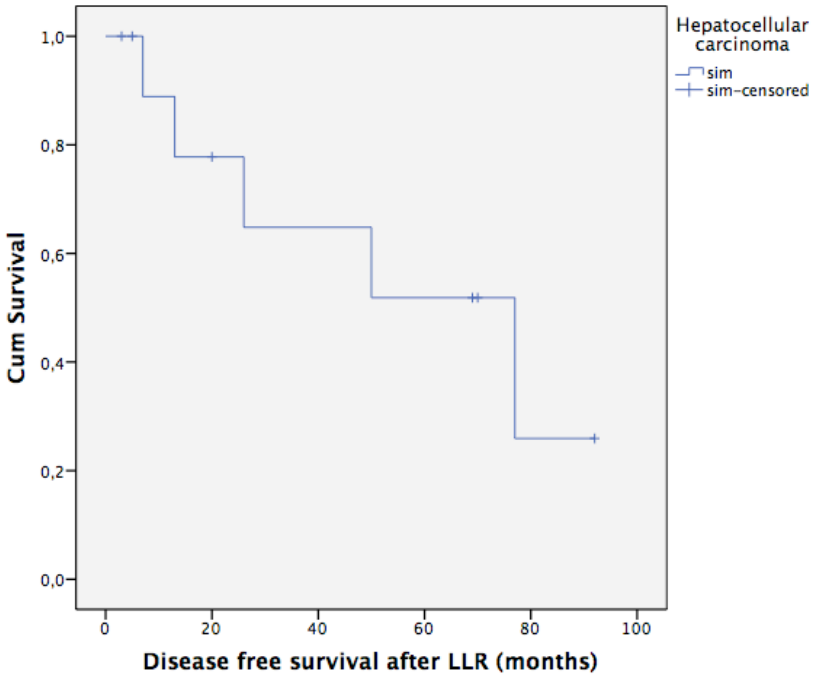
**Figure 5** Kaplan-Meier curves of overall (A) and disease free survival (B) after laparoscopic liver resection for hepatocellular carcinoma. OS (C) and DFS (D) with microvascular invasion.

**LLR**: Laparoscopic liver resection.

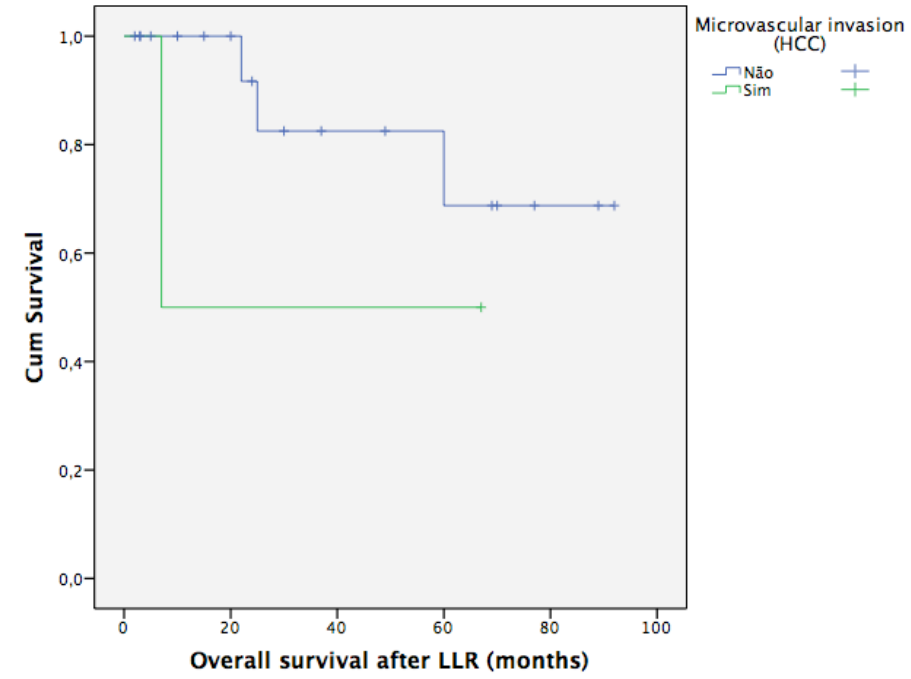
**A**



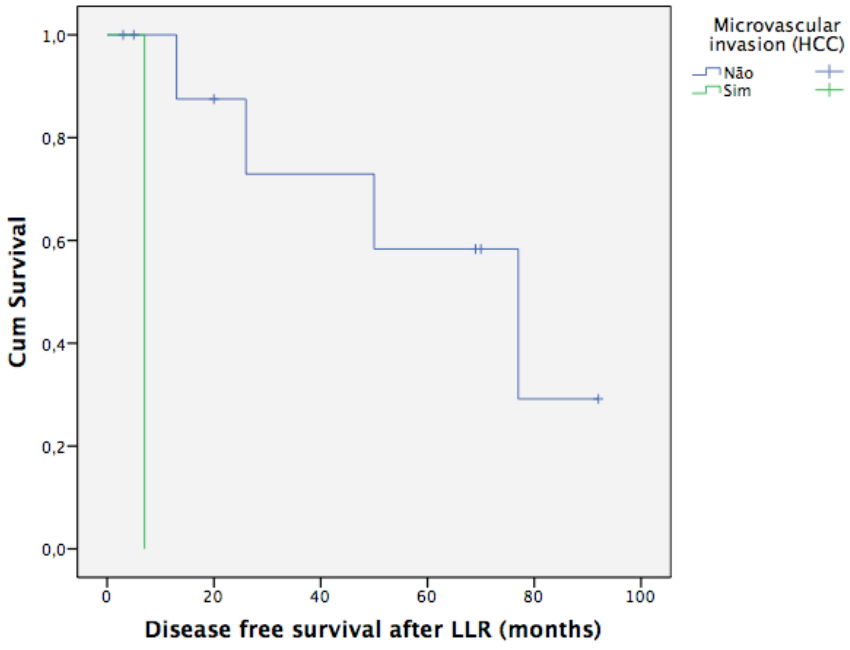

**B**



**C**


Microvascular invasion (HCC)
Não
Sim
Cum Survival
1,0
0,8
0,6
0,4
0,2
0,0
0
20
40
60
80
100
Overall survival after LLR (months)

**D**


Microvascular invasion (HCC)
Não
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Cum Survival
1,0
0,8
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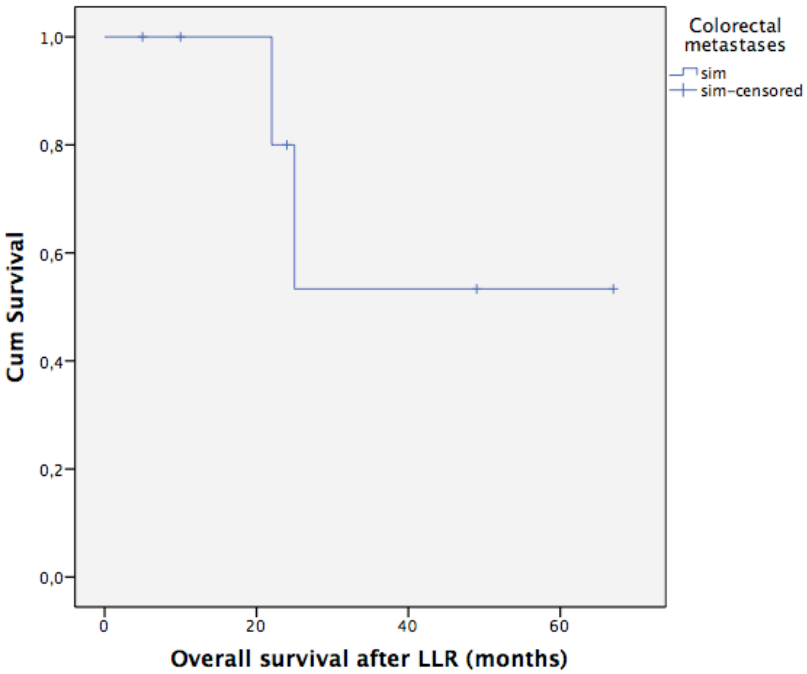
0,4
0,2
0,0
0
20
40
60
80
100
Disease free survival after LLR (months)

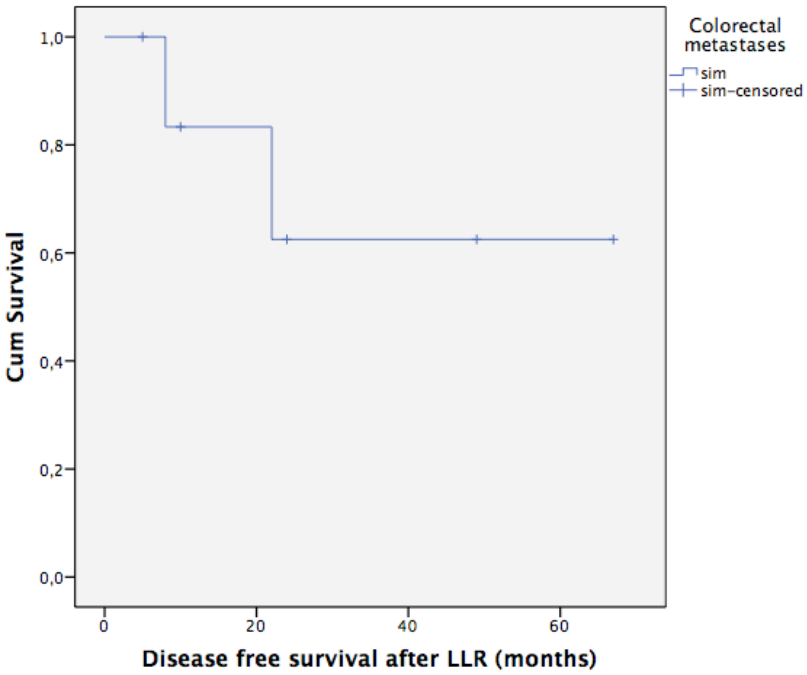
**Figure 6** Kaplan-Meier curves of overall (A) and disease free survival (B) after laparoscopic liver resection for colorectal metastases. DFS according to the number of lesions (C) and neoadjuvant chemotherapy (D).

**LLR**: Laparoscopic liver resection.

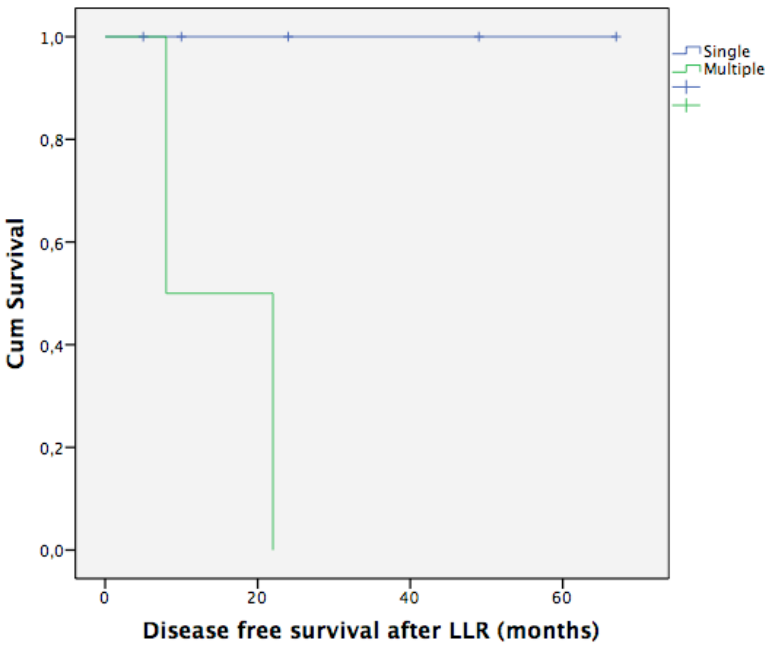
**A**



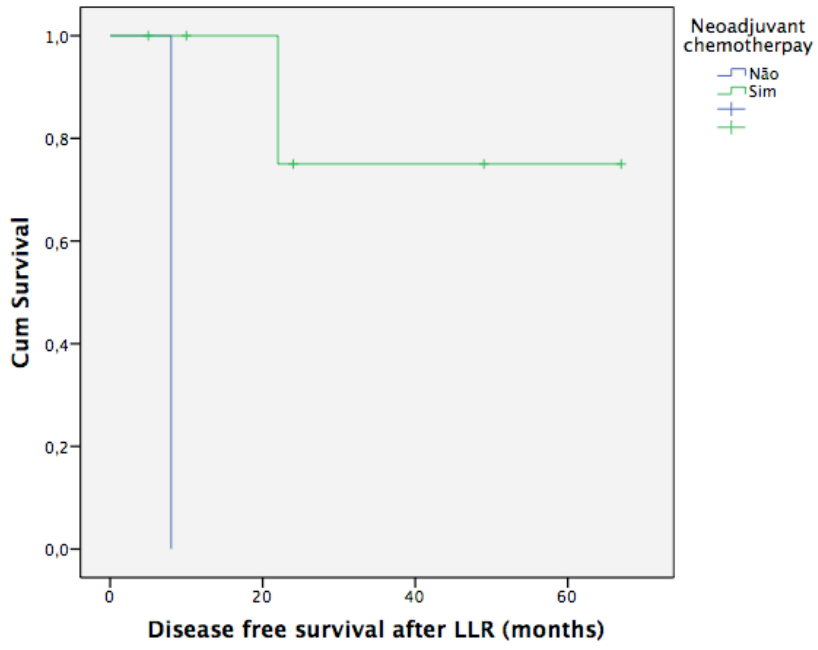

**B**



**C**


1,0
0,8
0,6
0,4
0,2
0,0
Cum Survival
0
20
40
60
Disease free survival after LLR (months)
Single
Multiple

**D**


1,0
0,8
0,6
0,4
0,2
0,0
Cum Survival
0
20
40
60
Disease free survival after LLR (months)
Neoadjuvant chemotherpay
Não
Sim

## IV. Discussion

Although considered a safe and feasible procedure, the role of LLS remains debatable. This study aimed to analyse the perioperative and long-term outcomes for patients who underwent LLR.

Over the last two decades, laparoscopy has evolved in hepatic surgery and LLR is now a well-established worldwide procedure and actually reported more for malignancies, such as hepatocellular carcinoma and liver metastases, than for benign diseases. In our department, the proportion of LLR has grown over the years.

In our study, the majority of resections were minor hepatectomies which could be explained by the fact that they are easier to perform and are preferably chosen by surgical teams due to fewer initial difficulties.(30) However, with greater experience and technological development, a greater percentage of major hepatectomies can be performed (31).

The low conversion rate (1.6%) (32) could be explained by careful patient selection (location, size and number of lesions), as well as the team's experience in advanced laparoscopy.

The present series demonstrated the safety of LLR regarding postoperative morbidity, with very few major complications and short hospital stay of 7.13 ± 6.07. (33) The association between liver-specific morbidity and chronic liver disease is due to the fact that cirrhotic patients are at increased risk of complications when undergoing liver resections (32), owing to the synthetic and metabolic dysfunction. Intraoperative plasma transfusion was a statistically significant risk factor for liver specific morbidity, while intraoperative plasma transfusion, chronic liver disease and hepatocellular carcinoma were also considered as an independent risk factors for PHLF, as previously described (34). Nevertheless, the use of laparoscopy affords undeniable advantages in cirrhotic patients, such as maintenance of

abdominal wall integrity and collateral vasculature, leading to fewer complications related to portal hypertension. (35) On the other hand, the pneumoperitoneum induces less blood loss due to haemostatic effect of intra-abdominal pressure. (18) Decrease in portal vein flow is a common event during laparoscopy (36), meaning that alternative clamping techniques, such as selective hepatic artery clamping could be used in this setting (37). Despite the wide spectrum of the PHLF definition used and the proportion of cirrhotic patients in our series, as the most patients were graded as A and only one had ascites, the PHLF rate (10.5%) (34) proves the safety of LLR.

Our study also showed good results that were comparable to open liver surgery, in oncological outcomes for hepatocellular carcinoma and colorectal metastases, as is described in the literature. However, as shown in previous studies, open surgery results in higher pro-inflammatory biomarkers, which are implied in tumour growth and proliferation (38). In addition, the enhanced recovery pathways after laparoscopy may facilitate early institution of adjuvant therapy, which may also improve oncological outcomes. On the other hand, LLR may also be advantageous in cases of HCC in cirrhotic patients.

Liver transplant is sometimes preceded by liver resections in some cases. (39) Recent studies suggested that transplantation after previous laparotomy is technically more difficult, longstanding and associated with significantly more blood loss than laparoscopy. (40) Furthermore, as many patients with CRCLM present with liver-only recurrence, repeat hepatectomy can prove much easier if the first approach was laparoscopic, given the lower risk of adhesions (41).

In our series, the prognostic factors in patients with malignant diseases were the expected, namely microvascular invasion with a negative impact in overall and disease-free survival in HCC group and multiple liver metastases with a negative impact in DFS in patients with CRCLM.

Despite the obvious role of patients' selection, the retrospective nature and the small study sample, our series certifies the feasibility and safety of LLS and shows that laparoscopy offers good postoperative outcome and at least not inferior oncological outcomes to open liver surgery.

## V. Conclusion

Laparoscopic liver surgery can be safely performed with low morbidity rates and favourable oncological outcomes.

The good results shown in our series, both short and long-term outcomes, support the role of laparoscopy in hepatic surgery. As described in the literature, although scarce and supported by low evidence studies, the results of laparoscopy are at least comparable to those of open liver surgery.

With technical improvements and well-trained and motivated teams, laparoscopic resection will soon be consolidated in the therapeutic armamentarium of modern liver surgeons.

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