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Laparoscopic liver resection: a single-centre experience

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Summary

BACKGROUND: The past 25 years have seen the increased use of minimally invasive surgery. The development of these techniques has impacted the domain of liver surgery. This study aimed to describe the safety, feasibility, benefits and results of laparoscopic liver resection in a single tertiary care centre.

METHODS: We reviewed the medical records of all patients who underwent liver surgery between January 2005 and December 2016 at the University Hospital of Basel. We selected all liver resections performed by laparoscopic surgery. To evaluate the results of the laparoscopic liver surgery, we chose the following data: the conversion rate from laparoscopy to open surgery, the median operating time, postoperative complications, the median length of stay following surgery and the median surgical margin in patients with malignant lesions.

RESULTS: Of the 274 liver operations, 201 (73%) were performed by open surgery and 73 (27%) by laparoscopy. Sixty-nine laparoscopic liver resections were included in this study. The selected laparoscopic liver resections were performed in 65 patients: 38 men and 27 women. The median age was 59 (range 29–85) years. Forty resections were performed for malignant lesions and 29 (42%) for benign diseases. The median operating time was 112 (range 50–247) minutes. The conversion rate was 19%. The most common cause for conversion was bleeding (69% of all conversions, 13% of all patients). Postoperative complications occurred in 15 patients (22%). The median hospitalisation time was 7.1 (range 2–23) days. Thirty-two patients (46.5% of all patients) had hepatocellular carcinoma. The mean tumour size was 25.6 (range 5–55) mm. The median surgical margin was 9 mm.

CONCLUSION: This study showed that in our centre laparoscopic liver surgery is a safe and effective treatment option for both benign and malignant liver lesions.

Keywords: *laparoscopic liver resection, laparoscopic hepatectomy, hepatocellular carcinoma, HCC*

Introduction

Minimally invasive liver resections are less invasive because they avoid large laparotomy wounds. These techniques allow a local or closed surgery and are characterised by many advantages, such as less abdominal wall morbidity, better cosmetic outcome and faster recovery [1].

Although the first laparoscopic liver resection was reported in the early 1990s, minimally invasive liver surgery came up against several barriers to widespread use. These obstacles included fear of uncontrollable haemorrhage, difficulty of performing an operation with the laparoscopic technique, difficulty of reproducing mobilisation and operative conditions used in open surgery, the longer learning process needed to obtain familiarity with laparoscopy and concerns about the oncological outcomes [2–4].

Nevertheless, in the last two decades laparoscopic liver resection has developed dramatically. As Nguyen et al. report in their global review of nearly 3000 laparoscopic liver resections, this surgical procedure has evolved dramatically, with improved understanding of the anatomical segments of the liver, enhanced imaging by computed tomography and magnetic resonance imaging scans, improved anaesthesia, critical care and postoperative nursing and technological advances in laparoscopic devices [2, 5].

Initially, most authors considered laparoscopic liver resection suitable only for benign lesions and for minor or wedge resections. However, in recent years, laparoscopic resection has been extended to more complex interventions such as major liver resection and malignant lesions [4, 6–8].

This study aimed to describe the experience and the results of laparoscopic liver resection at a single centre over 12 years.

Patients and methods

The medical records of all patients who underwent liver operations between January 2005 and December 2016 at the University Hospital of Basel were reviewed retrospectively.

Cases were identified with a keyword search of our electronic health records.

All surgical procedures intended to perform any operation other than liver resection were excluded from the study.

From the 274 liver interventions selected, we chose those operations performed by minimally invasive (laparoscopic) surgery. Cases converted to open surgery were included

Author contributions
Study conception and design: MG, DO, MR. Acquisition of data: MR, MG. Analysis and interpretation of data, drafting of manuscript: MG. Critical revision: DO

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in the study and constitute the conversion rate from laparoscopic to open surgery.

At our institution, three surgeons operate together to perform this type of surgery.

The operations included in the study were performed by a total of 15 different lead surgeons. Among these, three performed more than five operations as lead surgeon. Seven other surgeons were first assistant for more than five procedures.

Laparoscopic resection was performed under carbon dioxide pneumoperitoneum, with an intra-abdominal pressure of between 12 and 16 mm Hg. Four to six ports and a 30-degree laparoscope were generally used. Ultrasonographic exploration of the liver was performed before resection. An ultrasonic dissector (Thunderbeat; Olympus) or a harmonic scalpel (Ultracision; Ethicon) were used for parenchymal transection. Portal pedicles were sealed with clips or staplers and hepatic veins were divided using a linear stapler. Coagulation was performed with bipolar coagulation and an argon beamer. The resected liver specimen was extracted using an endobag, either through the umbilical access of the laparoscope or along a suprapubic horizontal incision. Abdominal drainage was usually omitted.

We present the following data: the conversion rate from laparoscopy to open surgery, the duration of the surgical operation, the postoperative complications, the hospital length of stay after the operation and the mean surgical margin for malignant lesions.

Patients' baseline data, including demographics (age at time of surgery, patient's sex), lesion pathology, location of lesions and extent of liver resection, were also extracted from the medical records and are presented in the results.

The Ethics Committee of Northwest and Central Switzerland evaluated our study and concluded that it fulfils the ethical and scientific standards for research according to the Human Research Act.

Results

Between January 2005 and December 2016, 274 liver operations were performed at the University Hospital of Basel: 201 operations were performed by open surgery (73%) and 73 by laparoscopy (27%).

The 73 laparoscopic liver surgeries included 69 liver resections, one biopsy, one diagnostic laparoscopy and two diagnostic laparoscopies with biopsy.

The selected 69 laparoscopic liver resections were performed in 65 patients (38 men and 27 women) with a median age of 59 (range 29-85) years. Four patients were operated on twice during the study period.

Forty resections (58% of the 69 cases) were performed for malignant lesions and 29 (42%) for benign diseases (table 1).

In the patients with malignant lesions, 80% of laparoscopic liver resections were performed for hepatocellular carcinoma.

Among this group, one case was operated by radiofrequency ablation (table 2). The histopathologic examination of the remaining 31 resections showed one cirrhosis-like growing tumour with infiltration of all surgical margins. The mean tumour size for the remaining 30 resections was 25.6 (range 5–55) mm. In 23 patients the surgical margin was free of tumor cells, with a mean resection of 9 mm. The resection exceeded 5 mm in 16 cases (details in table 3).

In five patients the histopathologic results showed tumor infiltration of the surgical margin. In two cases data regarding the margin status were missing.

Twenty-five patients (36%) presented Child-Pugh class A cirrhosis and seven patients (10%) had well-compensated Child-Pugh class B cirrhosis without significant ascites. The remaining 37 patients (54%) presented no signs of cirrhosis. Of the 32 patients with hepatocellular carcinoma, nine (28% of these cases) had no signs of cirrhosis, 18 (56%) presented Child-Pugh class A cirrhosis and the remaining five cases (16%) had Child-Pugh class B cirrhosis.

An absolute majority of the laparoscopic liver resections in this study were of the wedge resection type. This was followed by bisegmentectomy and segmentectomy (table 2).

Three patients (4%) had multiple lesion locations and a local destruction by radiofrequency ablation of one of those

Table 1: Histological diagnoses in 69 laparoscopic operations on the liver.

	n (percentage)
Malignant lesions	*40 (58)*
– Hepatocellular carcinoma	32 (46.5)
– Colorectal carcinoma metastasis	3 (4)
– Non-colorectal metastasis	2 (3)
– Intrahepatic cholangiocarcinoma	2 (3)
– Adenocarcinoma of gallbladder	1 (1.5)
Benign lesions	*29 (42)*
– Focal nodular hyperplasia	5 (7)
– Haemangioma	5 (7)
– Biliary adenoma	5 (7)
– Hepatic cyst	4 (6)
– Haematoma	3 (4)
– Hydatid cyst (= *Echinococcus*)	2 (3)
– Adenoma (hepatocellular adenoma)	1 (1.5)
– Hamartoma	1 (1.5)
– Regenerative hepatic nodule	1 (1.5)
– Focus of macrovesicular steatosis	1 (1.5)
– Inflammatory pseudotumor	1 (1.5)

Table 2: Types of laparoscopic procedure.

	n (percentage)
Wedge resection	48 (69.5)
Bisegmentectomy	6 (9)
Segmentectomy	5 (7)
Cyst deroofing	8 (11.5)
radiofrequency ablation*	1 (1.5)
Other†	1 (1.5)
Associated surgical procedures (radiofrequency ablation)‡	3

* Liver lesion operated by radiofrequency ablation † Excision of haematoma ‡ Three patients had multiple lesion locations. One of the lesions was operated by radiofrequency ablation

Table 3: Surgical margins in patients with hepatocellular carcinoma.

Mean, mm	9
>10 mm, n (percentage)	3 (13)
5–10 mm, n (percentage)	13 (57)
<5 mm, n (percentage)	7 (30)

lesions was executed. Other associated surgical procedures performed during the same operation, such as cholecystectomy or hemicolectomy, are excluded from table 2.

The locations of the resected lesions in the 69 patients are summarised in table 4.

The median operating time was 112 minutes. The maximum documented operation time was 247 minutes and the shortest was 50 minutes.

The procedure was completed laparoscopically in 56 cases. The conversion rate from laparoscopic to open laparotomy was 19%. The most common reason for conversion to open procedure was bleeding (nine cases; 69% of all conversions and 13% of all patients). Other reported reasons for conversion were anatomic limitation/inaccessible location of the lesion (three cases; 23% of all conversions) and positive tumor margin after completion of laparoscopic surgery.

Twenty-four postoperative complications occurred in 15 patients (22% of all patients) after laparoscopic liver resection. In seven of these cases (47% of the patients with complications, 10% of all patients) the procedure was not completed laparoscopically and the conversion to open laparotomy was necessary to complete the operation.

The documented complications after laparoscopic liver resection are summarised in table 5.

One patient died because of hepatorenal syndrome 18 days after surgery. This polymorbid patient had five concomitant conditions.

The postoperative length of stay in the hospital ranged from a minimum of two days to a maximum hospitalisation time of 23 days. In 11 cases the length of stay was ten days or longer. The median hospitalisation time was 7.1 days.

During the study period nine patients underwent a second liver resection for several reasons. Four patients were operated laparoscopically and five patients underwent an open hepatectomy. The four laparoscopic resections were in patients who presented a recurrence of the original liver lesion and in whom the procedure could be completed laparoscopically. One wedge resection was performed six months after the first operation for a recurrence of hepatocellular carcinoma in another liver segment. A cyst deroofing and a segmentectomy were performed after two years (recurrence of a hepatic cyst and hepatocellular carcinoma respectively). In both patients with a malignant lesion the surgical margins during the first resection were 5 mm. The fourth laparoscopic re-operation was performed three years later (recurrence of hepatocellular carcinoma due to a cirrhosis-like growing tumor).

Five patients were re-operated with an open approach. One hemihepatectomy was performed 43 days after the original laparoscopic liver resection for a newly discovered lesion. A segmentectomy, a wedge resection and a bisegmentectomy were required in three different patients (10 months, 2 years and 2½ years later, respectively) for recurrence of hepatocellular carcinoma. A bisegmentectomy was performed two and a half years later for a suspected recurrence of hepatocellular carcinoma, which the histopathology described as a regenerative hepatic nodule. In all patients the surgical margins of the first liver resection exceeded 3 mm. One operation was performed by radiofrequency ablation.

During the study we did not observe trocar site metastasis of hepatocellular carcinoma.

Table 4: Location of the lesions.

	n (percentage)
Anterolateral segments*	53 (77)
Posterosuperior segments†	10 (14.5)
Bilobar‡	5 (7)
Extrahepatic (gallbladder, biliary duct, etc.)	1 (1.5)

* Segments II, III, IVb, V, VI † Segments I, IVa, VII, VIII ‡ Patients with lesions in both the anterolateral and the posterosuperior segments

Table 5: Reported complications after laparoscopic liver resection.

	n (percentage*)
Liver-related complications	*4 (5.8)*
– Transient liver failure/ascites	4 (5.8)
General complications	*19 (27.7)*
– Severe anaemia†	7 (10)
– Acute renal failure	2 (2.9)
– Pneumothorax	2 (2.9)
– Urinary tract infection	2 (2.9)
– Oesophageal varices bleeding‡	1 (1.5)
– Pneumonia	1 (1.5)
– Ileus	1 (1.5)
– Systemic infection	1 (1.5)
– Urinary retention	1 (1.5)
– Hypokalaemia	1 (1.5)
Surgical-related complications	*1 (1.5)*
– Wound bleeding§	1 (1.5)

* Percentage of all patients † Severe anaemia is defined as haemoglobin <80 g/l. This was observed within the first 5 postoperative days ‡ Bleeding of the oesophageal varices caused severe anaemia § This surgery-related complication caused severe anaemia

Discussion

In the last two decades, laparoscopy has become the standard surgery for performing peripheral liver resection for the treatment of various benign and malignant liver lesions. In 2008 the Louisville Consensus Statement [9] concluded that the best indications for laparoscopic liver resection are in patients with solitary lesions 5 cm or less in size and located in the peripheral liver segments (segments II–VI). Furthermore, it suggested that the laparoscopic approach to left lateral segmentectomy should be considered the standard of care. In the same year Nguyen et al. [5] showed, in a worldwide review of nearly 3000 laparoscopic liver resections, that the postoperative morbidity and mortality of laparoscopy were comparable with those achieved in open surgery for both benign and malignant lesions.

The results of our study are in line with the conclusions of the Louisville Statement [9]: nearly all the operations were performed in the anterolateral segments, and the lesions were divided equally between segments II to VI. Only a few operations were performed in the posterosuperior segments (no operation was performed in segment I).

Concerning the histological aspect of the indications for the surgery, we observed that more than half the laparoscopic liver resections were performed for malignant lesions, and nearly all of these were for hepatocellular carcinoma. In the last decade many authors [4–7, 10–18] have

shown that laparoscopic liver resection is a safe and feasible treatment option for hepatocellular carcinoma, and have suggested that the laparoscopic approach should be considered in selected patients in centres experienced in liver surgery and advanced laparoscopy [6]. Moreover, in a meta-analysis of laparoscopic versus open resection for hepatocellular carcinoma, Zhou et al. [11] reported many advantages of laparoscopy in both the operative and postoperative outcomes. Their meta-analysis of the oncologic outcomes showed that there was no significant difference between the groups (laparoscopic vs open) regarding pathologic resection margins, overall survival and disease-free survival. Furthermore, they showed that by decreasing surgical stress, laparoscopic surgery resulted in reduced postoperative pain and need for analgesic drugs, earlier ambulation and oral food intake, faster recovery and faster hospital discharge. Therefore, the authors suggested that laparoscopic liver resection might be an alternative choice for treatment of hepatocellular carcinoma. In addition, a recent study demonstrated that subsequent salvage liver transplantation is facilitated by the initial liver resection having being done by laparoscopy compared to by open liver resection, and is associated with reduced operative time, blood loss and transfusion requirements [19].

In a recent systematic review, Cheng et al. [20] reached similar conclusions regarding laparoscopic liver resection in patients with colorectal liver metastasis. They found improved short-term outcomes without compromised oncologic outcomes in patients who underwent laparoscopic surgery compared to open surgery, and concluded that laparoscopic liver resection should be the standard approach for selected patients with colorectal liver metastasis.

As mentioned above, nearly all laparoscopic liver resections for malignant lesions in our study were for hepatocellular carcinoma. We achieved a similar oncologic outcome to other publications [6, 12, 14], with a mean surgical margin of 9 mm and an R0 resection in more than 80% of cases.

As noted by Nguyen et al. [5] and many other studies [6, 10, 21], and also in our institution, the most common type of resection performed laparoscopically is wedge resection. In our study, wedge resection made up nearly 70% of all resections, whereas Nguyen et al. [5] reported a rate of 45% for these types of resection.

No major liver resection was performed by laparoscopy in our centre. The absence of this kind of operation could influence other results of the study, especially the median operating time. Nguyen et al. [5] concluded that average operating times could vary widely depending on the type of surgery, and suggested that the average operating time is difficult to compare between different studies given the heterogeneous types of resections reported.

The difference in the median operating time between major and minor resection is well stressed in the laparoscopic liver resection study of Vibert et al. [10]. This study reports that the median operating time for major resections was double that for minor resections. The same findings are presented in Chung et al.'s review of laparoscopic liver resection for hepatocellular carcinoma [4]. This review reports a mean operative time of 189 minutes, but suggests that the prolonged operative times in the studies by Yoon et al. [22] (281 minutes) and Dagher et al. [12] (231 minutes) were probably caused by the greater proportion of major hepatectomies in those studies.

On the other hand, studies where major liver resections are absent or where only very few of them were performed show median operating times similar to that at our centre. For example, the laparoscopic liver surgery study of Cugat et al. [21] reported a median operating time of 150 minutes.

A further important result of this study is the conversion rate observed in our centre. Conversion from laparoscopic to open liver resection should not be viewed as a complication or a failure of the operation. Rather, the conversion is an important decision made by the surgeon to guarantee the safety of the patient.

As reported by Nguyen et al. [5] conversion rates vary hugely between studies. Our conversion rate of 19% is in line with the largest studies. On the other hand, many European publications [6, 10, 21] from the last decade have reported conversion rates equal to half the rate found in our institution.

As presented above, the median operating time of this study is below the average operating time of many European and international studies. With more accurate selection of patients for laparoscopic liver resection and a longer operating time, we speculate that our centre could lower its conversion rate whilst nevertheless ensuring the utmost importance of the safety of the patient.

As reported by Nguyen et al. [5] and in many other studies, the most common reason for conversion to open surgery was bleeding, and this was the case in our study as well. Haemorrhage control remains one of the most important obstacles for laparoscopic liver surgery, although nowadays several techniques for vascular control are described [9].

Two more important findings from our results should be noted: the complications reported after the surgery and the length of the hospitalisation after surgery.

Regarding complications, our centre showed a rate of 22%, which is somewhat higher than the complication rates reported by other authors [5, 6, 11, 21, 23]. However, none of our complications were directly related to the local operation field (i.e., hepato-biliary structures): only general complications were reported. As shown in a global review [5], the most common complication reported in most studies is postoperative bile leak, and this is usually managed conservatively with percutaneous drains and/or endobiliary stents. The absence of this particular liver-related complication in our study is noticeable.

Of interest, a recent study [24] compared perioperative and long-term outcomes of patients with and without liver cirrhosis who underwent laparoscopic liver resection for hepatocellular carcinoma. This study reported that there were no statistically significant differences between the two groups regarding hospital stay, postoperative complications or complication types. Bile leakage was reported as a complication occurring in both groups. Our study also included patients with Child-Pugh class A liver cirrhosis and well-compensated Child-Pugh class B liver cirrhosis. The totality of transient liver decompensations was observed in three (out of seven) patients with Child-Pugh class B cirrhosis.

Concerning the length of stay following the surgery, our results show a median hospitalisation time of 7.1 days. Other European studies [6, 21] present the same length of stay. However, an important finding to mention is the great difference between the hospitalisation times in Europe and in the United States. As suggested by Nguyen et al. [5] in their global review, the variability in hospital stay length, with shorter lengths of stay in the United States (1.9–2.9 days) and longer lengths of stay in Europe (3.5–8.3 days) and Asia (4.0–14.9 days), may be due to cultural and health system differences.

To reduce these differences, other authors [4] have proposed the time to resume a full diet as a better indicator of postoperative outcome, but very few studies have reported these data.

In conclusion, our study shows comparable results to other publications, and laparoscopic liver resection has proven to be a safe and feasible treatment for various benign and malignant liver lesions.

Nevertheless, as noted by Kirchberg et al. in their study of laparoscopic surgery of liver tumours [8], we have to remember that although it is now widely accepted that laparoscopic liver resection offers short-term advantages compared to open liver resection, these findings have still not been validated in randomised controlled trials.

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Disclosure statement
The authors have no conflicts of interest or financial ties to disclose.

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