Laparoscopic Hepatectomy for Benign and Malignant Liver Neoplasms: Preliminary Experience from a Chinese Center

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Abstract

**Background:** To investigate the indications, techniques and outcomes for Laparoscopic Hepatectomy (LH).

**Methods:** The clinical characteristics and outcomes of 500 patients who underwent LH in our institute from March 1, 2007 to September 31, 2013 were retrospectively analyzed.

**Results:** Among the patients analyzed, the preoperative diagnosis was primary liver cancer in 176 patients, metastatic liver cancer in 38, hepatic hemangiomata in 149, hepatolithiasis in 84, and other benign liver disease in 53. The procedures performed were left lateral lobectomy in 97 patients, left hepatectomy in 75, extended left hepatectomy in 6, right hepatectomy in 36, right posterior lobectomy in 28, segmentectomy VI in 59, extended right hepatectomy in 5, central hepatectomy in 10, and segmentectomy VII/VIII, segmentectomy IVa, caudate lobectomy, or resection of the junction of segments VI and VII in 43. Nonanatomic and wedge resection were performed in 126 patients, and combined resection in 15. Mean operation time was 244.71 ± 105.07 min, blood loss was 460.26 ± 425.81 mL, and length of hospital stay was 15.51 ± 4.36 days. The postoperative complication rate was 9.20%, and there were no perioperative deaths. Of 214 cases with malignant liver neoplasms, 204 were followed up for a period of 1–72 months. The 1, 3 and 5-year overall survival rates were 94.2%, 73.7%, and 60.3%, and disease-free survival rates were 84.2%, 73.7%, and 55.4% respectively.

**Conclusion:** LH is minimally invasive and is useful in the treatment of selected liver disease patients. It shows less trauma, faster recovery and better postoperative cosmesis than open hepatectomy. LH has superior short-term outcomes and similar long-term outcomes compared with open hepatectomy. LH is suitable for treating benign liver diseases and small hepatocellular carcinomas and metastatic liver cancers. Careful identification and management of the vessels during transecting liver parenchymal and effective control of bleeding are important during LH.

**Keywords:** Laparoscopy; Hepatectomy; Liver neoplasm; Hepatolithiasis

Introduction

Laparoscopic Hepatectomy (LH) has been widely performed in recent years because of the smaller wound, faster recovery time, and better cosmetic outcome compared with open hepatectomy. The indications for LH have gradually expanded, from local resection of benign neoplasms at the liver edge to hemihepatectomy and more extensive anatomical resections, segmentectomy for malignant neoplasms, and donor hepatectomy for liver transplantations. The numbers of LH procedures performed are increasing exponentially in surgical centers worldwide [1,2]. In some highly experienced laparoscopic centers, LH accounts for up to 80% of hepatectomy procedures [3]. However, few centers in China perform LH. To further increase the use of laparoscopic liver surgery, it is necessary to determine the indications, techniques, and outcomes for LH. We therefore retrospectively reviewed the clinical characteristics and outcomes of 500 patients who underwent LH at our center from March 1, 2007 to September 30, 2013, to determine the indications, techniques, and outcomes for LH.

Materials and Methods

**General data**

A total of 500 patients underwent LH during the study period, including 293 males and 207 females with a mean age of 48 years (range 14-82 years). The main symptoms included pain and discomfort in the hepatic region, but some patients were asymptomatic and were diagnosed with liver disease by routine health examinations including B-mode ultrasonography, computed tomography, magnetic resonance imaging, magnetic resonance cholangiopancreatography, and testing for liver function, tumor markers, and hepatitis B virus infection. The preoperative diagnosis was primary hepatic carcinoma in 176 patients, metastatic hepatic carcinoma in 38, hepatomnetic hemangiomata in 149, hepatolithiasis in 84 and other benign hepatic neoplasm in 53. Chronic hepatitis B virus infection and hepatitis C virus infection were present in 141 of the 176 patients with primary hepatic carcinoma. Liver function was Child-Pugh class A in 454 patients and Child-Pugh class B in 46. Hepatic functional reserve was evaluated by the indocyanine green retention rate at 15 min and the ratio of expected residual liver volume to preoperative liver volume. The mean maximum diameter of malignant tumors (primary liver cancer and metastatic hepatic carcinoma) was 5.41 ± 2.78 cm, and 95 patients had a tumor diameter of ≥ 5 cm.
Tumor nodules were single in 178 patients and multiple in 36. In the 84 patients with hepatolithiasis, stones were located in the left lateral lobe in 28 patients, left hemiliver in 32, right posterior lobe in 14, right anterior lobe in 4, and right hemiliver in 6; and concomitant cholecystolithiasis was present in 29 patients and choledocholithiasis in 25. Thirty-seven patients had undergone previous laparoscopic cholecystectomy or open biliary tract surgery.

**Selection criteria**

All patients in this study had indications for liver resection. Patients were selected for LH based on the location of liver lesions, the lesion’s proximity to major vascular structures, and the extent of resection required. Inclusion criteria for the LH were:

1. met the criteria for Open Hepatectomy (OH);
2. the lesion size of <10 cm if liver neoplastic diseases;
3. no intrahepatic or distant metastasis if liver malignant tumors;
4. no tumor thrombus in the portal vein, hepatic vein, vena cava, or bile duct; and no invasion of the diaphragm or surrounding tissues if liver malignant tumors;
5. no rupture or bleeding of the tumor if liver malignant tumors;
6. indocyanine green retention rate at 15 min of <15% and a remnant liver volume/standard liver volume ratio of <50% in patients with liver cirrhosis and >35% in patients without liver cirrhosis;
7. Child-Pugh class A or B liver function;
8. the tumor nodule number of ≤ 2 and only located in the same hemiliver if ≥ 2 nodules.

**Surgical procedure**

For LH, patients were placed in the supine position under general anesthesia with endotracheal intubation. A CO₂ pneumoperitoneum was established, with intra-abdominal pressure controlled at 12-14 mmHg (1 mmHg = 0.133 kPa). Five ports were usually used. The operating ports were placed in a fan-shape around the neoplasm. Based on individual characteristics, the operating table was tilted 15–45° to the right or left. The liver parenchymal transection plane was determined based on the findings of preoperative imaging, intraoperative exploration, intraoperative ultrasonography, and ischemic demarcation boundaries after hepatic vascular occlusion. The pattern of hepatic inflow occlusion was selected depending on the location of the neoplasm, the surgical approach, and the extent of liver cirrhosis. Selective hemi-hepatic inflow occlusion was used for anatomic hemihepatectomy. For neoplasms located in the left lateral lobe, right posterior lobe, or right anterior lobe, the intermittent Pringle maneuver was used if necessary, or the corresponding hepatic pedicle was dissected for selective regional occlusion. A harmonic scalpel was used to transect the liver parenchyma, in combination with other instruments such as a bipolar coagulator (Wolf Co., Inc., Germany), endoscopic rotation clip (Johnson and Johnson Co., Inc., USA), Hem-o-lok clip, and Endo-Linear stapler (Johnson and Johnson Co., Inc., USA). Endoscopic ultrasonography (GE Co., Inc., USA) was performed to prevent deviation from the transection plane and ensure tumor-free margins. In patients with severe liver cirrhosis, irregular hepatectomy was performed with an incision margin of >1 cm whenever possible. The resected specimens were placed in a specimen bag for removal from the abdomen.

**Surgical results**

LH was converted to open hepatectomy in 35 of the 500 patients and to hand-assistant laparoscopic hepatectomy in 5 patients (conversion rate 40/500, 8.0%). The remaining 460 patients underwent successful LH. The procedure performed was left lateral lobectomy in 97 patients, left hepatectomy in 75, extended left hepatectomy in 6, right hepatectomy in 36, right posterior lobectomy in 28, segmentectomy VI in 59, extended right hepatectomy in 5, central hepatectomy in 10 patients), and segmentectomy VII/VIII, segmentectomy IVa, caudate lobectomy, or resection of the junction of segments VI and VII in 43. Nonanatomic or wedge resection was performed in 126 patients, and resection of more than one segment or area was performed in 15 patients. Additional procedures at the time of LH included radiofrequency tumor ablation in 18 patients, laparoscopic cholecystectomy in 138, biliary tract exploration in 66, biliary-intestinal anastomosis in 8, spleenectomy and extensive devascularization around the gastric cardia in 3, appendectomy in 3, and unilateral ovarian tumor resection in 2. The mean operation time was 244.71 ± 105.07 min, mean intraoperative blood loss was 460.26 ± 425.81 ml, and mean length of hospital stay was 15.51 ± 4.36 days. The incidence of postoperative complications was 9.20%. Three right hepatectomies were converted to hand-assisted procedures because the tumors were large and it was difficult to expose and manipulate the right liver during laparoscopy, and two right posterior lobectomies were converted to hand-assisted procedures because it was difficult to expose and resect the appropriate lobes. The reasons for conversion to open hepatectomy were uncontrollable blood loss during parenchymal transection in 11 patients, tumor rupture and bleeding in 5, positive resection margins in 5, tumor invasion of the diaphragm or severe adhesions resulting in difficulty with exposure or handling of the liver in 9 cases, injury to the right hepatic vein during dissection of the second or third hepatic hilum in 3, and injury to the right suprarenal vein in 2. The final pathological diagnosis was hepatocellular carcinoma in 169 patients, cholangiocellular carcinoma in 5, mixed-cell liver cancer in 2, hepatic metastasis from colorectal cancer in 22, hepatic metastasis from renal carcinoma in 5, mixed-cell liver cancer in 2, hepatic metastasis from breast carcinoma in 4, hepatic metastasis from thyroid carcinoma in 2, hepatic metastasis from gastric carcinoma in 5, hepatic cavernous hemangioma in 149, intrahepatic bile duct stones with inflammation in 84, focal nodular hyperplasia in 19, hepatic angioleiomyoma in 13, hepatocytic adenoma in 8, chronic hepatic abscess in 6, inflammatory and eosinophilic granuloma in 2, hepatic echinococcosis in 2, and hepatic inflammatory pseudotumor in 3.

**Perioperative complications**

There were no perioperative deaths during the study period. Postoperative complications occurred in 46 patients (9.20%), including pulmonary infection in 5, localized pulmonary...
atelectasis in 2, reactive pleural effusion in 3, ascites and pleural effusion in 13, fluid collection at the hepatic transection site in 11, intra-abdominal abscess in 5, infection of the abdominal wall incision used to extract the specimen in 2, urinary tract infection in 3, and renal dysfunction in 2. All these complications resolved after conservative treatment (Table 1). One patient who underwent left lateral lobectomy developed intra-abdominal hemorrhage 3 hours after surgery, and laparoscopic exploration found active bleeding at the site of parenchymal transection which was treated by suturing. There were no cases of postoperative liver failure or bile leakage.

Postoperative outcomes

All patients with symptomatic benign liver tumors reported reduction or resolution of their symptoms after hepatectomy. Residual stones were detected in 8 patients after surgery. After a follow-up period of 5 years, bile duct stones occurred in 13 patients (recurrence rate 15.46%). Two hundred and four of the 214 patients with malignant liver tumors received a follow-up telephone call from a clinical nurse to assess their postoperative condition. In these 214 patients, the follow-up period was 1–72 months, during which local recurrence or intra- or extra-hepatic metastasis occurred in 46 patients. Twenty-five of these 46 patients died at 2–72 months after surgery, and the remaining 21 patients remain alive after receiving radiofrequency ablation, transcutaneous hepatic arterial chemoembolization, or resection. Metastasis occurred in 46 patients. Twenty-five of these 46 patients died at 2–72 months after surgery, and the remaining 21 patients remain alive after receiving radiofrequency ablation, transcutaneous hepatic arterial chemoembolization, or resection. In these cases, surgeons did not need not worry about tumor dissemination or radical resection to achieve cure. The resected specimens were crushed before extraction. The cosmetic benefits of minimally invasive incisions were significant. Most patients with benign neoplasms were young women who were willing to accept minimally invasive surgery. LH is therefore ideal for the treatment of benign liver neoplasms. However, the indications for surgery should be strictly adhered to, and patients with benign neoplasms who do not need LH should not be pressured into accepting this procedure. In this study, the indications for LH included: (1) benign tumor with the potential for malignant transformation; (2) lack of typical imaging examination findings of benign or malignant tumors, so that malignancy could not be ruled out; and (3) hepatic hemangioma with a diameter of ≥10 cm, or symptomatic hepatic hemangioma with a diameter of 5–10 cm and fast growth. In patients with hepatolithiasis, LH should only be performed if the hepatolithiasis is localized; according to the guidelines for diagnosis and treatment of hepatolithiasis [4]. Many studies have reported the use of LH for treatment of hepatocellular carcinoma and liver metastases from colorectal cancer. Metastatic liver cancers and small liver cancers in patients without liver cirrhosis or with mild liver cirrhosis are generally considered to be suitable for LH. More recently, some surgeons have investigated the feasibility of LH for the treatment of large liver cancers, and have reported outcomes similar to those after open hepatectomy [5]. Ninety-five of the patients in this study had a tumor diameter of ≥ 5 cm. We consider that patients with liver cancer are suitable for LH if they meet the indications for open hepatectomy as well as the following criteria: (1) no severe liver cirrhosis or portal hypertension; (2) tumor diameter of ≤ 10 cm; (3) no tumor invasion of the porta hepatitis, portal vein, or hepatic vein, and no bile duct cancer thrombus; (4) no tumor invasion of the diaphragm, and no tumor rupture or bleeding. In terms of the location of the neoplasm, the success of LH depends on the experience of the surgeon and the surgical team, and the laparoscopic techniques and equipment used. Neoplasms located in the left, anterior, and inferior lobes (Couinaud segments I, VII, VIII, and IVA), especially those at the liver edge, are suitable for LH during the early stages of the learning curve. LH for tumors of the right and posterolateral lobes (Couinaud segments VII, VIII, and IVA) and difficult procedures such as right hepatectomy, right posterior lobectomy, and extended hemihepatectomy should be performed only in larger centers by experienced laparoscopic hepatobiliary surgeons.

Discussion

Indications for LH

The results of this study show that LH is useful for the treatment of various types of liver neoplasms in various locations in selected patients. The characteristics and locations of neoplasms determine whether LH can be successfully performed. In this study, 286 of the 500 patients had benign neoplasms, accounting for 57.20% of all LH procedures. Patients with benign neoplasms generally had good liver function, and could therefore tolerate prolonged vascular inflow occlusion and large resections. In these cases, surgeons did not need not worry about tumor dissemination or radical resection to achieve cure. The resected specimens were crushed before extraction. The cosmetic benefits of minimally invasive incisions were significant. Most patients with benign neoplasms were young women who were willing to accept minimally invasive surgery. LH is therefore ideal for the treatment of benign liver neoplasms. However, the indications for surgery should be strictly adhered to, and patients with benign neoplasms who do not need LH should not be pressured into accepting this procedure. In this study, the indications for LH included: (1) benign tumor with the potential for malignant transformation; (2) lack of typical imaging examination findings of benign or malignant tumors, so that malignancy could not be ruled out; and (3) hepatic hemangioma with a diameter of ≥10 cm, or symptomatic hepatic hemangioma with a diameter of 5–10 cm and fast growth. In patients with hepatolithiasis, LH should only be performed if the hepatolithiasis is localized; according to the guidelines for diagnosis and treatment of hepatolithiasis [4]. Many studies have reported the use of LH for treatment of hepatocellular carcinoma and liver metastases from colorectal cancer. Metastatic liver cancers and small liver cancers in patients without liver cirrhosis or with mild liver cirrhosis are generally considered to be suitable for LH. More recently, some surgeons have investigated the feasibility of LH for the treatment of large liver cancers, and have reported outcomes similar to those after open hepatectomy [5]. Ninety-five of the patients in this study had a tumor diameter of ≥ 5 cm. We consider that patients with liver cancer are suitable for LH if they meet the indications for open hepatectomy as well as the following criteria: (1) no severe liver cirrhosis or portal hypertension; (2) tumor diameter of ≤ 10 cm; (3) no tumor invasion of the porta hepatitis, portal vein, or hepatic vein, and no bile duct cancer thrombus; (4) no tumor invasion of the diaphragm, and no tumor rupture or bleeding. In terms of the location of the neoplasm, the success of LH depends on the experience of the surgeon and the surgical team, and the laparoscopic techniques and equipment used. Neoplasms located in the left, anterior, and inferior lobes (Couinaud segments I, VII, VIII, and IVA), especially those at the liver edge, are suitable for LH during the early stages of the learning curve. LH for tumors of the right and posterolateral lobes (Couinaud segments VII, VIII, and IVA) and difficult procedures such as right hepatectomy, right posterior lobectomy, and extended hemihepatectomy should be performed only in larger centers by experienced laparoscopic hepatobiliary surgeons.

Technical difficulties during LH

LH includes several technically difficult procedures, but the most important aspect of successful LH is control of blood loss.
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during liver parenchymal transection. Control of blood loss involves use of suitable methods to occlude vascular inflow to the liver, good understanding of liver anatomy, and good handling techniques. Except for local resection of superficial and liver edge neoplasms, management of parenchymal bleeding involves occlusion of vascular inflow. The method of vascular inflow occlusion may differ among various procedures, and may include selective occlusion of inflow to the hemiliver or in one porta hepatis, or simultaneous occlusion of the hepatic vein. Occlusion of vascular inflow decreases bleeding during parenchymal transection, ensures good exposure of the operative field, and contributes to correct identification of anatomical structures. Parenchymal transection is performed with various instruments, such as the harmonic scalpel, bipolar coagulator, endoscopic rotation clip, Hem-o-lok clip, and Endo-GIA. In this study, the main instrument used for parenchymal transection was the harmonic scalpel. The harmonic scalpel can be used to ring and clamp, crush, and coagulate the hepatic tissues, and can be used in combination with suction apparatus to suck, push and pull, identify, and resect various structures. The endoscopic rotation clip, Hem-o-lok clip, and Endo-GIA can be used to clip and seal tubular structures. Incomplete occlusion of tubular structures was the main reason for bleeding. Laparoscopic ultrasonography is useful for determining the size of tumors and their location relative to the large vessels and bile ducts; to identify satellite neoplasms, multiple nodules, and cancer thrombus that were not detected preoperatively; and to determine the correct incision margins and plane of parenchymal transection to prevent damage to the tubular structures and ensure negative surgical margins.

In this study, most of the LH procedures that were converted to open or hand-assistant hepatectomy were performed during the early stage of the learning curve, and for neoplasms located in the right side of the liver or in segments I or IV, especially for large tumors that were particularly difficult to expose and resect in the relatively small operative field with non-curved laparoscopic instruments [6]. The main reasons for conversion to open resection were blood loss and positive resection margins. We think that conversion to open resection when appropriate does not indicate failure, as the safety of patients and the principles of radical resection are of primary importance. We recently described our techniques for laparoscopic resection of neoplasms of the right liver and of segments I and IV, including mobilization of the right liver, dissection of the right hepatic vein between the right posterior lobe and the inferior vena cava, use of real-time intraoperative ultrasonography, and placement of a self-made water bag adjacent to the right posterior lobe to assist with exposure and resection of the neoplasm, resulting in a lower rate of conversion to open surgery.

Evaluation of the therapeutic effectiveness of LH

There were no perioperative deaths in this study. The complication rate was 9.20%, with no serious complications such as postoperative liver failure or bile leakage. There was only one case of intra-abdominal hemorrhage, which was treated by repeat laparoscopy. There was a high rate of postoperative reduction or resolution of symptoms in patients with benign tumors. There were no cases of tumor metastasis to the site of trocar insertion in patients with malignant tumors, and survival was similar to recently reported rates after open hepatectomy [7]. LH has been reported to be feasible and safe for the treatment of benign and malignant liver tumors, with good outcomes and advantages over open resection in terms of the smaller incision size, reduced pain, smaller scar, faster recovery, shorter length of stay, and maintenance of abdominal wall integrity. Recently, an increasing number of LH procedures for the treatment of liver tumors have been reported, and the reported outcomes indicate that LH is feasible and safe for the treatment of selected liver tumors, depending on liver function and the location and size of tumors. LH results in reduced intraoperative blood loss and postoperative complications, shorter length of hospital stay, and improved postoperative quality of life compared with open hepatectomy. The short-term outcomes after LH are superior to those after open hepatectomy [8,9]. However, the long-term outcomes after LH and open hepatectomy for liver cancer should be studied further in prospective, randomized, controlled studies with large numbers of patients. In this study, postoperative recurrence and metastasis occurred in some patients with malignant liver tumors, and death occurred in some patients with multiple tumors, unclear tumor margins, poorly differentiated tumors, and microscopic vascular invasion. The rates of recurrence and metastasis are higher in cases of cholangiocellular carcinoma and mixed-cell liver cancer than in cases of hepatocellular carcinoma, indicating that the prognosis after LH for liver cancer depends mainly on the biological behavior of the tumor, rather than the choice of laparoscopic versus open surgery. We consider that the choice to perform LH does not change the ability to perform radical surgery or prevent intraoperative dissemination of hepatocellular carcinoma compared with open hepatectomy. Our ability to achieve negative resection margins was comparable with previously reported results for both LH and open hepatectomy [10,11], and there was no evidence that use of a CO₂ pneumoperitoneum resulted in intraoperative dissemination of cancer.

References

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