Laparoscopic left hemihepatectomy: a safety and feasibility study of 19 cases

Xiu-Jun Cai · Yi-Fan Wang · Yue-Long Liang · Hong Yu · Xiao Liang

Abstract

Background Laparoscopic liver resection was performed at some institutes. The procedure mainly included local resection, segmentectomy, and left lateral segmentectomy. With experience accumulation and technique innovation, laparoscopic left hemihepatectomy was performed in selected patients. This study was designed to introduce and evaluate the safety and feasibility of this procedure.

Methods Nineteen successive patients underwent laparoscopic left hemihepatectomy from 2005 to 2007. They were compared by the matched-pair method with 19 other patients who underwent conventional open left hemihepatectomy. Surgical feature, postoperative course, and the learning curve of laparoscopic left hemihepatectomy were studied.

Results Laparoscopic hemihepatectomy was successfully performed in 17 cases. Two conversions were required. Compared with the open group, the blood loss was significantly less in the laparoscopic group (462 ± 372 vs. 895 ± 704, $p = 0.03$). Postoperative hospital stay of the laparoscopic group was shorter but not significant compared with the open group (9 ± 5 vs. 13 ± 7, $p = 0.086$). Postoperative albumin level in the laparoscopic group was significantly higher than the open group (33 ± 4.8 vs. 27.6 ± 3.2, $p = 0.001$). There was no perioperative mortality in either group. Two complications occurred in the laparoscopic group (11%) and four in the open group (21%). A tendency of gradually decreased transecting time was noticed in the early cases ($R^2 = 0.676$; $p = 0.012$).

Conclusions Laparoscopic left hemihepatectomy is a safe and feasible procedure for select patients.

Keywords Laparoscopic hemihepatectomy · Liver resection · Hepatectomy · Laparoscopic surgery

The laparoscopic technique was applied to liver resection in the 1990s. Procedures included local resection, segmentectomy, and left lateral segmentectomy. The feasibility and safety of these procedures have been proved by some surgeons [1–7]. Laparoscopic hemihepatectomy—one of the most difficult laparoscopic surgeries—was rarely performed worldwide. In our institute, laparoscopic left hemihepatectomy has been performed in selective patients since 2005. By using the technique of hepatectomy by curettage and aspiration and selective inflow occlusion, which we developed, intraoperative blood loss decreased significantly. The procedure is introduced in this article, and the feasibility and safety of this procedure were evaluated by matched-pair study.

Patients and methods

From 2005 to 2007, a total of 19 successive patients underwent laparoscopic left hemihepatectomy (LH group) at our institution. Diagnosis included hepatolithiasis ($n = 16$), giant hemangiomas ($n = 2$), and liver cancer ($n = 1$). They were compared with patients who underwent left hemihepatectomy by open approach in a matched-pair analysis.

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For each patient in the LH group, patients who had open left hemihepatectomy were selected from a database of patients in the same institution who matched the following criteria: diagnosis, Child classification, lesion location, and lesion size. Nineteen patients fulfilled all selection criteria and constituted the control group (open hepatectomy: OH group).

All patients had a complete medical evaluation, including liver function, cardiovascular, and pulmonary assessments. Preoperative CT scan or magnetic resonance imaging was performed to locate the liver lesions. Patients' characteristics are listed in Table 1. Preoperative laboratory data, including total bilirubin and albumin level, which reflected liver function, are listed in Table 2. There was no statistical difference between the two groups.

Inclusion criteria

Patients in either group met the inclusion criteria for laparoscopic left hemihepatectomy, which included: unilateral liver lesion having the indication of left hemihepatectomy; liver function of child A to B classification; no extrahepatic bile duct stricture or suppurative cholangitis in patients of hepatolithiasis; no past history of cholangiojejunostomy.

Studied criteria

Surgical feature, postoperative course, and learning curve of laparoscopic left hemihepatectomy were studied. Postoperative liver function was assessed by bilirubin level, albumin level, presence of ascites etc.; hepatic damage was assessed by perioperative serum aminotransferase level. Follow-up was obtained from hospital charts or telephone contact. For LH group, surgical feature and postoperative

Table 1 Preoperative characteristics of patients who underwent laparoscopic hemihepatectomy and conventional open hemihepatectomy

Variables	LH group ($n = 19$)	OH group ($n = 19$)	p
Age (year)	53 ± 10	55 ± 9	0.376
Male:female ratio	7:12	7:12	
ALT (IU/l)	75 ± 159.2	86.7 ± 122.4	0.801
ALB (g/l)	37.8 ± 4.9	37 ± 7.4	0.708
T-BIL (mg/dl)	1.8 ± 3.5	1.8 ± 2.3	0.987

Table 2 Surgical feature

Variables	LH group	OH group	p
Operating time (min)	222 ± 104	204 ± 59	0.516
Intraoperative blood loss (ml)	462 ± 372	895 ± 704	0.03
Patients requiring blood transfusion (n)	2	8	0.062

course of late cases ($n = 9$) and early cases ($n = 10$) were compared, and transecting time of early cases obtained from surgical video record was studied.

Statistical analysis

Results were expressed as mean ± standard deviation. Comparisons between two groups were performed using the Student's t test or Fisher's exact test. Linear regression test were used for studying the laparoscopic liver transection time. Significance was defined as $p < 0.05$. Statistical analysis was performed using the SPSS® Statistical Software Package, version 13.0 (SPSS, Inc., Chicago, IL)

Procedure

Laparoscopic hemihepatectomy was performed under general anesthesia with the patient in the supine position. Three surgeons were needed, including two senior surgeons with more than 5 years of experience with open hepatectomy and a junior surgeon. Four entries were made, including the observation port (10 mm) below the umbilicus, main manipulation port (10 mm) below the left costal margin, and two assistant ports (5 mm) at right flank area (Fig. 1). The main operator stood at the left of patient. Liver lesion was located again with laparoscopic ultrasonography.

Laparoscopic selective inflow occlusion was performed first. Mobilized the liver to well expose the hepatic hilum.
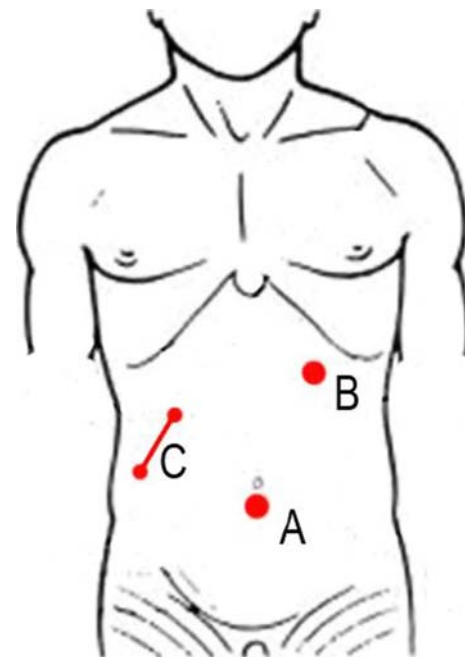

Fig. 1 Ports position right hemihepatectomy. A Observation port (10 mm). B Manipulation port (10 mm). C Two assistant ports (5 mm) and an incision for removing specimen
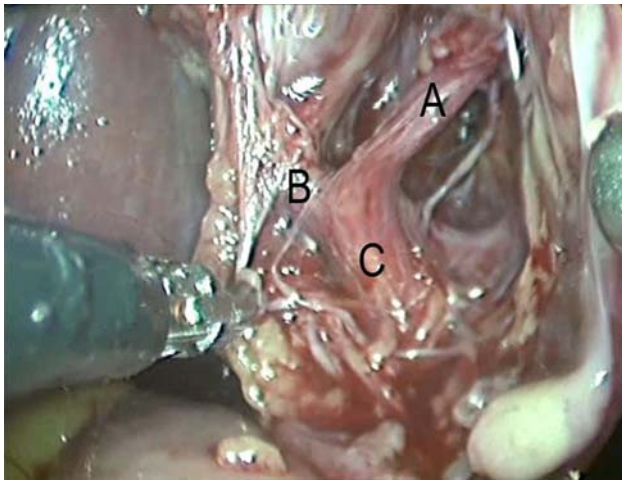
Fig. 2 Hepatic artery and its branch had been dissected. A Left branch of hepatic artery. B Right branch of hepatic artery. C Hepatic artery
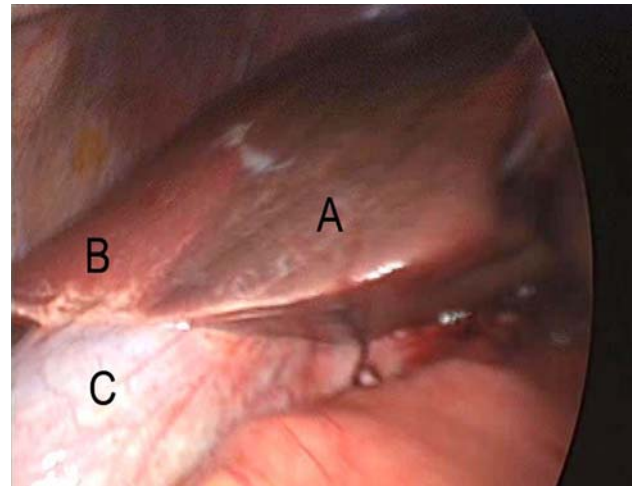

Fig. 4 Left lobe presented an ischemic change after completing laparoscopic selective inflow occlusion. A Gallbladder. B Right lobe. C Left lobe
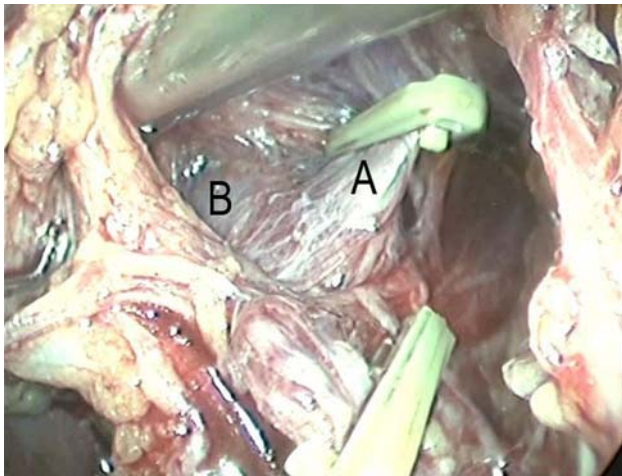

Fig. 3 Left branch of portal vein was dissected and clamped by an absorbable clip. A Left branch of portal vein (had been clamped by a absorbable clip). B Right branch of portal vein

Fig. 5 Left hepatic vein was dissected before liver transection

By meticulous blunt dissection, the hepatic artery and its branches were visualized (Fig. 2). The left branch was clamped with absorbable clips (12 mm Lopro-Clip, Tyco Healthcare UK LTD.) and divided. Then the left branch of portal vein, below the artery, was dissected by the same method, and was occluded by an absorbable clip, achieving left selective inflow occlusion (Fig. 3). The afferent blood flow of left lobe was blocked and the lobe showed an ischemic change, which could be observed on the liver surface (Fig. 4). In highly selected cases, the left hepatic vein was dissected and clamped by an absorbable clip before liver transection (Fig. 5).

Laparoscopic hepatectomy by curettage and aspiration (LHCA), described in previous literature, was performed [8]. Briefly, liver parenchyma was transected along the

ischemic line, vessels and bile duct in the transection plane, even vessels <2 mm, were bluntly dissected, clamped, and divided. The transection plane was coagulated to seal capillary vessels. Finally, the left hepatic vein was well exposed, dissected, and divided (Fig. 6). The integral specimen was packed into a plastic bag and was removed via an extended assistant hole of 4–6 cm. For patients with hepatolithiasis, intraoperative cholangiography via cystic duct and cholecystectomy were performed routinely. Exploration of common bile duct and T-tube drainage were performed if residual stones were found by cholangiography.

In control group, liver parenchyma was transected using the technique of hepatectomy by curettage and aspiration and Pringle maneuver was performed.

Fig. 6 Left haptic vein was exposed and dissected when transecting liver parenchyma

Results

Laparoscopic left hemihepatectomy completed successfully in 17 cases. Two cases were converted to open procedure: one for severe adhesion from previous surgery, and the other for bleeding from median hepatic vein (conversion rate, 11%). A patient with hepatolithiasis in the LH group had cholangiocarcinoma found intraoperatively and the left lobe, including the whole tumor, was resected laparoscopically.

Surgical features

There was no intraoperative death. No gas embolism was encountered during the operation. Surgical data, including the operating time and blood loss, are shown in Table 3. The intraoperative blood loss of the LH group was significantly less than the OH group (462 ± 372 vs. 895 ± 704, $p = 0.03$). Two patients in the laparoscopic group (11%) and eight in open group (42%) required blood transfusion. Operating time was similar between the two groups. More than 1 cm free margin had been achieved in all the patients with malignant tumor in both groups

Postoperative course

Postoperative length of hospital stay and complications are shown in Table 3. A shorter length of postoperative hospital stay was noticed in laparoscopy group (9 ± 5 vs. 13 ± 7, $p = 0.86$), but there was no statistical significance. There were no postoperative deaths. A total of six complications occurred: two in the LH group, and four in the OH group. In the LH group, the patient complicated with encapsulated abdominal effusion was reoperated to clear the effusion, and the other complication was infection of

Table 3 Postoperative course

Variables	LH group	OH group	p
Postoperative hospital stay (days)	9 ± 5	13 ± 7	0.086
Mortality	2 (11%)	4 (21%)	0.66
Bile leakage	0	1	
Incisional infection	1	2	
Encapsulated abdominal effusion	1*	0	
Residual stone	0	1	
Morbidity	0	0	

* Patient was reoperated to drain the effusion

the incision from which the specimen was extracted through. In the OH group, a specific complication of liver resection, minor bile leakage, was encountered, and it healed automatically after percutaneous drainage. Patients with complications recovered uneventfully in both groups.

For patients with hepatolithiasis (16 in each group), one patient in the OH group had a residual stone and was treated by choledochoscope 3 months after hepatectomy. The intermediate stone clearance rate was 100% in the LH group and 93.8% in the OH group, and the final rate was 100% in either group.

Postoperative laboratory data are shown in Table 4. Postoperative albumin level of the LH group was significant higher than the OH group (33 ± 4.8 vs. 27.6 ± 3.2, $p = 0.001$).

Follow-up

During follow-up, all the patients lived well. One patient with residual stone was rehospitalized for choledochoscopy. Patients with malignant tumors were followed until death. The patient with hepatocellular carcinoma (HCC) in the OH group and the patient with cholangiocarcinoma in the LH group died of tumor recurrence, and the patient with HCC in the LH group had a tumor recurrence 13 months after hepatectomy.

Learning curve for laparoscopic left hemihepatectomy

In the LH group, a tendency of gradually decreased liver transection time was noticed in the early cases (excluding two converted cases, $n = 8$, $R^2 = 0.676$, $p = 0.012$; Fig. 7). Surgical feature and postoperative course are shown in Table 5. All complications, blood transfusions,

Table 4 Postoperative laboratory data

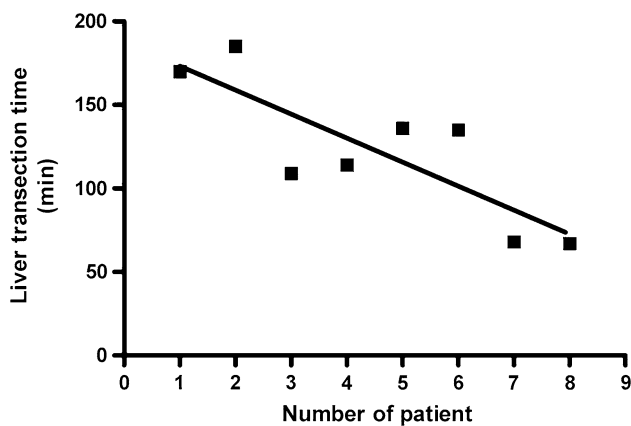| Variables	LH group	OH group	p
ALT (IU/l), peak level	145.2 ± 76.5	192.1 ± 173.1	0.31
ALB (g/l)	33 ± 4.8	27.6 ± 3.2	0.001
T-BIL (mg/dl), peak level	2.3 ± 2.6	1.9 ± 1.8	0.579

Fig. 7 Evaluation of liver transection time in early laparoscopic cases (excluding the two converted cases). $R^2 = 0.676$; $p = 0.012$

Table 5 Comparison between late cases and early cases in LH group

Variables	Late cases ($n = 9$)	Early cases ($n = 10$)	p
Operating time (min)	187 ± 68	263 ± 125	0.136
Intraoperative blood loss (ml)	239 ± 99	713 ± 412	0.004
Conversion	0	2	0.474
Patients requiring blood transfusion	0	2	0.474
Postoperative complication	0	2	0.474

and conversions occurred in early cases, none in late cases. Mean blood loss of late cases was significant lower than early cases (239 ± 99 vs. 713 ± 412, $p = 0.004$).

Discussion

Laparoscopic hemihepatectomy was rarely performed, mainly because of the risk of massive bleeding. The key of this procedure is how to control bleeding in liver transection. Before liver transection, blood flow coming from hepatic artery and portal vein was completely occluded by laparoscopic selective inflow occlusion. Blood vessels in transection plane, including left hepatic vein, were dissected and divided using the technique of hepatectomy by curettage and aspiration, which was introduced in previous literature [8]. By using these techniques, blood loss decreased significantly, which was proved in this study. Blood loss was significantly lower for the LH group compared with the OH group (462 ± 372 vs. 895 ± 704, $p < 0.05$); only two patients needed blood transfusions (mean, 4 units) in the LH group and eight in the OH group (mean, 6 units). The operating time of the LH group did not increase significantly (222 ± 104 vs. 204 ± 59, $p > 0.1$).

Total vascular occlusion was used to control intraoperative bleeding in some laparoscopic liver resections [2, 9–11].

Laparoscopic selective inflow occlusion is more difficult than total vascular occlusion, but it avoided complications of ischemial reperfusion injury and gastrointestinal congestion, corresponding with the goal of minimal invasion of laparoscopic surgery [12–15]. Furthermore, selective inflow occlusion does not require fast liver transection and allows surgeons to take time for meticulous dissection. This is the reason that we chose selective inflow occlusion instead of total vascular occlusion.

Gas embolism is another dangerous complication of laparoscopic surgery. In major hepatectomy, the vena cava may be partly occluded by compression or torsion. The venous pressure of the proximal vena cava decreased significantly and gas could be sucked into it via hepatic vein, which was described as venturi effect by Hatano [16]. In such a situation, even a small hole in the hepatic vein may lead to gas embolism. We bluntly dissected the left hepatic vein and clamped the proximal end immediately if the vein was injured. In recent cases, we tried to occlude the hepatic vein before liver transection to prevent gas embolism, but it is skill-demanding and dangerous work, which may lead to unmanageable bleeding and emergency conversion. Therefore, we did not regard it as a routine procedure, and it was only performed on selected patients whose left hepatic vein could be exposed sufficiently and was easy to dissect.

In this study, two cases in the LH group were converted to the open procedure (conversion rate, 10.5%). According to previous studies of liver resection, the conversion rate ranged from 3.3–16.7%, and the majority of procedures were local resection, segmentectomy, and left lateral segmentectomy, which are simpler than left hemihepatectomy [1–4, 6, 17]. However, the conversion rate for the LH group is still comparable to that in previous reports. Careful dissection using the technique of curettage and aspiration can partly explain this result, because most conversions of laparoscopic hepatectomy were due to the massive bleeding as a sequence of injuring main vessels. One case in the LH group converted for bleeding from a small hole in the wall of venae hepaticae intermediate, which was caused by excessive coagulation on the raw surface. The other case converted for severe adhesion in the upper abdomen from previous open cholecystectomy. We do not regard previous upper abdominal surgery as a contraindication for laparoscopic left hemihepatectomy unless the normal anatomic structure of bile duct has been changed.

The complication rate of the LH group is 10.5%, lower than the OH group (21%). No specific complications of liver resection occurred in the LH group, but a troublesome complication did occur: encapsulated abdominal effusion. The diagnosis for this patient was hepatolithiasis-associated extrahepatic duct stones. Generous fluid accumulated in the

abdominal cavity during the course of intraoperative choledochoscope. This is the second case in the LH group. The operating time was more than 8 hours for the additional procedure and lack of experience in laparoscopic hemihepatectomy.

Hepatolithiasis is a prevalent liver disease in Asian countries, and hepatectomy is considered an effective and safe approach. Sixteen cases in each group had hepatolithiasis and stone clearance rate was satisfactory in either group. Only one patient in the OH group had residual stones, which were cleared by cholangioscopy postoperatively. No patient in the LH group had residual stones. The intermediate stone clearance rate was 100% in the LH group and 93.8% in the OH group, and the final rate was 100% in either group. Stone clearance rate was similar between the two groups and was comparable to previous reports of open hepatectomy (87–98%) [18–22]. The high clearance rates in the LH group are attributed in part to the use of intraoperative laparoscopic ultrasound, which makes up the loss of tactile sensation in open hepatectomy and is more accurate than tactile sensation in detecting and locating stones deep in the liver parenchyma.

In the patients with malignant lesion, more than 1-cm free margin had been achieved in all cases. The relationship between cholangiocarcinoma and hepatolithiasis has been reported [23, 24]. In selected patients, hepatectomy may eradicate tumor and hepatolithiasis simultaneously, and provides the only chance for long-term survival. One associated cholangiocarcinoma was found in the LH group. The tumor was located in the left lateral segment very close to segment IV, and laparoscopic left hemihepatectomy was performed with a 2-cm free margin.

Except for significant lower intraoperative blood loss, the postoperative albumin level was significantly higher in the LH group compared with the OH group (33 ± 4.8 vs. 27.6 ± 3.2, $p < 0.05$), and the same result had been found in previous studies of laparoscopic hepatectomy [25]. Preservation of the abdominal wall, less protein losses, and less transfusion could partly account for this result. The major advantage of laparoscopic surgery—fast postoperative recovery—was found in this study. Postoperative hospital stay for the LH group was shorter but not significant compared with the OH group (9 ± 5 vs. 13 ± 7, $p = 0.086$).

The learning curve of laparoscopic left hemihepatectomy was studied. In the LH group, a tendency of gradually decreased transecting time was noticed in the early cases ($R^2 = 0.676$, $p = 0.012$). Blood transfusion, conversion, and complication all occurred in the first ten cases, and blood loss decreased significantly in the late cases (239 ± 99 vs. 713 ± 412, $p < 0.05$). The result indicated a gradual improvement of this procedure; more cases are needed to study the learning curve.

Conclusions

The results of this study showed that laparoscopic left hemihepatectomy is a safe and feasible procedure for selected patients. It suggests that this is an acceptable procedure for lesions of the left lobe in selected patients.

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