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The safety and feasibility of reoperation for the treatment of hepatolithiasis by laparoscopic approach

Ju Tian · Jian-wei Li · Jian Chen · Yu-dong Fan · Ping Bie · Shu-guang Wang · Shu-guo Zheng

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Abstract
Background Hepatolithiasis removal is associated with high rates of postoperative residual and recurrence, which in some cases may require multiple surgeries. The progress and development of laparoscopic techniques introduced a new way of treating hepatolithiasis. However, the selection criteria for laparoscopic hepatolithiasis surgery, particularly among patients with a history of biliary surgery, remain undetermined. This study aimed to evaluate the safety, feasibility, and efficacy of reoperation for the treatment of hepatolithiasis via a laparoscopic approach.
Methods A retrospective analysis of the perioperative course and outcomes was performed on 90 patients who underwent laparoscopic procedures for hepatolithiasis between January 1, 2008, and December 31, 2012. Thirty-eight patients had previous biliary tract operative procedures (PB group) and 52 patients had no previous biliary tract procedures (NPB).
Results There was no significant difference in operative time (342.3 ± 101.0 vs. 334.1 ± 102.7 min), intraoperative blood loss (561.2 ± 458.8 vs. 546.3 ± 570.5 ml), intraop erative transfusion (15.8 vs. 19.2 %), postoperative hospi talization (12.6 ± 4.2 vs. 13.4 % ± 6.3 days), postoperative complications (18.4 vs. 23.1 %), conversion to open laparotomy (10.5 vs. 9.6 %), or intraoperative stone clearance rate (94.7 vs. 90.4 %). There was also no significant difference in stone recurrence (7.9 vs. 11.5 %) and recurrent cholangitis (5.3 vs. 13.5 %) at a mean of 19 months of follow-up (range, 3–51 months) for PB patients compared to NPB patients. The final stone clearance rate was 100 % in both groups.
Conclusions Reoperation for hepatolithiasis by laparoscopic approach is safe and feasible for selected patients who have undergone previous biliary operations.

Keywords Bile duct stones · Hepatectomy · Laparoscopy · Reoperation · Therapeutic effect

Hepatolithiasis is defined as the primary formation of calculi (stone, mud, and/or sludge) within the intrahepatic bile ducts proximal to the common hepatic duct (confluence of the right and left hepatic ducts). It is a prevalent disease in Southeast Asia but rare in Western countries. The relative incidence (hepatolithiasis cases against all cases with gallstone disease) in Western countries is approximately 0.6–1.3 %, whereas in Taiwan, South Korea, and China, it has been reported to be 4–52 % [1]. During the late stages of the disease, hepatolithiasis may lead to biliary cirrhosis and cholangiocarcinoma (10 %), for which treatment is often less efficacious [2–4].

Laparotomy has been the standard approach for treating hepatolithiasis, but residual stones and high recurrence rates have been a major problem, often leading to multiple procedures [5–10]. In recent years, advances in laparoscopic and endoscopic surgical techniques have allowed minimally invasive surgical treatment of hepatolithiasis [11–13]. Compared to traditional laparotomy, laparoscopy has the advantages of smaller incisions, reduced pain and scarring,

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J. Tian · J. Li · J. Chen · Y. Fan · P. Bie · S. Wang · S. Zheng (✉)
Institute of Hepatobiliary Surgery, Southwest Hospital, Third Military Medical University, Shapingba District, Gaotanyan Road, Chongqing 400038, China
e-mail: shuguozh@yahoo.com.cn

J. Tian
e-mail: jtian1984@hotmail.com

faster recovery, shorter hospitalization, and improved maintenance of the abdominal wall integrity [14].

However, the selection of patients suitable for laparoscopic surgery, especially in those with a history of biliary surgery, is still being evaluated. Ahn et al. [15] have reported cases of laparoscopic liver resection in patients with a history of upper abdominal surgery, but to our knowledge, no systematic studies have reported on laparoscopic reoperation for hepatolithiasis.

We retrospectively analyzed the clinical data and follow-up results for 90 consecutive patients with hepatolithiasis treated with a laparoscopic hepatectomy combined or not combined with bile duct exploration.

Materials and methods

Inclusion criteria

No guidelines exist for the indication of laparoscopic hepatectomy for the treatment of hepatolithiasis. On the basis of the classification criteria of hepatolithiasis diagnosis and treatment developed by the Biliary Surgical Science Section of the Chinese Medical Association Surgery Branch in 2007, hepatolithiasis can be divided into the following three types: regional, diffusive, and complementary. The inclusion criteria for our laparoscopic procedures were as follows: (1) regional hepatolithiasis (stones are distributed along the intrahepatic biliary tree limited to one or more liver segments) located in unilateral intrahepatic bile duct; (2) with biliary strictures or parenchymal fibrosis or atrophy; (3) no extrahepatic or future remnant bile duct stricture or suppurative cholangitis, more than half a year after the last previous biliary operation. (4) liver function of Child A to B classification; without serious atrophy-hypertrophy complex and severe hepatic portal translocation; (5) for stones located in the reserved intrahepatic and extrahepatic bile duct, laparoscopic exploration were considered; (6) diagnosis of cholangiocarcinoma are excluded.

Patient information

Between January 1, 2008, and December 31, 2011, a total of 90 consecutive patients with regional hepatolithiasis had undergone laparoscopic hepatectomies combined or not combined with bile duct exploration at the Institute of Hepatobiliary Surgery, Southwest Hospital, Third Military Medical University. Thirty-eight patients had a history of previous biliary operative procedures (PB) and 52 patients had no previous biliary procedures (NPB). The patients in the PB group received a total of 46 previous biliary procedures, including six patients with two procedures and one patient with three procedures. The average interval between the last surgery and the current surgery was 8.8 (range, 1–33) years. Patients in both groups had significant symptoms of pain and discomfort in the liver area before surgery. Preoperative ultrasound, computed tomography, and magnetic resonance cholangiopancreatography (MRCP) were used to determine stone location, liver lesions, hepatic biliary system, and vascular system. Endoscopic retrograde cholangiopancreatography or percutaneous transhepatic cholangiography (PTC) were used if necessary. For patients requiring a major hepatectomy (left or right hemihepatectomy, right posterior sectionectomy), the indocyanine green retention rate at 15 minutes was determined, and the future remnant liver volume and standard liver volume ratio were calculated.

All patients underwent a preoperative electrocardiogram, chest radiography, and routine laboratory testing, including blood, urine, stool, liver and kidney function, and electrolytes. Informed consent was obtained from all patients. When patients were anesthetized, prophylactic antibiotics (third-generation cephalosporin or semisynthetic penicillins) were initiated and continued for 5–7 days. Patient characteristics are listed in Table 1. Additional patient information for the PB group is listed in Table 2. No significant differences in patient characteristics were found between the two groups ($P > 0.05$).

Operative technique

With the patient in the supine position, the laparoscopic procedure was performed under general endotracheal anesthesia. The Veress needle was inserted near the umbilicus. For patient with previous surgery, an open method was performed if the previous incision site was less than 3 cm away from the umbilicus. After pneumoperitoneum was established, the intraabdominal pressure was maintained at 12–14 mmHg (1 mmHg = 0.133 kPa). The initial trocar was placed where adhesions were expected to be absent or minimal. Then the laparoscope (Olympus, Japan) was introduced, and additional trocars were inserted carefully. The five-hole method was generally used, and on the basis of individual needs, the trocar and the puncture had a fan-shaped placement around the diseased lobe (segment), with the endoscope puncture located at the midpoint of the fan-shaped edge. If conversion to laparotomy was required, punctures were connected in a single line to comply with open abdominal liver resection requirements. Adhesiolysis was performed by using electrocautery and harmonic scalpel (Johnson & Johnson, USA).

After adhesiolysis and mobilization of the liver, the hepatectomy was performed in the usual manner. The resection line was determined on the basis of the preoperative imaging, intraoperative exploration, intraoperative ultrasound, and ischemia boundaries after hepatic vascular

Table 1 Characteristics of 90 patients[a]

Characteristic	PB group ($n = 38$)	NPB group ($n = 52$)	P
Gender			0.090
Male	7 (18.4)	18 (34.6)	–
Female	31 (81.6)	34 (65.4)	–
Age (years)	51.9 (27–77)	47.7 (21–73)	0.125
Stone distribution			0.829
Segments II, III	13 (34.2)	12 (23.1)	–
Segments II, III, IV	16 (42.1)	23 (44.2)	–
Segments VI, VII	3 (7.9)	5 (9.6)	–
Segments V, VIII	1 (2.6)	2 (3.8)	–
Segments V, VI, VII, VIII	4 (10.5)	7 (13.5)	–
Segment III	0 (0)	2 (3.8)	–
Segment VI	1 (2.6)	1 (2.0)	–
Combined with extrahepatic bile stones	28 (73.7)	40 (76.9)	0.724
Prior cholangitis attack	17 (44.7)	25 (48.1)	0.754

PB previous biliary tract operative procedures, *NPB* no previous biliary tract operative procedures

[a] Data are expressed as n (%) or median (range)

occlusion. The vascular occlusion methods were chosen on the basis of the lesion site and surgical approach. Selective hemihepatic vascular occlusion was used for regular hemihepatectomy. For lesions located in the left lateral segment, right posterior segment, or right anterior segment, the intermittent Pringle maneuver was often used if necessary, or the corresponding hepatic pedicle was dissected for regional blood flow occlusion selectively. The harmonic scalpel, Hem-o-Lok clip, bipolar coagulator (Wolf, German), endoscopic rotation clip applied (Johnson & Johnson, USA), and endolinear stapler (Endo Cutter; Johnson & Johnson, USA) were used in conjunction to transect the hepatic parenchyma. Endoscopic ultrasound was used to prevent transection offsets and to ensure proper separation from normal tissue. The resected specimen was stored in a specimen bag and retrieved through a 12-mm tunnel after disintegration. For cases combined with extrahepatic biliary stones or cases of suspected residual stones, the bile duct exploration and stone removal were performed through the common bile duct or through the left or right hepatic bile duct terminus via choledochoscope, and the T tube was selectively placed. The row surface was carefully checked for bleeding, and bile leakage and the abdominal cavity was thoroughly cleaned, followed by the placement of a drainage tube.

Patient follow-up

Outpatient follow-up for all 90 patients began 1.5 months after surgery, followed by additional telephone and outpatient patient examinations once every 6 months. Liver function tests and abdominal ultrasound were regularly performed. CT scan and MRCP were selectively performed in cases of suspected of stone recurrence and in patients with symptoms of cholangitis.

Table 2 Characteristics of 38 previous biliary procedures in the PB group

Procedure	n (%)
Laparoscopic cholecystectomy	2 (4.3)
Open cholecystectomy	5 (10.8)
Open cholecystectomy + bile duct exploration/lithotomy	23 (50.0)
Cholecystectomy + bile duct exploration + partial hepatectomy	15 (32.6)
Cholecystectomy + bile duct exploration + choledochojejunostomy	1 (2.2)

PB previous biliary tract operative procedures

Statistical analysis

All values are presented as mean ± standard deviation. SPSS 13.0 statistical software was used for statistical analysis. The t test was used to compare the mean between two groups. Rates were compared by the Pearson's χ^2 and Fisher's exact test. A P value of <0.05 was considered statistically significant.

Results

The surgical approaches of the two groups are shown in Table 3. Perioperative and follow-up results are shown in Table 4. The differences between the two groups of patients were not statistically significant ($P > 0.05$) for operative time, intraoperative blood loss, intraoperative transfusion, rate of conversion to laparotomy, postoperative hospitalization, incidence of complications, stone clearance rate, stone recurrence, and recurrent cholangitis. Four patients from the PB group required conversion to laparotomy. Of these, three patients developed severe adhesions and one patient had intractable hepatic vein hemorrhage during liver parenchyma transection. Five NPB patients required laparotomy. Of these, two patients developed severe adhesions, one patient had severe first hepatic portal fibrosis (which was hard to dissect), and two patients had intractable hemorrhage. There were no perioperative deaths in the two groups. Seven PB patients and 12 NPB patients developed postoperative complications. Of these, ten received conservative medical treatment, seven underwent chest/abdominal puncture and drainage, and two required debridement. All patients with complications were successfully treated. No patient developed

Table 3 Surgical procedure in 90 patients

Procedure	PB group, *n* (%) (*n* = 38)	NPB group, *n* (%) (*n* = 52)	*P*
Hepatectomy			0.778
Left lateral lobectomy (segments II, III)	10 (26.3)	12 (23.1)	–
Left hemihepatectomy (segments II, III, IV)	19 (50.0)	24 (46.2)	–
Right posterior lobectomy (segments VI, VII)	3 (7.9)	5 (9.6)	–
Partial right anterior lobectomy (segments V, VIII)	0 (0)	2 (3.8)	–
Right hemihepatectomy (segments V, VI, VII, VIII)	6 (15.8)	7 (13.4)	–
Segmentectomy III	0 (0)	1 (2.0)	–
Segmentectomy VI	0 (0)	1 (2.0)	–
Joint cholecystectomy/bile duct exploration and stone removal	37 (97.4)	44 (84.6)	0.073

PB previous biliary tract operative procedures, *NPB* no previous biliary tract operative procedures

complications such as intraabdominal hemorrhage, liver failure, or nonhealing of bile leakage. The intraoperative stone clearance rates were 94.7 and 90.4 % for the PB and NPB groups, respectively. Forty days after the initial surgery, seven patients with residual stones had their stones successfully removed through a T tube tract choledochoscope. The final stone clearance rate was 100 %.

We successfully implemented follow-up of 84 patients (93.3 %) until March 2012. The average follow-up duration was 19 (range, 3–51) months. Three PB patients and six NPB patients developed recurrent common bile duct stones; three of these patients received repeated surgeries. Two PB patients and seven NPB patients continue to report symptoms of cholangitis of different degrees; five patients required hospitalization.

Discussion

Hepatolithiasis is prevalent in China. Late stages of the disease lead to secondary biliary cirrhosis, liver parenchymal damage, and cholangiocarcinoma [16, 17]. Hepatolithiasis has high postoperative residual stone (13.6 %) and recurrence rates (9.5 %). With China's health care disparity, some community hospitals do not have the technical expertise to treat hepatic lesions or bile duct stenosis. Surgical procedures are often limited to extrahepatic bile duct stone removal, leading to frequent residual bile duct stones and lesions that require additional surgeries.

A history of abdominal procedures has been considered a contraindication for laparoscopic surgery. With advancements in laparoscopic instruments, laparoscopic surgery has gradually begun to be used to treat patients with a history of abdominal surgery [18–22].

Although treating residual and recurrent hepatolithiasis with a repeat laparoscopic approach in patients who have undergone previous surgeries is still in the exploratory stage, published reports suggest that repeat laparoscopic exploration of choledocholithiasis and resection of hepatic tumors are feasible and safe [23, 24]. The primary treatments for hepatolithiasis are resection and choledochoscopic exploration/stone removal; therefore, we have reason to believe that repeat laparoscopic surgery for hepatolithiasis is practical. Our results found no significant differences between perioperative and follow-up results in the PB and NPB groups, suggesting that reoperation of hepatolithiasis by laparoscopic approach is safe and feasible and can be used as the surgical approach in repeated hepatolithiasis surgery.

Previous surgeries, especially peritoneal adhesions caused by a previous laparotomy, often complicate peritoneal insufflation, trocar placement, and surgical field exposure; such previous surgery is the primary factor complicating the implementation of repeat laparoscopic surgery [23]. In addition, hepatolithiasis is often associated with atrophy–hypertrophy complex, hepatic portal translocation, inflammatory adhesions, and bile duct fibrosis. These pathological factors inherently affect the operative field detachment and exposure [25, 26]. In patients with right hepatic lobe stones, the affected lobe atrophies while the left lobe undergoes compensatory enlargement, causing a posterior medial rotation and translocation of the vena cava inferior to the first hepatic portal and hepatic segment/interlobular fissure. The right hepatic lobe often forms pathological adhesions with the diaphragm, posterior abdominal wall, adjacent tissue, and inferior vena cava. This complicates the detachment of the right posterior segment from the inferior vena cava, surgical field exposure, and proper determination of the plane of resection. In our experience, at locations no less than 3 cm away from the original surgical scar site, the Veress needle may be inserted or the first trocar may be placed with the Hasson technique to establish pneumoperitoneum [27]. Under endoscopic guidance, the second trocar may be inserted into nonadhesive areas to effectively avoid visceral injury. The surgery should first detach tissues such as the liver, intestine, omentum, and abdominal wall adhesions to expose the upper abdominal surgical field fully. Subsequently, the adhesions between hepatic surfaces with the gastrointestinal tract, omentum, and other tissue should be separated. The first hepatic portal should be exposed from anterior to posterior and exterior to interior. The posterior

Table 4 Perioperative and long-term results of 90 patients in both groups[a]

Parameter	PB group ($n = 38$)	NPB group ($n = 52$)	P
Operative time (min)	342.3 ± 101.0	334.1 ± 102.7	0.725
Intraoperative blood loss (ml)	561.2 ± 458.8	546.3 ± 570.5	0.904
Intraoperative transfusion	6 (15.8)	10 (19.2)	0.673
Conversion to laparotomy	4 (10.5)	5 (9.6)	0.887
Postoperative hospitalization (d)	12.6 ± 4.2	13.4 ± 6.3	0.563
Complications	7 (18.4)	12 (23.1)	0.593
Bile leakage	1	3	–
Row surface collection	4	3	–
Abdominal infection	1	2	–
Pleural effusion	0	1	–
Main puncture site infection	1	3	–
Intraoperative stone clearance	36 (94.7)	47 (90.4)	0.694
Final stone clearance	38 (100)	52 (100)	–
Stone recurrence	3 (7.9)	6 (11.5)	0.728
Recurrent cholangitis	2 (5.3)	7 (13.5)	0.293

PB previous biliary tract operative procedures, *NPB* no previous biliary tract operative procedures

[a] Data are expressed as mean ± SD, *n* (%), or *n*

peritoneum of the liver anterior to the hepatoduodenal ligament is dissected and the duodenal ampulla is moved inferiorly, thereby allowing for the dissection of the foramen of Winslow and the lesser peritoneal sac. Subsequently, adhesions between the diaphragm and the liver are removed and the perihepatic lobe/segment ligaments are predissected.

Through the comparative analysis of the clinical data from 90 patients treated with laparoscopic surgery for regional hepatolithiasis, we found that adhesion in the surgical field and ambiguous anatomy caused by previous biliary surgery indeed increased the difficulty of repeated surgeries. The PB group had an increase in operative time, intraoperative blood loss, and intraoperative transfusion rate compared to the NPB group, but these differences were not statistically significant. Neither group developed complications related to trocar placement, peritoneal insufflation, and adhesion separation. In the PB group, adhesions caused by previous biliary tract surgeries did not increase the laparotomy rate or the incidence of complications. Instead, the use of the endoscope magnification features, the ability to control peritoneal insufflation pressure, and the separation of adhesions may be superior to laparotomy. The postoperative hospitalization, complications, stone clearance rate, stone recurrence, and cholangitis symptoms were not significantly different between the two groups, suggesting that previous biliary surgeries for patients with residual or recurrent hepatolithiasis are not a contraindication for laparoscopic surgery.

This study is novel in that it compared the safety and efficacy of hepatolithiasis laparoscopic surgery for patients with and without previous biliary surgeries. Through retrospective analysis, we found that reoperation by laparoscopic approach is feasible and safe for selected patients with hepatolithiasis and can achieve the same efficacy as in patients with no history of biliary tract surgery, providing a minimally invasive surgical approach for residual or recurrent hepatolithiasis patients who require multiple surgeries. This is a retrospective study; therefore, the number of cases is small, and the previous procedures were relatively simple, thus acting as limitations of our study. Future prospective studies with larger sample sizes should provide evidence-based support for our current observations.

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