Observational Study

Medicine®

OPEN

Biliary tract exploration through a common bile duct incision or left hepatic duct stump in laparoscopic left hemihepatectomy for left side hepatolithiasis: which is better?

A single-center retrospective case–control study

Xintao Zeng, MD[a,b], Pei Yang, MD[b], Wentao Wang, PhD[a,*]

Abstract

Laparoscopic left hemihepatectomy (LLH) followed by biliary tract exploration is used to treat left-sided hepatolithiasis (LSH). The purpose of this study was to compare the efficacy of 2 methods of biliary tract exploration in LLH:biliary tract exploration through a common bile duct (CBD) incision (with T-tube drainage) or through the left hepatic duct (LHD) stump (without T-tube drainage).

LSH patients (113 patients) were recruited retrospectively in our hospital from December 2008 to January 2016. To compare different methods of biliary tract exploration during LLH, the patients were divided into 2 groups: 41 patients underwent biliary tract exploration through the LHD stump (LHD group), and 72 patients underwent biliary tract exploration through a CBD incision (CBD group). Baseline characteristics, surgical outcomes, surgery-related complications, postoperative hospital stay (PHS) and long-term results were compared between the 2 groups.

There was no unplanned reoperation in the 2 groups. One patient in the CBD group had a residual stone, which was removed by choledochoscopy 2 months postoperation. Two patients in the LHD group and 3 patients in the CBD group had bile leakage and were cured with abdominal drainage. There were no significant differences in the total operation time, incidence of residual stones and bile leakage between the 2 groups ($P > .05$). The PHS and the incidence of hypokalemia or hyponatremia in the LHD group were significantly lower than those in the CBD group ($P < .05$). T-tube-related complications occurred in 13.9% (10/72) of the CBD patients. The mean follow-up period was 37.2 ± 13.8 months. There were no significant differences in the incidence of recurrence stones or cholangitis ($P > .05$) between the 2 groups.

Exploration of the biliary tract through the LHD stump without T-tube drainage is safe with satisfactory short- and long-term results for selected LSH patients.

Abbreviations: CBD = common bile duct, CT = computed tomography, CVP = central venous pressure, ERCP = endoscopic retrograde cholangiopancreatography, EST = endoscopic sphincterotomy, ICG-R15 = 15-minute retention rate of indocyanine green, LHD = left hepatic duct, LLH = laparoscopic left hemihepatectomy, LSH = left-sided hepatolithiasis, LUS = laparoscopic ultrasonography, MHV = middle hepatic vein, MRCP = magnetic resonance cholangiopancreatography, PHS = postoperative hospital stay.

Keywords: electrolyte disturbance, hepatolithiasis, laparoscopic hepatectomy, T-tube drainage

1. Introduction

Hepatolithiasis refers to calculi formed in the proximal part of the junction of the left and right hepatic duct within the liver, irrespective of the coexistence of gallstones in the common bile duct and/or gallbladder.[1] It is common in East Asia (4%–52%), including China, South Korea, and Japan, but is rare in Western countries (0.6%–1.3%).[2,3] According to a previous census, the relative incidence of hepatolithiasis in China decreased from 16.1% in 1985 to 4.7% in 1992, but the number of patients with hepatolithiasis remains very large for the following reasons: First, previous treatments of hepatolithiasis had high residual and recurrence rates (30%–60%).[4,5] Additionally, due to the improvement of medical and health conditions, an increasing number of patients with hepatolithiasis are diagnosed in early stages through health surveys. Furthermore, the population is increasing.

The confluence of the left hepatic duct and the common hepatic duct is usually an acute angle, and the right posterior segments are located at a lower position, which is likely to cause cholestasis. Therefore, the left and right posterior lobes of the liver are the most common sites of hepatolithiasis, and approximately 81% of hepatolithiasis occurs in the left side.[6]

Hepatolithiasis is localized in the early stage, but in the late stage, it may be diffusely distributed. This causes secondary biliary cirrhosis or even cholangiocarcinoma,[7] which seriously

Editor: Muhammed Mubarak.

Funding: This research was supported by the Health and Family Planning Commission of Sichuan Province (grant no. 17PJ146).

The authors have no conflicts of interest to disclose.

[a] Department of Liver Surgery, West China Hospital, Sichuan University, Chengdu, [b] Department of Hepatobiliary Surgery, Mianyang Central Hospital, Sichuan, Mianyang, China.

[*] Correspondence: Wentao Wang, Department of Liver Surgery, West China Hospital, Sichuan University, Chengdu, China, 610041 (e-mail: wwt02@163.com).

Medicine (2018) 97:46(e13080)

Received: 19 April 2018 / Accepted: 10 October 2018

http://dx.doi.org/10.1097/MD.0000000000013080

affects patients' quality of life and imposes serious economic burdens on their families and society.[8] Previous studies have shown that 2.0% to 12% of hepatolithiasis cases will progress to cholangiocarcinoma, a rate that is 20-fold higher than normal.[9,10] Bile duct obstruction, chronic cholangitis, and liver parenchymal damage are common pathologic features associated with hepatolithiasis. Moreover, the main manifestations of chronic cholangitis are thickening of the bile duct wall and hyperplasia of the glands, even following the removal of the stones. These changes cannot be reversed and are an important cause of stone recurrence; approximately 40% to 95.8% of hepatolithiasis cases are accompanied by biliary strictures.[11–13] The treatment of hepatolithiasis has substantially changed; the ideal hepatolithiasis treatment method should aim to remove the lesion and obstruction and prevent the recurrence of stones.[14] According to Otani et al,[11] hepatolithiasis treated with hepatectomy could reduce the incidence of recurrence and stricture of the remaining bile duct.

Compared with open surgery, laparoscopic hepatectomy for hepatolithiasis has many advantages, including less trauma, faster postoperative recovery, and fewer complications.[15,16] Biliary tract exploration is traditionally performed through the CBD incision to find residual stones and potential lesions.[17] After exploration, T-tube drainage is performed to prevent bile leakage and to remove residual stones.[18] However, T-tube drainage often leads to bile loss, T-tube displacement, and infection at the T-tube site.[19] These complications affect a patient's activity and quality of life and therefore contradict the concepts of rapid rehabilitation and minimal invasiveness.[20,21] For treatment of hepatolithiasis by LLH, the choledochoscope enters the biliary tract through the left hepatic duct (LHD) stump without choledochotomy. However, the efficacy and safety of biliary tract exploration through the LHD stump, specifically concerning the incidence of bile leakage and residual stones, requires further research.

2. Materials and methods

This retrospective study was approved by the Ethics Committee of West China Hospital, Sichuan University, and was performed in accordance with the ethical guidelines of the Declaration of Helsinki. All the patients were informed of the advantages and disadvantages of the 2 methods and gave their informed consent prior to the operation. The surgical procedure was ultimately chosen by the patients.

2.1. Patients

The study was based on a retrospective review and analysis of the electronic medical records of 113 consecutive patients with LSH treated with LLH at West China Hospital from December 2008 to January 2016. There were 49 male and 64 female patients whose ages ranged from 21 to 73, with an average age of 45.8 ± 11.3 years. To analyze different methods of biliary tract exploration in LLH, 113 patients were divided into 2 groups: 41 patients underwent biliary tract exploration through the LHD stump (LHD group), and 72 patients underwent biliary tract exploration through CBD incision (CBD group). There was no significant difference in basic data between the 2 groups (Table 1).

The inclusion criteria were as follows: LSH with or without gallbladder stones, left caudate lobe or right hepatic duct stones in first order or second order; and liver function classified as Child–Pugh A or a 15-minute residual rate of indocyanine green (ICG R15) ≤ 10%. The exclusion criteria were as follows: biliary stricture present in any part of the biliary tract other than the LHD or right side hepatolithiasis combined with liver atrophy; an association with a malignant tumor; acute pancreatitis, cholangitis, or obstructive jaundice (TBIL ≥ 34 μmol/L) without remission; and abnormal cardiopulmonary function that could not tolerate LLH, and the patient was reluctant to undergo hepatectomy.

Table 1

Clinicopathological characteristics of the 113 LSH patients.

	LHD group (n = 41)	CBD group (n = 72)	*P* value
Gender,n			.351
Male	17	32	
Female	24	40	
Age, years, mean ± SD	43.2 ± 12.5	46.8 ± 10.2	.280
Clinical manifestations, n			
Fever	11	21	.793
Abdominal pain	24	47	.801
Jaundice	7	12	.872
Concomitant diseases, n			
Acute pancreatitis	4	6	.836
Acute cholecystitis	13	25	.764
Distribution of left liver stones, n			.579
Left lateral lobe	24	39	
Left hemiliver	17	33	
Concomitant biliary stones, n			
Right hepatic duct stones	3	8	.751
Extrahepatic bile duct stones	13	24	.329
Gall bladder stones	16	26	.656
Diameter of LHD, mm, mean ± SD	9.2 ± 4.8	8.5 ± 5.1	.443

CBD = common bile duct, LHD = left hepatic duct, LSH = left-sided hepatolithiasis.

2.2. Preoperative assessment

Before surgery, color Doppler ultrasound, computed tomography (CT), or magnetic resonance cholangiopancreatography (MRCP), an examination was performed to determine the distribution of gallstones, liver lobe atrophy and cholangiocarcinoma. We then determined whether these were combined with bile duct stricture and aberrance. The diameter of the LHD was measured by color Doppler ultrasound. The shortcomings of endoscopic retrograde cholangiopancreatography (ERCP) include destroying the sphincter of Oddi, which leads to acute pancreatitis, gastrointestinal perforation and bleeding. Furthermore, this treatment is unable to remove stones from the intrahepatic bile duct; it is mainly used in the treatment of acute gallstone-related pancreatitis and obstructive jaundice. Liver function was evaluated based on the Child-Pugh classification system and/or the indocyanine green (ICG) clearance test.

2.3. Surgical treatment

An experienced laparoscopic surgeon (in a senior professional and technical position) performed the operations. Five holes were established in the abdominal wall with pneumoperitoneum pressure between 12 and 14 mm Hg. To control for the infusion speed during the hepatectomy, the central venous pressure (CVP) was maintained below 5 cmH_2O. After inspection of the abdominal cavity and the liver, laparoscopic cholecystectomy was performed first. Then, the left hepatic artery and left portal vein were clipped and cut off sequentially. Next, the left hepatic ligaments (falciform ligament, left coronary ligament, and left triangular ligament) were freed, the middle hepatic vein (MHV) and stones were detected by laparoscopic ultrasonography (LUS), and hepatic parenchyma was transected using an ultrasound knife on the left side of the MHV. If the bleeding was obvious during hepatectomy, the intermittent Pringle maneuver (IPM, 15/5 min) was performed. The left hepatic duct was cut off at the proximal site of stenosis. An electronic choledochoscope (4.9 mm) was inserted via the left upper quadrant port through the LHD stump (Fig. 1A and B) or the CBD incision (Fig. 1C and D) into the biliary tract to observe the bile duct mucosa and sphincter of Oddi and to remove residual stones. The LHD stumps were sutured continuously by 4-0 Prolene after biliary tract exploration. Choledochotomy and T-tube insertion were not needed in the LHD group, and one drainage tube was placed beside the liver section. In the CBD group, choledochotomy was performed and a suitable T-tube was placed in the common bile duct after biliary tract exploration. Two drainage tubes were placed beside the liver section and the foramen of Winslow, respectively. To reduce the residual rate of stones, choledochoscopy was performed by 2 surgeons per patient and confirmed by LUS.

2.4. Postoperative care

If there was no bile leakage or infection, the drainage tubes were removed on the third day after surgery. In the CBD group, the T-tube was clamped on the seventh day after surgery, and biliary tract radiography was performed one month after the operation. If there were no residual stones or stenosis, the T-tube could be removed. If residual stones were found, they were removed by ERCP/endoscopic sphincterotomy (EST) in the LHD group and by choledochoscopy in the CBD group 2 months postoperation.

All patients received follow-up care in an outpatient clinic or by a telephone interview. Patients underwent color Doppler ultrasound examination and liver function testing 3 months after the operation. Thereafter, they were followed every 6 to 12 months, and MRCP or CT was performed if recurrent stones were suspected. Patients with a recurrence of stone or cholangitis were treated with either conservative treatment, ERCP/EST, laparoscopic surgery or open surgery based on the location of stones and the severity of symptoms.

2.5. Statistical analysis

All data were analyzed using SPSS statistical software for Windows (ver. 13.0; SPSS Inc., Chicago, IL). All data are presented as the mean (standard deviation) or number (% incidence). For continuous variables, Kolmogorov–Smirnov test

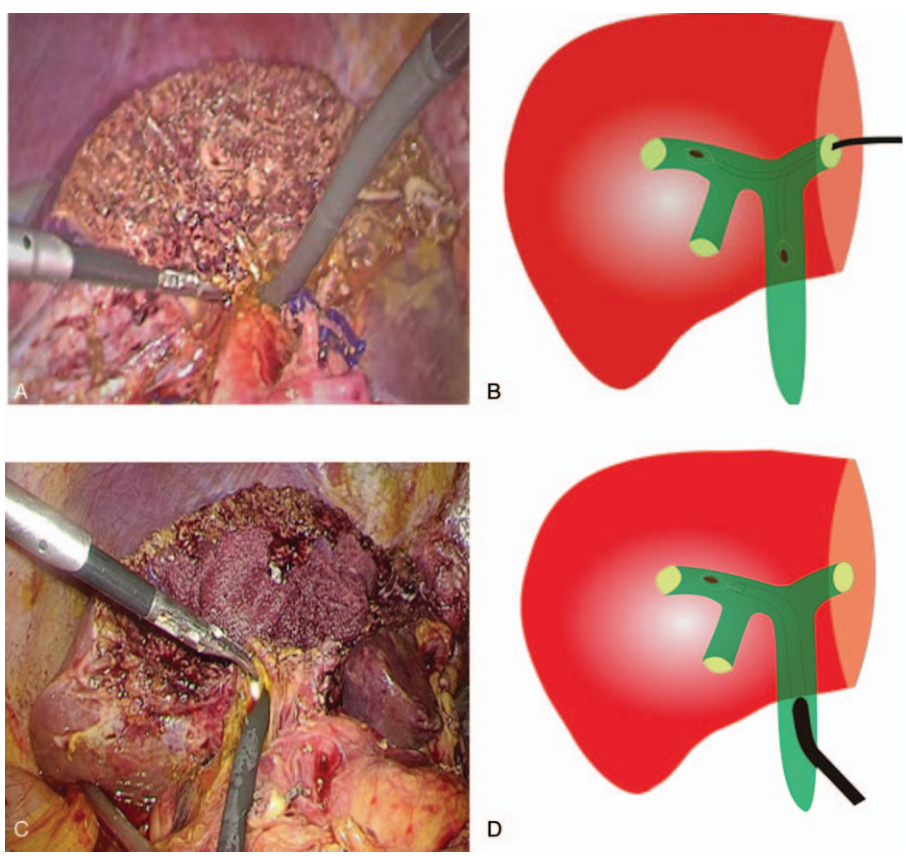

Figure 1. Choledochoscope through the left hepatic duct (LHD) stump or the common bile duct (CBD) incision to explore the biliary tract. (A) Choledochoscope through the LHD stump to explore the biliary tract; (B) Schematic diagram of bile duct exploration and stone removal through the LHD stump; (C) Choledochoscope through the CBD incision to explore the biliary tract; (D) Schematic diagram of bile duct exploration and stone removal through the CBD incision. CBD = common bile duct, LHD = left hepatic duct.

and Shapiro–Wilk test were performed to check the distribution condition. For variables showing normal distribution, the Levene test of equality and Student's *t* test were used. For variables with an abnormal distribution, the Mann–Whitney *U* test was used. For categorical variables, chi-squared test and Fischer exact test were used. The patients were divided into the LHD group and the CBD group, and variables were compared using the Student's *t* test, Mann–Whitney *U* test, chi-square test, and Fischer exact test, as appropriate. *P*-values<.05 were considered statistically significant.

3. Results

3.1. Perioperative outcomes

Bile duct injury, liver failure, and unplanned reoperation did not occur in either group. T-tube insertion was performed in all patients of the CBD group. In the LHD group, 2 patients had large-sized CBD stones which could not be extracted through the LHD stump. Those patients received a choledochotomy, and CBD incision was primary sutured after biliary tract exploration. In these patients, bile leakage did not happen. Grade A bile leakage[22] (leakage that has little or no impact on patients' clinical management) occurred in 2 and 3 patients in the LHD and CBD groups, respectively, and was cured with conservative treatment. There were no significant differences in the total operation time, bleeding volume, incidence of conversion and residual stones between the 2 groups ($P>.05$) (Table 2). The time of choledochoscopy in the LHD group was significantly longer than that in the CBD group ($P<.05$) (Table 2). The incidences of hypokalemia or hyponatremia and PHS were significantly lower in the LHD group than those in the CBD group ($P<.05$) (Table 2). In the CBD group, infection at the T-tube site occurred in 8 patients, and 2 patients suffered accidental displacement of the T-tube. In total, 13.9% of T-tube related procedures had complications (10/72) (Table 2).

Table 2

Perioperative and Follow-up Outcomes of the 113 LSH Patients.

	LHD group (n=41)	CBD group (n=72)	*P* value
The time of choledochoscopy,min, mean ± SD	31.5 ± 16.9	18.2 ± 11.7	.004
Total operation time,min, mean ± SD	195.2 ± 96.4	181.6 ± 101.3	.183
Bleeding volume,ml, mean ± SD	370.1 ± 112.3	355.8 ± 149.8	.287
Conversion to laparotomy, n	1	3	.608
Conversion to choledocholithotomy, n	2	—	—
PHS,days, mean ± SD	6.1 ± 1.8	10.7 ± 3.2	.015
Surgical complications, no. (%)			
Subphrenic abscess	2	4	.783
Bile leakage (Grade A), [22]	2	3	.902
Pulmonary infection	3	7	.659
Residual stones	0	1	.790
Hypokalaemia (<3.5 mmol/L)	3	11	.000
Hyponatraemia (<5 mmol/L)	4	12	.002
T-tube complications, n			
Infection at the T-tube site	—	8	—
T-tube displacement	—	2	—
Follow-up results, n			
Recurrent stones	1	0	.421
Recurrent cholangitis	2	2	.519

CBD = common bile duct, LHD = left hepatic duct, LSH = left-sided hepatolithiasis, PHS = postoperative hospital stay.

3.2. Recurrence patterns and treatments

Unfortunately, 18 (15.9%) patients in this study were disqualified due to lack of follow-up. The follow-up time ranged from 26 to 84 months, with an average time of 37.2 ± 13.8 months. The clinical symptoms of all patients were significantly relieved. One patient in the LHD group experienced a recurrence of CBD stones 38 months after the operation that was cured with ERCP/EST. Two patients in the LHD group and one patient in the CBD group experienced recurrent cholangitis; however, the clinical symptoms were mild and were effectively controlled with oral antibiotics and hepatoprotective drugs. There were no significant differences between the 2 groups with respect to the recurrence rates of stones or cholangitis ($P>.05$) (Table 2). No cholangiocarcinomas were observed during follow-up.

4. Discussion

LSH treatment with open left hemihepatectomy and biliary tract exploration through the LHD stump could simplify the operation procedure by avoiding choledochotomy and subsequent T-tube insertion. To this end, 90.1% of the patients avoided T-tube placement.[23] Exploration the biliary tract through the LHD stump during laparoscopic surgery offers patients shorter operative duration and length of hospitalization.[24,25] However, more than half of the LSH patients in their study had undergone left lateral sectionectomy. Moreover, the authors did not indicate whether there was any difference between the left lateral sectionectomy and left hemihepatectomy in terms of biliary tract exploration through the LHD stump. Under ordinary circumstances, the diameter of the LHD stump is smaller and further away from the CBD when left lateral sectionectomy is performed. The biliary tracts of the left medial segment are difficult to explore through the LHD stump, which may increase the incidence of residual stones. Previous studies have indicated that the treatment of left-sided hepatolithiasis by left lateral sectionectomy has a high recurrence rate.[6,23] Left hemihepatectomy was performed routinely in our study, and the biliary tract was explored by choledochoscope through either CBD incision or LHD stump. We compared the efficacy of the 2 groups and confirmed that biliary tract exploration through the LHD stump had the advantages of reducing PHS and avoiding electrolyte disturbance due to bile loss.

Maging examinations are very important for patients with hepatolithiasis. The diameter of the LHD, distribution of calculi, and morphology of the liver should be carefully analyzed before surgery. Color ultrasound, enhanced CT and MRCP each have their own merits in the diagnosis of hepatobiliary disease.[6,26,27] In our study, MRCP combined with color ultrasound or CT was often used to confirm the diameter of the LHD and the distribution of stones. Notably, intrahepatic or extrahepatic bile duct stones and vessels could be precisely localized by LUS,[28,29] and this technique could be used to guide the removal of stones and the cutting plane.

In 60% to 73.1% of patients with hepatolithiasis, stones are also present in the extrahepatic bile duct,[10,24] and the function of the sphincter of Oddi needs to be observed during surgery. Therefore, a thorough exploration of the biliary tree should be performed during laparoscopic hepatectomy to check for hepatolithiasis. Choledochotomy and T-tube insertion were needed.[30,31] The purpose of T-tube insertion is to decompress the biliary tract and remove residual stones. However, T-tube-related complications are relatively common, and 10% to 15% of patients may experience complications, such as fluid and electrolyte imbalance, bile leakage, infection at the T-tube site, and T-tube displacement.[19,32–35] The incidence of T-tube-related complications in the CBD group in this study (13.9%) was similar to that reported in previously published work. The proportion of T-tube-related complications is not reduced after changes in T-tube materials.[36] However, the choledochoscope could enter the biliary tract through the LHD stump (as shown in the LHD group). After exploration, the LHD stump underwent primary closure, this avoiding choledochotomy and subsequent T-tube insertion (and therefore T-tube complications). Bile is rich in electrolytes and bile salts, which can inhibit the propagation of intestinal pathogenic bacteria and stimulate gastrointestinal peristalsis.[37–39] With the loss of bile, electrolyte disturbance may occur, and the recovery of gastrointestinal function may be delayed. Therefore, exploration of the biliary tract through the LHD stump is beneficial to avoid the complications related to T-tube placement and bile loss, thus promoting quick patient recovery and reduction of PHS.

More patience and skill are needed when exploring the biliary tract through the LHD stump.[23] The difficulty of stone extraction depends not only on the diameter of the LHD but also on the number and size of the CBD stones. The results of this study show that the biliary tract exploration time was significantly longer in the LHD group than in the CBD group, mainly because of differences in choledochoscopy habits and a longer stone removal path. However, there was no significant difference in total operation time because there was no need for T-tube placement in the LHD group.

For patients without T-tube placement, residual stones may require ERCP/EST or even reoperation, which increases the economic and mental burden on the patient and may cause them additional harm and may result in legal action. Consequently, patients should be fully informed of any surgical risk preoperation. Exploration of the biliary tract through the LHD stump when left lateral sectionectomy is conducted, the left medial segment duct may become a blind area. LSH treated with a left hemihepatectomy can reduce the blind area and reduce the possibility of residual stones. Measures to reduce residual stones also include assessing the distribution of stones according to the preoperative imaging data, performing LUS routinely, and exploring biliary tract with choledochoscope by 2 surgeons separately. Bile leakage is another problem that needs to be noticed when a T-tube is not placed. One study showed that T-tube insertion after anatomic hemihepatectomy did not reduce the incidence of bile leakage but may be effective for extended hemihepatectomy.[19] Unskilled suturing and biliary obstruction are the main factors contributing to bile leakage.[40,41] In our study, there was no significant difference in the incidence of bile leakage between the 2 groups.

However, removal of stones from the LHD stump is not suitable for all patients. In patients with a narrow LHD and large stones in CBD, choledocholithotomy and T-tube drainage is recommended. Additionally, in patients with obvious sphincter edema and biliary tract infection, the T-tube is required to relieve biliary tract decompression and reduce the incidence of bile leakage.

In conclusion, selected LSH patients were treated with LLH and biliary tract exploration through the LHD stump. Combined with intraoperative choledochoscopy, LUS is safe and effective. This method avoids a series of complications resulting from choledochotomy and T-tube placement without increasing the incidence of bile leakage and residual stones. This method could reduce PHS and avoid electrolyte disturbance and reflects the superiority of minimally invasive techniques that lead to rapid rehabilitation. A prospective randomized controlled trial is being planned to further validate these results.

Acknowledgments

The authors thank the patients for allowing us to publish this study and Kimberly Yasutis, PhD, from the AJE Group (www.aje.com), for editing a draft of this article. We also thank Miss Li Jing for conducting the statistical analyses in this study.

Author contributions

Conceptualization: Wentao Wang.
Data curation: Xintao Zeng, Pei Yang.
Formal analysis: Xxintao Zeng.
Investigation: Pei Yang.
Methodology: Xxintao Zeng, Pei Yang.
Resources: Xxintao Zeng.
Software: Xxintao Zeng, Pei Yang.
Supervision: Wentao Wang.
Visualization: Wentao Wang.
Writing – original draft: Xxintao Zeng, Pei Yang.
Writing – review & editing: Wentao Wang.

References

[1] Liu FB, Yu XJ, Wang GB, et al. Preliminary study of a new pathological evolution-based clinical hepatolithiasis classification. World J Gastroenterol 2015;21:2169–77.
[2] Tian J, Li JW, Chen J, et al. The safety and feasibility of reoperation for the treatment of hepatolithiasis by laparoscopic approach. Surg Endosc 2013;27:1315–20.
[3] Cheung KL, Lai EC. The management of intrahepatic stones. Adv Surg 1996;29:111–29.
[4] Tazuma S, Unno M, Igarashi Y, et al. Evidence-based clinical practice guidelines for cholelithiasis 2016. J Gastroenterol 2017;52:276–300.
[5] Jarufe N, Figueroa E, Muñoz C, et al. Anatomic hepatectomy as a definitive treatment for hepatolithiasis: a cohort study. HPB (Oxford) 2012;14:604–10.
[6] Sun WB, Han BL, Cai JX. The surgical treatment of isolated left-sided hepatolithiasis: a 22-year experience. Surgery 2000;127:493–7.
[7] Tyson GL, El-Serag HB. Risk factors for cholangiocarcinoma. Hepatology 2011;54:173–84.
[8] Tian J, Li JW, Chen J, et al. Laparoscopic hepatectomy with bile duct exploration for the treatment of hepatolithiasis: an experience of 116 cases. Dig Liver Dis 2013;45:493–8.
[9] Tsui WM, Chan YK, Wong CT, et al. Hepatolithiasis and the syndrome of recurrent pyogenic cholangitis: clinical, radiologic, and pathologic features. Semin Liver Dis 2011;31:33–48.
[10] Tsui WM, Lam PW, Lee WK, et al. Primary hepatolithiasis, recurrent pyogenic cholangitis, and oriental cholangiohepatitis: a tale of 3 countries. Adv Anat Pathol 2011;18:318–28.
[11] Otani K, Shimizu S, Chijiiwa K, et al. Comparison of treatments for hepatolithiasis: hepatic resection versus cholangioscopic lithotomy. J Am Coll Surg 1999;189:177–82.
[12] Kim HJ, Kim JS, Suh SJ, et al. Cholangiocarcinoma risk as long-term outcome after hepatic resection in the hepatolithiasis patients. World J Surg 2015;39:1537–42.
[13] Lee JY, Kim JS, Moon JM, et al. Incidence of cholangiocarcinoma with or without previous resection of liver for hepatolithiasis. Gut Liver 2013;7:475–9.
[14] Tabrizian P, Jibara G, Shrager B, et al. Hepatic resection for primary hepatolithiasis: a single-center Western experience. J Am Coll Surg 2012;215:622–6.
[15] Jin RA, Wang Y, Yu H, et al. Total laparoscopic left hepatectomy for primary hepatolithiasis: eight-year experience in a single center. Surgery 2016;159:834–41.
[16] Namgoong JM, Kim KH, Park GC, et al. Comparison of laparoscopic versus open left hemihepatectomy for left-sided hepatolithiasis. Int J Med Sci 2014;11:127–33.

[17] Sioulas AD, El-Masry MA, Groth S, et al. Prospective evaluation of the short access cholangioscopy for stone clearance and evaluation of indeterminate strictures. Hepatobiliary Pancreat Dis Int 2017;16:96–103.

[18] Eurich D, Henze S, Boas-Knoop S, et al. T-drain reduces the incidence of biliary leakage after liver resection. Update Surg 2016;68:369–76.

[19] Zhang HW, Chen YJ, Wu CH, et al. Laparoscopic common bile duct exploration with primary closure for management of choledocholithiasis: a retrospective analysis and comparison with conventional T-tube drainage. Am Surg 2014;80:178–81.

[20] Yin Z, Xu K, Sun J, et al. Is the end of the T-tube drainage era in laparoscopic choledochotomy for common bile duct stones is coming? A systematic review and meta-analysis. Ann Surg 2013;257:54–66.

[21] Wilmore DW, Kehlet H. Management of patients in fast track surgery. BMJ 2001;322:473–6.

[22] Koch M, Garden OJ, Padbury R, et al. Bile leakage after hepatobiliary and pancreatic surgery: a definition and grading of severity by the International Study Group of Liver Surgery. Surgery 2011;149:680–8.

[23] Hwang S, Lee SG, Kim MH, et al. Intraoperative biliary exploration through the left hepatic duct orifice during left hepatectomy in patients with left-sided hepatolithiasis. Langenbecks Arch Surg 2008;393:383–9.

[24] Hu MG, Zhao GD, Ouyang CG, et al. Lithotomy using cholangioscopy via the left hepatic duct orifice versus the common bile duct in laparoscopic treatment of left-sided hepatolithiasis: a comparative study. J Laparoendosc Adv Surg Tech A 2013;23:332–8.

[25] Zhou Y, Zha WZ, Wu XD, et al. Biliary exploration via the left hepatic duct orifice versus the common bile duct in left-sided hepatolithiasis patients with a history of biliary tract surgery: a randomized controlled trial. Medicine (Baltimore) 2018;97:e9643.

[26] Park DH, Kim MH, Lee SS, et al. Accuracy of magnetic resonance cholangiopancreatography for locating hepatolithiasis and detecting accompanying biliary strictures. Endoscopy 2004;36:987–92.

[27] Fulcher AS. MRCP and ERCP in the diagnosis of common bile duct stones. Gastrointest Endosc 2002;56(6 suppl):S178–82.

[28] Jamal KN, Smith H, Ratnasingham K, et al. Meta-analysis of the diagnostic accuracy of laparoscopic ultrasonography and intraoperative cholangiography in detection of common bile duct stones. Ann R Coll Surg Engl 2016;98:244–9.

[29] Pan W, Xu E, Fang H, et al. Surgical treatment of complicated hepatolithiasis using the ultrasound-guided fiberoptic choledochoscope. Surg Endosc 2011;25:497–502.

[30] Kumar P, Orizu M, Leung E. Laparoscopic T-tube placement after common bile duct exploration: a simple technique. Surg Laparosc Endosc Percutan Tech 2009;19:e36–7.

[31] Deo KB, Adhikary S, Khaniya S, et al. Laparoscopic choledochotomy in a solitary common duct stone: a prospective study. Minim Invasive Surg 2018;2018:1–5.

[32] Jia CK, Weng J, Chen YK, et al. Hepatectomy with primary closure of common bile duct for hepatolithiasis combined with choledocholithiasis. World J Gastroenterol 2015;21:3564–70.

[33] Zhang WJ, Xu GF, Wu GZ, et al. Laparoscopic exploration of common bile duct with primary closure versus T-tube drainage: a randomized clinical trial. J Surg Res 2009;157:e1–5.

[34] Estellés Vidagany N, Domingo Del Pozo C, Peris Tomás N, et al. Eleven years of primary closure of common bile duct after choledochotomy for choledocholithiasis. Surg Endosc 2016;30:1975–82.

[35] Wen SQ, Hu QH, Wan M, et al. Appropriate patient selection is essential for the success of primary closure after laparoscopic common bile duct exploration. Dig Dis Sci 2017;62:1321–6.

[36] Koivusalo A, Eskelinen M, Wolff H, et al. Development of T-tube tracts in piglets: effect of insertion method and material of T-tubes. Res Exp Med 1997;197:53–61.

[37] Wills VL, Gibson K, Karihaloot C, et al. Complications of biliary T-tubes after choledochotomy. J Surg 2002;72:177–80.

[38] Yoon S, Yu J, McDowell A, et al. Bile salt hydrolase-mediated inhibitory effect of Bacteroides ovatus on growth of Clostridium difficile. J Microbiol 2017;55:892–9.

[39] Holtmann G, Shah A, Morrison M. Pathophysiology of functional gastrointestinal disorders: a holistic overview. Dig Dis 2017;35(Suppl. 1):5–13.

[40] Cauchy F, Fuks D, Nomi T, et al. Incidence, risk factors and consequences of bile leakage following laparoscopic major hepatectomy. Surg Endosc 2016;30:3709–19.

[41] Liu D, Cao F, Liu J, et al. Risk factors for bile leakage after primary closure following laparoscopic common bile duct exploration: a retrospective cohort study. BMC Surg 2017;17:1.