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Reoperation for recurrent hepatolithiasis: laparotomy versus laparoscopy

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Abstract
Background Laparoscopy has been proposed for the management of recurrent hepatolithiasis, but no comparative study of its relative efficacy versus laparotomy has been performed, and the patient selection criteria for laparoscopy are not clear. This study aimed to investigate the therapeutic effect of laparoscopy versus laparotomy for repeated hepatolithiasis and to highlight how to select patients best suited for laparoscopy.
Methods We performed a cohort study of 94 patients who underwent laparotomy or laparoscopy for recurrent hepatolithiasis between January 2010 and May 2014. The clinical data of 53 patients who underwent open biliary exploration (laparotomy group) and 41 patients who underwent laparoscopic biliary exploration (laparoscopy group) for recurrent hepatolithiasis were retrospectively analyzed and compared.
Results Intestinal adhesions to the porta hepatis occurred in 62 (66%) patients. There was no difference in operating time between the two groups. In comparing the laparoscopic group versus the laparotomy group, the intraoperative blood loss was less ($P = .001$), the incidence of postoperative ascites (9.8 vs. 30.2%, $P = .016$) and/or pleural effusion (7.3 vs. 28.3%, $P = .010$) was lower, and the stone clearance rates were comparable. Wound morbidity appeared peculiarly in 15 (28.3%) patients among the laparotomy group. The postoperative hospital stay in the laparoscopy group was shorter than that in the laparotomy group ($P = .000$).
Conclusion Laparoscopy is a safe and effective treatment for recurrent hepatolithiasis patients who are scheduled for bile duct exploration.

Keywords Hepatolithiasis · Biliary reoperation · Laparoscopy · Therapeutic effect

Residual or recurrent stones have been major problems in the treatment of primary hepatolithiasis. Repeated hepatolithiasis tends to be more difficult to resolve due to stone remnants or reformation and episodes of pyogenic cholangitis. A multidisciplinary approach consisting of surgical and nonsurgical measures as well as open and laparoscopic surgical interventions has been applied effectively to treat hepatolithiasis. However, 20% of patients who have undergone interventional procedures for hepatolithiasis experience reoccurrence of intrahepatic stones. These patients often require multiple procedures, including integrated radiological interventions such as percutaneous cholangiography (PTC) and endoscopic retrograde cholangiopancreatography (ERCP), endoscopic interventions such as percutaneous transhepatic cholangioscopic lithotripsy (PTCSL), and peroral cholangioscopic lithotomy (POCSL) [1, 2]. These nonsurgical approaches to stone extraction and stricture dilatation are often limited by the inability to access diffuse intrahepatic stones [3]. In the majority of those who inevitably require reoperation, the reoperative options include choledocholithotomy, resection of the hepatic lobe or segment-dominant lesion, and even extended hepatectomy or cholangioenterostomy.

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Laparotomy has been the standard approach for treating recurrent hepatolithiasis. A history of abdominal surgery has been considered a counterindication for laparoscopic surgery. However, the development of laparoscopic and endoscopic surgical techniques and instruments over the last two decades has greatly influenced hepatobiliary surgery [4]. Laparoscopic reoperation is also an alternative treatment option for patients with recurrent hepatolithiasis. Recently, some authors have reported that laparoscopic hepatobiliary reoperation is a safe and feasible therapeutic measure for patients with hepatolithiasis [4, 5]. Due to the presence of dense perihepatic or hepatic portal inflammatory adhesions and a high risk of intraoperative vascular incidents, the utilization of laparoscopic hepatectomy and/or cholangioenterostomy has been limited in recurrent hepatolithiasis patients. Thus, laparoscopic biliary exploration may be more suitable for recurrent hepatolithiasis patients who are scheduled for common bile duct exploration with extraction of stones.

To date, no comparative study between laparoscopy and laparotomy has been performed to contrast their relative efficacies in managing patients with recurrent hepatolithiasis, and selection criteria for laparoscopy are not clear. We retrospectively analyzed and compared the clinical data and postoperative follow-up outcomes in 94 patients with symptomatic recurrent hepatolithiasis who underwent laparoscopic or open biliary exploration at our institution and aimed to evaluate the therapeutic effect of the two procedures. Based on these results, the treatment strategy for patients with repeated hepatolithiasis must be reconsidered.

Patients and methods

Preoperative assessment

Between January 2010 and May 2014, a consecutive series of 116 patients who were diagnosed with recurrent hepatolithiasis based on their histories (previous surgery for primary hepatolithiasis, recurrent pyogenic cholangitis) and imaging findings were referred to our institution. These patients had already undergone one or more bile duct operations for initial intrahepatic stones. All patients were evaluated by a combination of diagnostic imaging examinations, including ultrasonography (US), computed tomography (CT), magnetic resonance cholangiopancreatography (MRCP), ERCP, and PTC. These assessments of the locations of stones, strictures, and liver atrophy were used to determine the treatment options.

Selection criteria for laparoscopy or laparotomy

The patients who were elderly (more than 80 years old) and poor operative candidates, and those who had bilateral intrahepatic stones without liver atrophy, especially those who had undergone cholangioenterostomy or multiple biliary operations, were considered for laparoscopic or open biliary tract exploration. In our department, the author's team of surgeons favored laparoscopy as the first-line procedure, and the other three teams of surgeons preferred laparotomy for the above patients. All other treatment choices for these patients were consistent during the period of the present study between the two treatment teams.

Reoperative procedures

Of the 116 patients with recurrent hepatolithiasis, 18 underwent hepatic resection because of localized intrahepatic calculi with liver atrophy and 4 refused surgical interventions aside from therapeutic ERCP due to poor operative risk. The remaining 94 patients who pursued bile duct exploration were included in the present study. Of the 94 patients, 41 were treated with laparoscopic biliary exploration by consultant hepatobiliary surgeons from the author's team and were included in the laparoscopy group. The other 53 patients were part of the laparotomy group and underwent open bile duct exploration, which was performed by experienced general surgeons mostly from other three treatment teams. These procedures were carried out after obtaining approval from our hospital's Ethics Board, the patients themselves, and authorized persons. Intra- and postoperative fiberoptic cholangioscopic lithotomy or lithotripsy was used if necessary. Large and impacted stones were fragmented using a cholangioscopic plasma shock wave lithotripsy system. At the completion of the stone extraction, a T-tube was routinely placed into the bile duct to allow for choledochoscopic examination, the removal of residual stones, and the dilatation of strictured bile ducts through the T-tube route 8–10 weeks after surgery. A drainage tube was placed near the Winslow foramen and removed 3–5 days after the operation if there was no evidence of bile leakage or abdominal bleeding. Intraoperatively, abdominal adhesions were graded as intestinal adhesions and omental adhesions. Intestinal adhesions were defined as the occurrence of dense, flaky gastrointestinal adhesions to the abdominal wall or gallbladder fossa, and hepatoduodenal ligament. Omental adhesions were defined by the presentation of only omental adhesions between the hepatic portal or abdominal wall and the gastrointestinal tract. Hepatic portal translocation was defined as the alteration of the anatomical positions of the hepatic hilum and hepatoduodenal ligament resulting from the rotation of the liver along the axis of the inferior vena cava, which is caused by one-sided hepatic atrophy and hepatic hypertrophy of the other side in a compensatory manner. All patients were followed up regularly in

the hepatobiliary outpatient clinics or through telephone interviews.

Statistical analysis

The patients' clinical characteristics, operative information, and outcomes were collected prospectively and analyzed retrospectively. Continuous data were expressed as the mean ± standard deviation (SD) and were analyzed statistically with the Student's t test. The nonparametric data were compared using Pearson's χ^2 test and the continuity correction test. Comparisons with P values of .05 or less were considered statistically significant. All statistical analyses were performed using the SPSS software (version 19.0; SPSS Inc., Chicago, IL).

Results

Comparison of clinical characteristics

The preoperative clinical characteristics are summarized in Table 1. There were 94 patients with recurrent hepatolithiasis that underwent open or laparoscopic biliary exploration from January 2010 to May 2014. The patients included 33 (35.1%) men and 61 (64.9%) women. The median age was 62.5 years (range 27–91 years). Twenty-six patients (27.7%) had a major comorbid illness, such as cardiovascular disease, pulmonary disease, or diabetes mellitus. Sixty patients (63.8%) presented with cholangitis, whereas the remaining patients presented with acute pancreatitis, liver abscess, or fever. Seventy-three patients (77.7%) had Grade A liver function according to the Child–Pugh classification preoperatively. Seventy-nine patients (84.0%) had undergone one type of hepatobiliary surgery for primary hepatolithiasis, including common bile duct exploration, hepatectomy, and cholangioenterostomy. Fifteen patients (16.0%) had undergone two or more hepatobiliary operations, and four patients had undergone three biliary tract surgeries. Moreover, ten patients had combined abdominal surgeries previously. Forty-five (47.9%) patients had stones localized in the left lobe of the liver. The mean interval between the last two surgeries was 12.8 years. Five (8.6%) patients were converted to laparotomy due to dense intestinal adhesions to the porta hepatis and were included in the laparotomy group. There was no significant difference in these clinical characteristics between the two groups.

Intraoperative information

Table 2 shows the intraoperative information. Hepatic portal translocation was found in 14 (14.9%) patients with recurrent hepatolithiasis, particularly with right liver atrophy. There was a predominance of intestinal adhesions to the porta hepatis in recurrent hepatolithiasis patients (66.0%). Omental adhesions to the abdominal wall occurred in 73 patients (77.7%). Bile duct strictures developed in 52 patients (55.3%). Thirteen patients with liver atrophy refused hepatectomy due to the risks and entered the present study. Twenty-three patients (24.5%) had concomitant biliary cirrhosis. Intraoperative cholangioscopic lithotripsy was more commonly applied for patients in the laparoscopy group than for those in the laparotomy group ($P = .000$). There was no difference in operating time (140.4 ± 23.2 vs. 138.5 ± 25.9 min, $P = .718$) between the two groups. Intraoperative blood loss was less in the laparoscopy group than in the laparotomy group (72.0 ± 65.6 vs. 150.8 ± 137.0 ml, $P = .001$).

Operative outcomes

Table 3 presents operative outcomes. The levels of postoperative serum albumin (31.4 ± 3.5 vs. 29.1 ± 4.4 g/L, $P = .006$) and prealbumin (0.12 ± 0.03 vs. 0.10 ± 0.03 g/L, $P = .002$) were higher in the laparoscopy group compared with the laparotomy group, and the levels of alanine transaminase (ALT) and aspartate transaminase (AST) were lower in the laparoscopy group than in the laparotomy group (ALT, $P = .039$; AST, $P = .004$). Twenty-one patients (22.3%) developed intestinal wall injury of various degrees, which more commonly occurred in the laparotomy group. The incidence of intra-abdominal collection (30.2 vs. 9.8%, $P = .016$) and/or pleural effusion (28.3% vs. 7.3%, $P = .010$) was higher in the laparotomy group than in the laparoscopy group. Peculiarly, wound infection and/or dehiscence appeared in 15 (28.3%) patients in the laparotomy group and in no patients in the laparoscopy group ($P = .000$). Of the 15 patients with wound morbidity, 9 cases with wound infection needed simple drainage, and 6 patients with wound dehiscence required resuture. All postoperative complications were minor and easy to treat. No complication-associated deaths occurred. There was no difference in the immediate stone clearance rate (54.7 vs. 73.2%, $P = .066$) and in the frequency of postoperative cholangioscopic lithotomy (58.3 vs. 36.4%, $P = .227$) between the two groups. The final stone clearance rate in all patients was 96.8%. The postoperative hospital stay in the laparoscopy group was shorter than that in the laparotomy group (6.5 ± 2.3 vs. 10.5 ± 3.4 days, $P = .000$).

The median follow-up duration for the 94 patients with recurrent hepatolithiasis was 12 months (range 1–51 months). Three patients in the two groups died of unresectable cholangiocarcinoma and subsequent liver failure, 18 patients developed repeated cholangitis and required broad-spectrum antibiotic treatments, and seven cases with asymptomatic recurrent stones were detected by imaging studies.

Table 1 Clinical characteristics of the 94 patients with recurrent hepatolithiasis

Clinical characteristics	Laparotomy group ($n = 53$)	Laparoscopy group ($n = 41$)	P value
Male/female (n)	20/33	13/28	.544
Age (years), median (range)	62 (27–84)	59 (38–91)	.425
Major comorbid illness (n)	17	9	.276
Presentation (n)			
Cholangitis	34	26	.941
Pancreatitis	8	7	.795
Liver abscess	6	2	.461
Fever	5	6	.650
Child–Pugh classification (n)			.675
A	42	31	
B	11	10	
Previous surgery (n)			
Common bile duct exploration	26	19	.794
Hepatectomy	20	17	.714
Cholangioenterostomy	7	5	.884
Combined other abdominal surgeries	8	2	.209
Interval between last two surgeries (years)	12.0 ± 8.8	13.9 ± 10.1	.327
Multiple prior biliary surgeries (n)	9	6	.758
Associated extrahepatic stones (n)	29	18	.298
Hepatic stone distribution (n)			
Left	25	20	.877
Right	18	15	.792
Bilateral	10	6	.588

Table 2 Intraoperative information on patients with recurrent hepatolithiasis

Intraoperative information	Laparotomy group ($n = 53$)	Laparoscopy group ($n = 41$)	P value
Hepatic portal translocation (n)	8	6	.950
Porta hepatis adhesions (n)			.647
Omentum adhesion	17	15	
Intestine adhesion	36	26	
Abdominal wall adhesions (n)			.358
Omentum adhesion	43	30	
Intestine adhesion	10	11	
Hepatobiliary pathology (n)			
Bile duct stricture	30	22	.776
Liver atrophy	8	5	.686
Biliary cirrhosis	11	12	.341
Intraoperative lithotripsy, n (%)	12 (22.6%)	28 (68.3%)	.000
Operating time (min)	140.4 ± 23.2	138.5 ± 25.9	.718
Blood loss (ml)	150.8 ± 137.0	72.0 ± 65.6	.001

Discussion

The present study highlights that laparoscopic biliary tract exploration is an alternative option for recurrent hepatolithiasis patients who are scheduled to undergo choledocholithotomy. We showed that laparoscopy is a minimally invasive modality with the advantages of a shorter postoperative hospital stay, lower wound morbidity, lower postoperative serum ALT and AST levels, elevated postoperative serum albumin and prealbumin levels, and a

Table 3 Operative outcomes of patients with recurrent hepatolithiasis

Operative outcomes	Laparotomy group ($n = 53$)	Laparoscopy group ($n = 41$)	P value
Liver function test 2 days after operation			
ALT (U/L)	110.1 ± 58.7	87.1 ± 44.1	.039
AST (U/L)	98.8 ± 42.7	75.9 ± 28.7	.004
Serum albumin (g/L)	29.1 ± 4.4	31.4 ± 3.5	.006
Serum prealbumin (g/L)	0.10 ± 0.03	0.12 ± 0.03	.002
Intraoperative hemobilia	10 (18.9%)	2 (4.9%)	.044
Intraoperative intestinal injury	16 (30.2%)	5 (12.2%)	.038
Postoperative complications, *n* (%)			
Intra-abdominal collection	16 (30.2%)	4 (9.8%)	.016
Pleural effusion	15 (28.3%)	3 (7.3%)	.010
Wound infection and/or dehiscence	15 (28.3%)	0 (0%)	.000
Bile leakage	6	2	.461
Stone clearance, *n* (%)			
Immediate stone clearance	29 (54.7%)	30 (73.2%)	.066
Final stone clearance	51 (96.2%)	40 (97.6%)	1.000
Postoperative hospital stay (days)	10.5 ± 3.4	6.5 ± 2.3	.000
Postoperative multiple cholangioscopic lithotomy	14 (58.3%)	4 (36.4%)	.227
Long-term outcomes			
Repeated cholangitis	12	6	.328
Recurrent stones	4	3	1.000
Cholangiocarcinoma	1	1	1.000
Mortality	2	1	1.000

higher stone removal rate if used in conjunction with intraoperative cholangioscopic lithotripsy. Similar results have been noted in previous reports, which indicate that laparoscopy can facilitate postoperative recovery in primary hepatolithiasis patients who undergo hepatectomy [6–9].

Partial hepatic resection, which is limited to the removal of the destroyed segment or lobe, is a basic procedure for hepatolithiasis, and hepatic segment-based anatomical resection offers the optimal strategy to treat this disease in selected patients [10–14]. Both of these aggressive treatments are definitely indicated for cases with stones localized in a unilateral lobe, strictured intrahepatic ducts containing stones, or liver atrophy of the affected segments or lobe [15–19]. Although laparoscopic hepatectomy has recently been utilized to treat hepatolithiasis, the high incidence of intraoperative vascular events and serious perihepatic adhesions often restrict this approach to the treatment of recurrent hepatolithiasis [7]. Overall, it seems that the long-term clinical outcomes after hepatectomy are still unsatisfactory. Cheon et al. [20] showed that recurrent hepatolithiasis occurred in 18% of patients with complete stone clearance after successful hepatectomy in addition to intra- and postoperative cholangioscopy within a mean 8-year follow-up period. In our study, 37 (39.4%) patients with recurrent intrahepatic stones had undergone hepatectomy for primary hepatolithiasis. Noninvasive treatments such as PTCSL and POCSL have been applied to treat hepatolithiasis for more than 30 years, but these nonsurgical procedures are associated with recurrence rates of 30–60%, they are mainly indicated for patients who are elderly with prohibitive operative risks or who are poor surgical candidates, and for those who have a history of multiple previous biliary tract operations or choledochoenterostomy and refuse surgery [21, 22].

The curative surgical principle of "removing lesions" for hepatolithiasis may be laborious to achieve in patients with recurrent intrahepatic stones, particularly those who have concomitant biliary cirrhosis, those who have undergone hepatectomy and even multiple biliary operations for hepatolithiasis, and those who are elderly or who have difficulties tolerating hepatectomy. These patients are more suited for stone removal reoperations than lesion-removal reoperations. Bile duct exploration with the extraction of stones should be considered for those with biliary cirrhosis or bilateral intrahepatic stones and for those without liver atrophy, which may be the only acceptable therapeutic procedure at some institutions

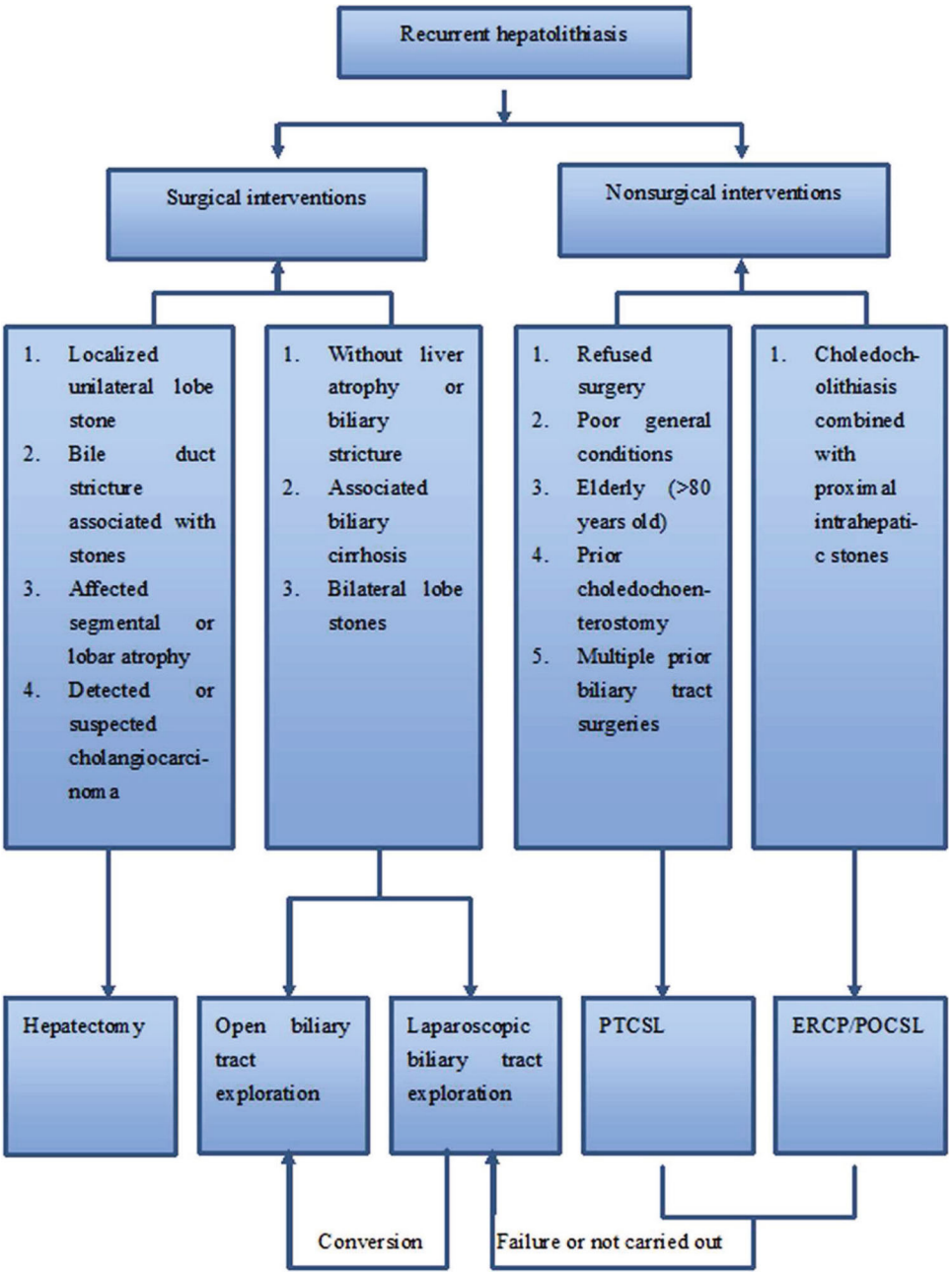

Fig. 1 Suggested flow chart of interventional procedures for patients with recurrent hepatolithiasis

where PTCSL and POCSL have not yet been carried out for hepatolithiasis patients. Furthermore, both of these approaches require sophisticated instruments and technology, and they also involve surgical stress and risks, such as pain caused by the creation of a fistula tract, the removal of stones, the prolonged treatment period, and the potential need for repeated attempts [2, 8]. The morbidity and mortality of PTCSL have been reported to be 14.5–22 and 2.1–8%, respectively [22]. In the present study period, 94 (81.0%) of 116 patients with recurrent hepatolithiasis were eligible for biliary tract exploration on the basis of the comprehensive assessment of preoperative information, and only 18 (15.5%) of these patients underwent liver resection. Four patients who refused surgery chose therapeutic ERCP.

Our prior study reported that laparoscopic common bile duct exploration in adjunction with choledochoscopic plasma shock wave lithotripsy was well established for hepatolithiasis at our institution (Accepted manuscript: published in Am J Surg online 13 April 2014). The present study confirmed that laparoscopically choledochoscopic lithotripsy elevated the intraoperative stone clearance rate and decreased the risk of hemobilia. Moreover, laparoscopically choledochoscopic lithotripsy did not increase the frequency of postoperative choledochoscopic lithotomy. However, this approach to recurrent hepatolithiasis

is a technically challenging and exacting procedure in comparison to using stone forceps lithotomy or choledochoscopic lithotripsy in laparotomy, and it was performed only by the author's team. According to our experience, in case of suspended tension of the visceral adhesions to the abdominal wall at laparoscopic pneumoperitoneum, the abdominal wall adhesion seems more easily dissected by using a harmonic scalpel than with laparotomy. Hepatic portal translocation caused by atrophy–hypertrophy complex and gastrointestinal adhesion to the hepatic hilum may interfere with the exposure of the extrahepatic bile duct, particularly after multiple previous biliary operations. Identifying the inferior border and round ligament of the liver and the Winslow foramen as anatomical landmarks will make surgeons aware of the location of the common bile duct during adhesiolysis. To avoid intestinal injury, the adhesions on the right side of the hepatic round ligament should be separated not only from Glisson's capsule down to the hepatic-duodenal ligament but also close to the liver parenchyma, especially for patients who have undergone biliary-enteric anastomosis. Our results showed that intestinal adhesion to the porta hepatis occurred in 66% of patients with recurrent hepatolithiasis and omental adhesion to the abdominal wall appeared in 77.7% of these patients. Two (2.1%) patients developed intestinal ruptures in laparoscopy, which were successfully repaired laparoscopically without the occurrence of postoperative intestinal fistula. Nineteen patients (20.2%) in the two groups developed intestinal seromuscular layer tears, which more commonly occurred in the laparotomy group. Laparoscopic conversion to laparotomy developed in five (8.6%) cases with multiple previous upper abdominal operations and choledochoenterostomy. Therefore, laparoscopy should be selected for patients with repeated hepatolithiasis with biliary cirrhosis or diffuse hepatic stones and those without liver atrophy or strictured bile ducts. Laparoscopy must be cautiously considered for patients with multiple prior biliary surgeries or choledochoenterostomy. Moreover, we found that laparoscopic biliary exploration decreased operative blood loss, did not prolong the operating time, and reduced the incidence of postoperative complications (i.e., intra-abdominal collection, pleural effusion, wound events) compared with laparotomy. These results can be explained by more extensive adhesiolysis and original incision scar removal in laparotomy.

Conclusion

The present study showed that laparoscopic biliary exploration combined with choledochoscopic lithotripsy is a safe and effective treatment for recurrent hepatolithiasis. Based on the present study, we suggest the flow chart presented in Fig. 1 of laparoscopy or laparotomy for patients with repeated hepatolithiasis. We recommend laparoscopic biliary tract exploration in combination with intra- and postoperative cholangioscopic lithotripsy for patients with symptomatic repeated hepatolithiasis who are not candidates for hepatectomy and for patients who experience failure of PTCSL or ERCP/POCSL.

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Compliance with ethical standards

Disclosure Drs. Qingfan Pu, Chuanrong Zhang, Zhenfeng Huang, Yu Zeng have no conflicts of interest or financial ties to disclose.

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