Int J Clin Exp Med 2018;11(8):7945-7953
www.ijcem.com /ISSN:1940-5901/IJCEM0074771

Original Article

Intraoperative biliary exploration via left hepatic duct orifice with vertical incision versus common bile duct with oblique incision for treatment of left hepatolithiasis

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Received February 21, 2018; Accepted June 29, 2018; Epub August 15, 2018; Published August 30, 2018

Abstract: Background: Left-sided hepatolithiasis often requires left hepatectomy and biliary exploration of common bile duct and right hepatic bile duct and T-tube inserting. The aim of this study was to evaluate the feasibility of an alternative method of using cholangioscopy through left hepatic duct (LHD) orifice in vertical incision versus common bile duct (CBD) in oblique incision. Methods: Case from 98 consecutive patients of left hepatectomy for left intrahepatic stones (LIHS) and bilateral intrahepatic stones (BIHS) were retrospectively reviewed. Cases were grouped by applying biliary exploration through LHD orifice with vertical incision (LHD group, n=37) or CBD with oblique incision (CBD group, n=61). T-tube inserting was performed in all the patients in CBD group, in contrast to no T-tube inserting in LHD group. Demographics, operative time, blood loss, surgical procedures, hospital stay, and short-term and long-term outcomes were evaluated. Results: The preoperative data shows no difference in two groups (P>0.05). Additionally, the estimate blood loss and operation time in the CBD group was more than those in the LHD group (P<0.05). The short-term outcomes showed that the CBD group had higher postoperative pain score, longer hospital stay, and lower health economic benefits than the LHD group (P<0.05). Conclusions: LHD cholangioscopy with vertical incision is a preferred alternative method to choledochotomy in LIHS for decreasing surgical trauma, avoiding cholechotomy and subsequent T-tube insertion, improving short-term outcomes, as well as increasing health economic benefits.

Keywords: Left intrahepatic stones, T-tube, surgical incision, health economical benefits

Introduction

Primary hepatolithiasis (PHL) which is caused by the formation of calculus deriving from the cystic dilation of intrahepatic biliary tree is a common disease in Eastern and Southeastern Asia population, and rare in Western countries [1]. It is typically characterized by acute illness, such as abdominal pain, fever, and jaundice. Left intrahepatic stone is involved in the majority of cases due to the anatomical relationship of intrahepatic bile duct.

Hepatectomy as well as subsequent T-tube inserting has been proven to be effective in dealing with hepatolithiasis, since it gets rid of the existing calculus, removes the stricture ducts, and prevents recurrence [2-7]. Furthermore, because of the high incidence of LIHS and less complicated anatomical structure of left liver compared to right lobe, left hepatectomy is more technically feasible to achieve curative effects in open surgery. However, post-operative pain caused by long surgical incision and complicated T-tube nursing is troublesome for patients. Additionally, the loss of bile through T-tube may revoke some complications, like anorexia and electrolyte disturbance [5].

In this comparative retrospective study, the effectiveness of intraoperative biliary exploration through the LHD orifice with vertical incision versus CBD with oblique incision was determined in LIHS patients.

Materials and methods

Patients

This study was approved by the West China Hospital Ethics Committee and was performed

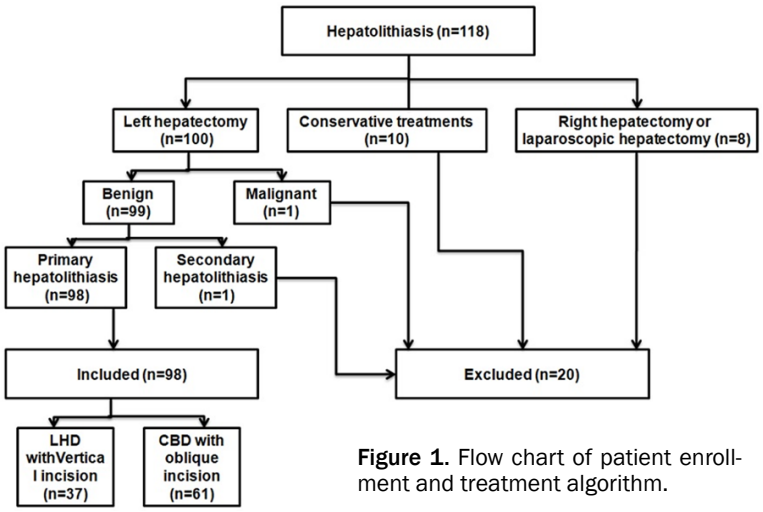

Figure 1. Flow chart of patient enrollment and treatment algorithm.

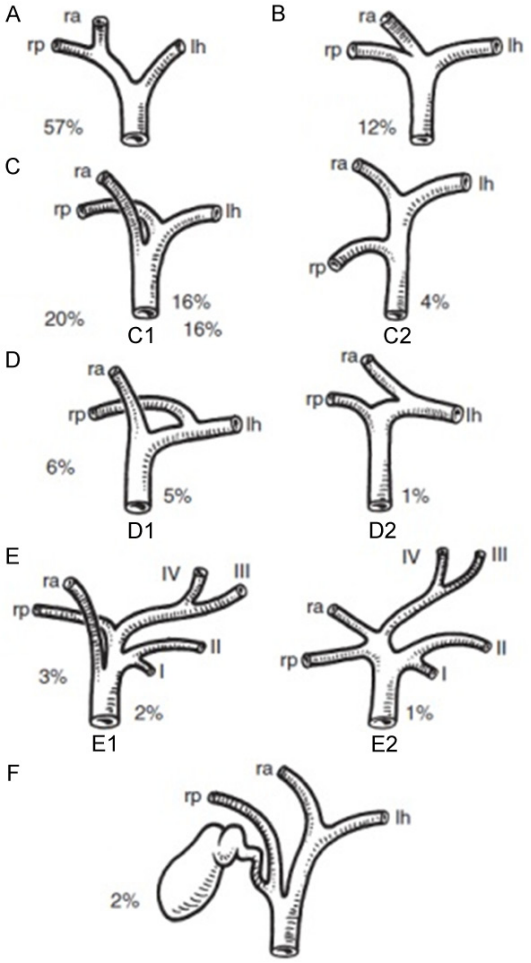

Figure 2. Main variations of the hepatic duct confluence (Couinaud, 1957). A. Typical anatomy of the confluence (57%). B. Triple confluence (12%). C-F. Other variances of the hepatic duct confluence. More than 60% of them have an angle of more than 120 degrees.

in accordance with the ethical guidelines of the Declaration of Helsinki.

During this study, 118 consecutive hepatolithiasis patients were studied in which the clinical records were complete and the surgeries were manipulated by same surgeon at West China Hospital between January 2009 and April 2016. Twenty patients were excluded from this study. Ten were recommended for resection but refused and chose conservative treatments. Eight patients received a right hepatic resection or laparoscopic hepatectomy and were not included in this study. One patient who had a history of biliary ascariasis was considered as secondary hepatolithiasis and excluded. One patient was diagnosed with a malignant tumor and excluded (**Figure 1**).

The medical records of 98 patients who underwent left hepatectomy due to LIHS and bilateral intrahepatic stone (BIHS) were retrospectively reviewed. All surgeries were conducted by same surgeon. Patients were grouped by applying biliary exploration through LHD orifice with vertical incision (LHD group, n=37) or CBD with oblique incision (CBD group, n=61). T-tube insertion was performed in all the patients in CBD group, in contrast to no T-tube insertion in LHD group. Furthermore, all patients received the biliary exploration and intraoperative ultrasound to ensure no residual calculus.

Records were reviewed with respect to patient demographics, presenting symptoms, medical history, operative details, postoperative course, and pathologic characteristics. All patients were evaluated with preoperative abdominal ultrasonography, contrast-enhanced CT scan or MRI to ensure the existence of stones.

Minimum requirements for inclusion were: Patients only received left hepatectomy and biliary exploration. Biliary exploration and intraoperative ultrasound didn't find any stone remained. No history of previous hepatectomy. Preoperative ultrasound, CT scan or MRI scan

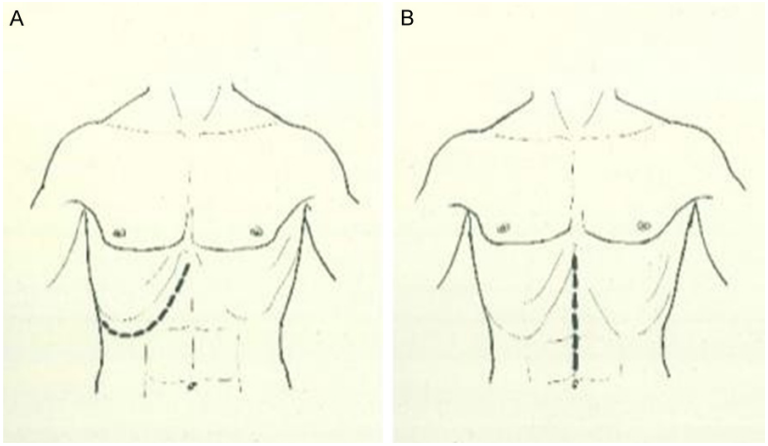

Figure 3. The incision of both surgical approaches. A. Shows oblique incision. B. Indicated vertical incision.

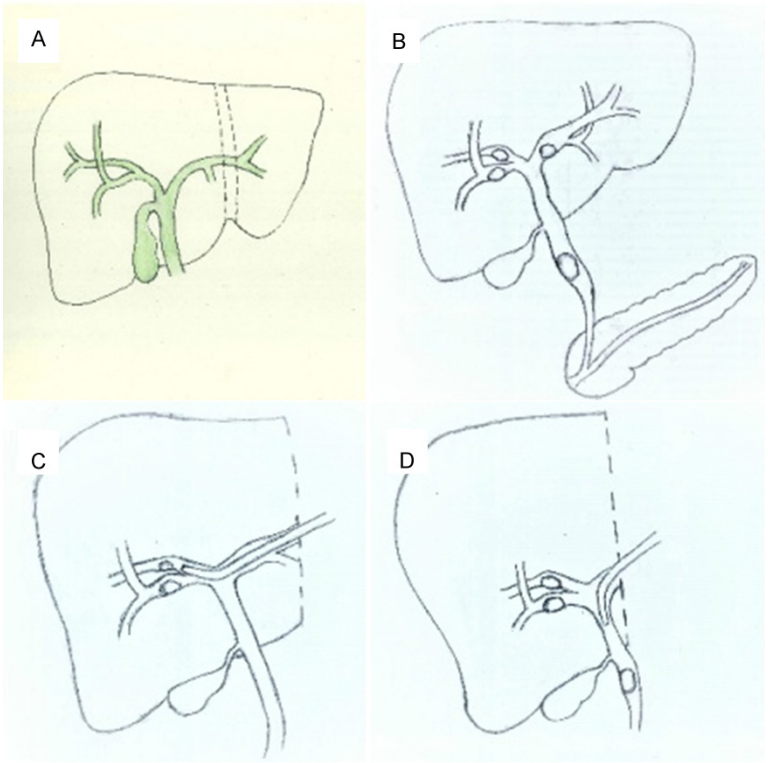

Figure 4. Introduction of intraoperative biliary exploration via left hepatic duct orifice with vertical incision. A. Normal hepatic bile duct. B. Calculus in the left intrahepatic bile duct, right hepatic bile duct and common bile duct. C. When stones were just in the left and right intrahepatic bile duct, the left lateral lobe was removed and cholangioscopy was applied for the right intrahepatic bile duct. D. When stones were in common bile duct, the left medial lobar duct was cut off and a choledochoscope was used to explore the common bile duct.

showed dilatation of intrahepatic bile duct. Patients with malignant tumors were excluded.

Surgery

The resection indications included intrahepatic bile duct stricture associated with stones, atrophy, and presence of liver abscess. Selection criteria for resection required patients to have Child Pugh class A and the indocyanine green (ICG) retention rate in 15 minutes was less than 10%.

Principle of choledochoscopy through LHD orifice

Some studies showed that more than 60% of the intrahepatic bile duct has an angle of more than 120 degrees (**Figure 2**) [8]. At the same time, the angle of the front end of the choledochoscope can be bent to 120 degrees, which provided a theoretical basis for the study.

Intrahepatic bile duct stones cause intrahepatic bile duct dilatation, and the dilated bile duct can become a potential channel for choledochoscope exploration, and can also increase the angle between the left and right intrahepatic bile ducts.

The tip length of the choledochoscope is about 4 cm. If the common bile duct stones was suspected before surgery, part of segment IV bile duct was removed to form a large enough angle so that the choledochoscope could be inserted into the common bile duct.

Surgical procedures

Traditional surgical procedures: Xiphoid was chosen as the upper margin of incision and the intersection of middle anterior axillaries line and the

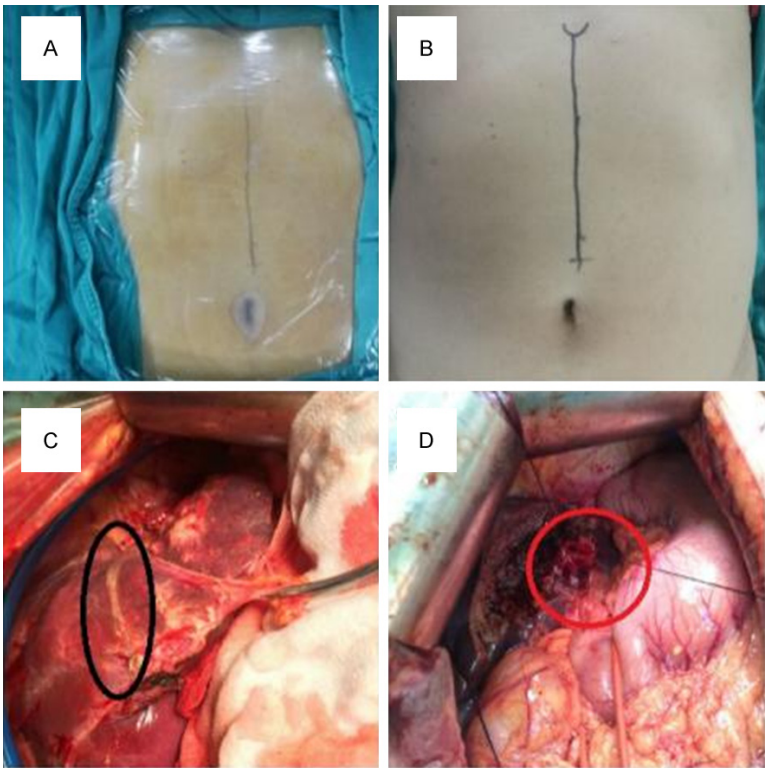

Figure 5. The surgical procedure of intraoperative biliary exploration via left hepatic duct orifice with vertical incision. A, B. The vertical incision of this method. C and D. Shows the operation procedure of this approach. The black ellipse shows the resection line of the left lobe, while the red circle shows the expansive left intrahepatic bile duct.

11th rib as the lower margin, between two points arced line incision of 25 cm (**Figure 3A**). Then the round ligament, falciform ligament, left ligamentum triangulare and coronary ligament were dissociated. Intraoperative Color Doppler Ultrasonograph was then used to help making the appropriate resection margin. Then the left liver (left lateral lobe or left lobe) was extracted with vascular inflow occlusion by the Pringle maneuver. The vascular and biliary stump was sutured with 5-0 vascular slide wires and retrograde choledochotomy with exploration and choledocholithotomy and T-tube drainage was applied for these patients. The gallbladder was also removed.

New surgical methods: First, the middle abdominal incision was chosen (**Figure 3B**). Then, the ligaments around the left liver were dissocated. After that, intraoperative color Doppler ultrasonography was used to help making the appropriate resection margin and explore the stones in the right lobe or common bile duct. The left lateral lobe was then extracted with vascular inflow occlusion by the Pringle maneuver. If there were stones in the common bile duct, the left medial segmental duct was removed to get enough angles for biliary exploration by choledochoscope. The left hepatic bile duct was clipped with a Satinsky's clamp and the left liver lobe was removed (**Figures 4** and **5**). Following that, antegrade biliary exploration was applied through the left biliary stump. After resection, vascular slide wires were used to seal the bile duct stump, and no subsequent T-tube inserting.

Follow-up

Patients were routinely followed with laboratory tests and serial contrast-enhanced imaging every 3 to 6 months for the first 2 years after hepatectomy and then annually or when the patient had symptoms of recurrence. The lengths of the short-term follow-up were the first three months, and after three months were classified as the long-term follow-up. Recurrence was deemed to have occurred when clinical and imaging evidence of new stone was detected in the intrahepatic biliary duct or common bile duct.

Statistical analysis

Variables are presented using descriptive statistics with measures of central tendency and dispersion. Chi-square and Fisher's tests were used for univariate subT-tube grouped categorical variable analyses. Student's t-test and analysis of variance (ANOVA) were used for continuous variables. The results were considered statistically significant at a value of $P<0.05$. All analyses were performed using SPSS Version 19.0 (SPSS, Inc., Chicago, IL, USA).

Results

The demographic and clinical data are presented in **Table 1**. There was no significant differ-

Table 1. Demographics and Clinical Variables of Patients with Hepatolithiasis

Patient characteristics	CBD with oblique incision (n=61)	LHD with vertical incision (n=37)	P
Age, mean ± SD, y	57.7±10.3	52.2±11.8	>0.05
Sex, male/female, n	19/42	12/25	
Preoperative Laboratory values			
Total bilirubin, mean ± SD, μmol/L	21.6±31.2	28.3±38.4	>0.05
GGT, mean ± SD, IU/L	239.5±321.2	241.2±299.7	>0.05
ALP, mean ± SD, IU/L	193.6±204.3	184.0±164.7	>0.05
Albumin, mean ± SD, g/L	42.5±3.98	40.9±5.19	>0.05
INR, mean ± SD	0.99±0.10	1.00±0.12	>0.05
Creatinine, mean ± SD, μmol/L	63.2±11.2	68.6±9.5	<0.05
Ca 19-9, median (range)	54.8±76.4	53.1±50.8	>0.05
Previous treatment, n (%)	15 (24.6%)	7 (18.9%)	
Cholecystectomy	12 (19.7%)	6 (16.2%)	
Biliary-enteric anastomosis	1 (0.16%)	0	
History of ERCP or choledochotomy	2 (0.33%)	1 (2.7%)	>0.05
Hepatolithiasis type, n			
Primary hepatolithiasis (PHL), n	60	37	
Secondary hepatolithiasis	1	0	
Combined disease, n (%)	11 (18.0%)	10 (27.0%)	
Pancreatitis	3 (4.9%)	3 (8.1%)	
Diabetes mellitus	3 (4.9%)	3 (8.1%)	
Hypertension	2 (3.3%)	2 (5.4%)	
hepatopostema	2 (3.3)	0	
Hepatic cyst	1 (0.16%)	2 (5.4%)	<0.05

ence in age, sex, preoperative laboratory values, and previous treatment in two groups.

Diagnoses were obtained through ultrasound, enhanced computed tomography or MRI. The preoperative image examinations showed that there were stones in the left intrahepatic bile ducts of all patients. Twenty-two patients had previous treatments such as cholecystectomy, biliary-enteric anastomosis, choledochotomy, and ERCP. Twenty-one patients had comorbidities, such as diabetes mellitus, hypertension, pancreatitis, hepatapostema and hepatic cyst. The details of the previous surgeries and comorbid diseases are presented in **Table 1**, and there was no significant difference between two groups (P>0.05).

Surgical treatment

During surgery, thirty-eight (38.8%) patients were found to have atrophy in left lobe, twenty-five (41.0%) in CBD group, and thirteen (35.1%) in LHD group. The mean ± standard deviation (SD) of operative time in LHD group was 105.0±35.6 minutes (range: 77-220 minutes) which was less than that in CBD group, with P<0.01. Furthermore, the estimated blood loss, transfusion rate and occlusion time in LHD group was less than in the CBD group (P<0.05) (**Table 2**).

Short-term follow-up (three months)

Postoperative complications were found in seven patients (11.5%) in the CBD group. Three patients were pulmonary infection and the sputum culture suggested the Klebsiella pneumoniae infection. Three patients were found wound infection on the fourth day after surgery which the pathogens were Escherichia coli. (Two patients) and Enterococcus faecium respectively. One patient underwent a reoperation due to wound cracking. However, there were only two patients (5.4%) that got disease in the LHD group. One patient got a severe pneumonia due to old age and chronic obstructive pulmonary disease (COPD), another got a wound infection.

Table 2. Operative Data of Patients with Hepatolithiasis Receiving left Hepatectomy

Operative data	CBD with oblique incision (n=61)	LHD with vertical incision (n=37)	P
Surgical finding, n (%)			
Atrophy	25 (41.0%)	13 (35.1%)	
Cholangitis	20 (32.8%)	11 (29.7%)	
Location of stone, n (%)			
Left lobe	61 (100%)	37 (100%)	
Right lobe	23 (37.7%)	10 (27%)	
Caudate lobe	1 (1.6%)	0	
Common bile duct	15 (24.6%)	5 (13.5%)	>0.05
Operative time, mean ± SD (range), min	195.1±63.5 (120-315)	105.0±35.6 (77-220)	<0.01
Estimated blood loss, mean (range), mL	312.5 (100-1200)	201.3±37.3 (50-400)	<0.05
Transfusion, n (%)	3	0	-
Occlusion time, mean ± SD, min	31.8±6.32	18.8±4.46	<0.05
Short-term follow-up			
Complications, n (%)	7 (11.5%)	2 (5.4%)	
Pulmonary infection	3 (4.9%)	1 (2.7%)	
Wound infection	3 (4.9%)	1 (2.7%)	
Perioperative mortality, n (%)	0	0	
Reoperations, n (%)	1 (1.6%)	0	>0.05
Postoperative pain score (Prince-Henry)	3.31±1.1	2.2±0.99	<0.05
Health economics data			
Hospital stay, d	15.0±4.2	10.5±4.5	<0.05
Total hospital costs (CNY)	32980.09±8886.9	22002.63±2320.4	<0.05
Drugs (CNY)	14081.07±5308.3	10208.62±2386.9	<0.05
Surgery (CNY)	3877.24±1268.9	3116.85±484.4	>0.05
Long-term Follw-up			
Residual disease, n (%)	1 (1.6%)	1 (2.7%)	
Complications, n (%)	17 (27.9%)	11 (29.7%)	
Stone recurrence, n (%)	10 (16.4%)	7 (18.9%)	
Cholangitis, n (%)	10 (16.4%)	5 (13.5%)	>0.05

After 2014, the Prince Henry Pain Score (PHPS) was applied to evaluate the usage of painkiller drugs in our center. The same dosage of painkiller drugs were gave to two groups. The average score in the first three days after surgery was significantly different in two groups (P<0.05).

The health economics data showed that the total hospital cost in the LHD group (22002.63±2320.4 CNY) (1 CNY=0.1576 USD) was less than that in the CBD group (32980.09±8886.9 CNY) (P<0.05). The mean hospital stay in two groups were 15.0±4.2 day and 10.5±4.5 day respectively, which meant that patients who received the new approach spent less time in hospital than that in traditional approach (P<0.001).

Long-term follow-up (five years)

The median follow-up was 68 months (range: 6-99 months). Complete intrahepatic stone clearance was achieved more than 96% patients. Late complications occurred in seventeen (27.9%) patients in CBD group and were of stone recurrence in ten (16.4%). Eleven patients (29.7%) were found late complications in the LHD group, and seven (18.9%) of them found stone recurrence. Some patients had more than one complication (**Table 2**).

Discussion

Left hepatectomy is the safest and most effective treatment for symptomatic left hepatolithiasis, as it simultaneously removes intra-

hepatic stones and biliary strictures [9-11]. In this research, cholangioscopy through the orifice of LHD stump in open surgery with vertical incision was compared with choledochotomy with oblique incision. Moreover, patients in both two groups received left hepatectomy and a T-tube in the previous one.

For the viewpoint of recurrence, left hepatectomy for LIHS can be a certain treatment, for it removes all the possible lesions and the surgical risk is relatively low. In this study, with median follow-up time about 68 months, the recurrence rate in CBD group was about 16.4%, and 18.9% in LHD group. These were a little bit higher than those in Hwang's study [12]. The possible reason may be that the follow-up duration was much longer than that in his study.

The advantages of bile duct exploration through the LHD stump has been demonstrated by several surgeons [12, 13]. Hwang et al. had found that the intraoperative biliary exploration through LHD orifice in left-sided hepatolithiasis patients is an effective approach simplifying the operation procedure by avoiding choledochotomy and subsequent T-tube insertion. The T-tube inserting rate in left hepatic duct group was none, which were in agreement with this of previous study. Furthermore, biliary exploration through LHD stump won't be influenced by the peritoneal adhesion and past surgery of choledochojejunostomy and T-tube inserting history in our observation. The main reason may contribute to that the LHD orifice would be easily found after left hepatectomy and didn't need to expose common bile duct.

As for the surgical incision, there was an interesting finding in our clinical series. In our research, all patients in the LHD group were applied for vertical incisions while the other patients in CBD group chose oblique incisions. Vertical surgical incision was found to have a shorter operative time and less estimated blood loss than oblique surgical incision ($P< 0.05$), indicating a less-damage incision could lead to a better outcome [14]. Our finds are consistent with those of Hu et al. who found that LHD cholangioscopy is a preferred alternative to choledochotomy in the laparoscopic treatment of LSH because it offers patients shorter operative duration and length of hospitalization [13].

In the literature, we found that the vertical incision were usually used for gastrointestinal surgeries and sometimes used for liver transplantation [15, 16]. The vertical incision in the middle abdomen broken less muscle and nerves than oblique incision did. Moreover, this kind of incision could easily expose the left lobe so that the operative time could be shortened and the postoperative pain could be lightened [17]. As for postoperative conditions, health economics data show differences in the two groups. The hospital stay and total hospital costs in the LHD group was obviously less than that in the CBD group and lower than the average ($P<0.05$). The probable reason may come to the shorter hospital stay and less use of expensive hemostatic materials and painkiller drugs.

Simultaneously, we counted the incidence of postoperative electrolyte imbalance and anorexia in two groups. The incidence of postoperative anorexia in the CBD group was higher than that in the LHD group. There were also thirty patients (49.2%) diagnosed a hypokalemia and hyponatremia in the CBD group contrast to that of five patients (13.5%) in the LHD group. But the disorder returned to normal in the first three days in most of the patients due to fluid infusion. The physiological amount of bile produced by liver was about 800-1000 ml per day. In our study, drainage of bile in CBD group was about 440 ml in average. Patients may lose a lot of electrolyte through the drainage [18-20]. Yet we also found that if patients voluntarily drank the bile drainage could relief the symptom of anorexia.

Our study has several limitations. First, this is a retrospective study from a single-institution experience. The number of patients enrolled may be not sufficient enough and the sample size of two groups was different. The impact of various treatments related outcome could not be fully evaluated and the follow-up duration of the study may be not long enough. Second, there was a limited application of in LPD group; it cannot be applied to patients with proximal intra-hepatic disease. Additionally, it is difficult to be applied to patients who have a stricture pre-dominant disease with maximal stone load proximal to a stricture. Third, the middle abdominal incision couldn't expose the right lobe even the hilar very well, making it very

difficult to remove gallbladder and radical resection of liver malignant tumors.

Conclusion

The middle abdominal incision as well as antegrade biliary exploration is a safe and effective procedure for left hepatolithiasis associated with peritoneal adhesion, choledochojejunostomy, and doesn't need insertion of a T-tube. Although the long-term follow-up showed no difference in recurrence and there are some limitation for the application, the short-term outcomes revealed that the postoperative pain and total hospital cost was less in new surgical treatment than that in traditional treatment, making it a good way for increasing health economic benefits.

Acknowledgements

Thanks Yang Xu and Ling-Yan Wang for drawing the picture. We also thank the Medical Records Department of West China Hospital for offering the medical records of these patients. This study does not have any financial support need to disclose.

Disclosure of conflict of interest

None.

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