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Comparison Between Percutaneous Transhepatic Rigid Cholangioscopic Lithotripsy and Conventional Percutaneous Transhepatic Cholangioscopic Surgery for Hepatolithiasis Treatment

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Background: Percutaneous transhepatic cholangioscopy (PTCS) is one option for treating hepatolithiasis without surgical resection. This approach can use conventional biliary drainage methods over a long period, but a shorter procedure needs to be evolved.

Objective: To evaluate the short-term and the long-term therapeutic outcomes of percutaneous transhepatic cholangioscopic lithotripsy (PTCSL) in comparison with conventional PTCS.

Methods: In this retrospective study, 118 patients with hepatolithiasis were enrolled who underwent treatment in our hospital between March 2007 and July 2014. About 67 of them received PTCSL and the remaining 51 patients received conventional PTCS. Preoperative data, surgical operation-related records, the postoperative therapeutic effect, and the long-term hepatolithiasis recurrence rate were collected for comparison between the 2 groups.

Results: The age, sex, and surgical history were similar between the 2 groups, but there was a significant difference in the Child-Pugh score, with more grade 3 patients in the PTCS group ($P = 0.002$). However, the operation time, intraoperative blood infusion, and the blood loss were similar between the 2 groups. The final clearance ratio of calculus in the PTCSL group was significantly better than in the PTCS group after multivariate analysis ($P = 0.021$; OR = 0.201; 95% CI, 0.051-0.785). Calculus recurrence was 9% (PTCSL) and 22% (PTCS). The postoperative hospital stay was significantly shorter in the PTCSL group ($P = 0.001$; OR = 1.337; 95% CI, 1.132-1.58).

Conclusions: PTCSL was a satisfactory therapeutic option for hepatolithiasis treatment, with less operation time and a superior long-term therapeutic effect compared with conventional PTCS.

Key Words: hepatolithiasis, percutaneous transhepatic cholangioscopy, percutaneous transhepatic cholangioscopic lithotripsy

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Hepatolithiasis is the presence of gallstones (calculus) in the biliary ducts of the liver, and is common in East Asia where it has been considered endemic, but rare in Western countries.[1] In China and other parts of East Asia, 20% to 45% of the patients who underwent surgical operations for gallstones had hepatolithiasis.[2–5] Clinical progression of the disease may lead to liver parenchymal destruction due to recurrent cholangitis or subsequently result in biliary cirrhosis and even cholangiocarcinoma.[6] In contrast to gallbladder stones, hepatolithiasis is considered to be intractable, with frequent recurrence,[1] and patients with concomitant biliary stricture or residual stones are at a high risk of complications after treatment.[7]

Current treatment strategies include surgical resection of the affected lobe, and this is recommended in many cases.[8,9] Alternatively, in cases where resection is difficult, multiple lobes are affected, the patient has undergone previous biliary surgery, or has a high preoperative risk, nonresection methods can be used. These involve endoscopic retrograde cholangiopancreatography, peroral cholangioscopy, and percutaneous transhepatic cholangioscopy (PTCS).[10–12] PTCS is particularly useful when locations cannot be approached in a retrograde manner.[1,13] The conventional PTCS approach is to expand the sinus gradually and perform percutaneous transhepatic biliary drainage.[14,15] This procedure has a relatively long operation time, usually between 2 and 3 weeks, with multiple expanding sheath sizes, leading to the potential for bleeding, biliary fistula, biliary tract infection, and peritonitis. Alternatively, the same approach can be used with lithotripsy to break up the calculus in percutaneous transhepatic cholangioscopic lithotripsy (PTCSL).[16] Compared with conventional PTCS, PTCSL has the merits of minimal invasiveness, a shorter operation time, lesser intraoperative blood loss, and blood transfusion, all due to an optimized operation channel establishment and a shorter time period.

The objective of this study was to evaluate the short-term and the long-term therapeutic outcomes of PTCSL, by comparison with that of conventional PTCS. The results should provide important information on which technique is more beneficial for the treatment of hepatic calculus.

MATERIALS AND METHODS

The study was approved by the Ethics Committee of the First Affiliated Hospital of Guangzhou Medical University (Guangzhou province, China), and all the information obtained during the study was used only for scientific research.

Patients

Patients with hepatolithiasis, who underwent treatment in the First Affiliated Hospital of Southern Medical University or in First People's Hospital of Shunde City affiliated to Guangzhou Medical University between March 2007 and July 2014, were enrolled.

Inclusion criteria were as follows: (1) patients diagnosed with complicated hepatolithiasis; (2) adult patients; (3) patients with liver function preoperatively assessed as Child-Pugh A or B grades, or C grade without coagulation disorders; and (4) patients who underwent PTCS.

Exclusion criteria were as follows: (1) patients lost to follow-up; and (2) patients with other concurrent diseases diagnosed preoperatively, such as diabetes, hypertension, and cancer.

The diagnostic method and the standard for hepatolithiasis involved preoperative assessments including the B-ultrasound test, computed tomography (CT), magnetic resonance imaging (MRI), magnetic resonance cholangiography (MRCP), 3-dimensional digital image construction, endoscopic retrograde cholangiopancreatography, and PTCS, to determine the location, size, and number of gallstones, and the location of any stenosis.

The diagnostic criteria for complicated hepatolithiasis in this study combined multiple criteria including the Chinese guidelines of diagnosis and treatment for hepatolithiasis revised in 2011,[17] the Japanese classification,[18] and the Tsunoda classification[19]:

(1) Location (L): the localization of the lithiasis or the bile duct lesion (distention or stenosis) was pinpointed accurately by the rebuilt CT images on hepatic fragments I to VIII.
(2) Stenosis (S): the diameter of the secondary normal bile duct ranges between 2 and 3 cm; therefore, 2 cm was used as the standard to define stenosis of the bile duct. S0 was defined as no stenosis; S1 was relatively stenosed with a diameter ratio of the proximal bile duct stenosis and the distal bile duct distention $>1/2$; S2 was absolute stenosis with a diameter ratio of the proximal bile duct stenosis and distal bile duct distention $<1/2$.
(3) Distention (D): the internal diameter of the bile duct of 10 mm was used as the criterion to distinguish between mild and severe distention; D0 was no distention; D1 was mild distention with an internal diameter between 2 and 10 mm; D2 was moderate distention with an internal diameter between 10 and 15 mm; and D3 was severe distention with an internal diameter larger than 15 mm.
(4) Hepatic cirrhosis (C) and portal hypertension: portal hypertension and splenomegaly were the result of extensive hepatolithiasis, chronic hepatocholangeitis, and cholestatic cirrhosis, which were important prognostic factors of hepatolithiasis.

In the current study, if hepatolithiasis affected 2 or more hepatic lobe bile ducts and was complicated with S1, S2 or D2, D3, or C, it was considered to be complicated hepatolithiasis

The joint diagnosis was made and confirmed on the basis of images by the same 3 experts from the First Affiliated Hospital of Guangzhou Medical University: P.W. (13-y experience, from the Department of Hepatobiliary Surgery), Y.L. (33-y experience, from the Department of Hepatobiliary Surgery), and Yu Deng (13-y experience, from the Radiological Department).

Patients were divided into group PTCSL and group PTCS according to the treatment they received.

The Operative Procedure

All procedures were performed at the Department of Hepatobiliary Surgery, the First Affiliated Hospital of Guangzhou Medical University.

PTCSL

The procedure was undertaken by P.W., B.S. (18-y experience), and B.H. (5-y experience). Instruments and equipments used during the procedure included a Nephrolithotome (12-degree Ultra-Wide-Angle Ureterorenoscope; Richard Wolf GmbH, Germany), which was used to replace a rigid choledochoscope, with a distal diameter of 2.8 mm. Other tools for lithotripsy used with nephrolithotomy included a ballistic lithoclast (Intracavity Lithotripsy Machine, type APL; Guangzhou Jielun Medical Equipment Co., Ltd., Guangdong Province, China) including electrohydraulic lithotripsy, ultrasonic lithotripsy, and a holmium laser. Other instruments were also utilized such as a C-arm x-ray machine (SIREMOBIL Compact L; Siemens, Germany), the light source (Voice-control compatible X8000 Xenon Light Source of 300 W; Stryker Corporation, MI), the camera system (1088i HD Camera Control Unit, PAL 220 V; Stryker Corporation), an adjustable pressure pump (type APL; Guangzhou Jielun Medical Equipment Co., Ltd, Guangdong Province, China), a zebra guidewire (type HAW; Cook Medical, Bloomington, IN), an expander of 8 to16 Fr series (type PLVW, Cook Medical), sheaths of 14, 16, and 18 Fr, and a biliary balloon dilator (ATB Advance; Cook Medical).

The Operation Method

The puncture point for cholangioscopy entrance was selected carefully and determined according to preoperative CT and B-ultrasound images, usually at the lateral abdominal wall close to the caudal of the xiphoid process. A biliary drainage catheter of 8 Fr was placed through PTCS guided by B-ultrasound or a C-arm x-ray machine under epidural or intravenous anesthesia. The correct positioning for cholangioscopy was confirmed once the bile was drained out, and the puncture point was enlarged to 6 mm. The zebra guidewire was placed while the drainage catheter was removed. Biliary expanders from 8 to 16 Fr were used along the guidewire to expand the sinus gradually until it reached 16 or 18 Fr. Then a 16 or 18 Fr catheter covering the dilator was sent into the intrahepatic biliary duct together with the dilator. One end of the catheter remained in the duct and the other end was fixed to the skin after the dilator was removed, so that a fistulous channel from outside to the intrahepatic duct was established. Physiological saline was injected into the targeted biliary duct through the guidewire and the sheath of a rigid choledochoscope. Lithotripsy was performed once the calculus was found, and the shattered calculi were flushed out with physiological saline by "wash and suction" technology. The calculus could also be taken out with a basket (NTSE-045065-UDH; Cook Medical) or a clamp (Ureteral Grasping Forceps; Richard Wolf Medical Instruments Corporation, Vernon Hills, IL). Stenosis of the biliary duct was expanded with a series of soft expanders or a biliary balloon dilator, and the stricture could be cut open by an electric knife for columnar stenosis (tubular stricture), which is usually found in the scar stricture of the bile duct, before expansion (mannitol was injected into biliary tract before cutting it open). A drainage catheter of 14 Fr was indwelled beyond the stricture fragment, and the support catheter was indwelled for 8 to 11 months. All operational manipulations were performed within the sheath or biliary ducts, and the instruments did not come in contact with the wall of the sinus. The remnant calculus was evaluated by postoperative imaging examination, and a suitable withdrawal time of the indwelled drainage catheter was determined depending on the postoperative condition.

PTCS

The procedure was undertaken by Y.L., Tianling Fang (12-y experience), and J.X. (5-y experience).

The sinus was expanded gradually in a conventional PTCS approach, and a drainage catheter of 10 Fr was replaced by a 10 Fr or a 11 Fr PTCS catheter 1 week after percutaneous transhepatic biliary drainage. The sinus was further expanded using a catheter of larger diameter twice or thrice a week, until a 16 Fr catheter could be placed around 2 or 3 weeks later. Then, the calculus could be taken out by fibrocholangioscopy (Olympus, Japan) through a 16 Fr catheter.

Outcomes

Procedure Assessments

Operation-related data were collected for both groups, including the operation time, the intraoperative blood loss, and intraoperative blood infusion. Other information was also recorded such as the immediate clearance ratio, the final clearance ratio, the postoperative hospitalization time, the stricture rate of the intrahepatic biliary duct, the mortality, the complication rate (including the recurrence of calculus and the cholangitis recurrence rate), and preoperative and postoperative laboratory tests (including the serum transaminase level, the serum bilirubin level, the serum albumin level, the hemoglobin level, and the prothrombin time).

The Immediate Clearance Ratio

An intraoperative choledochoscope instead of cholangiography was used as the routine examination to investigate the clearance of calculus.

The Final Clearance Ratio

Final imaging examination to confirm whether the stone was clean at the end of the therapeutic course.

Recurrence

The biliary drainage tube was indwelt postoperatively for each patient as a routine procedure to facilitate choledochoscope examination or cholangiography. Cholangiography, ultrasound examination, or CT inspection were performed during the follow-up examination; if hepatolithiasis was found within 3 months after surgery, it was defined as remnant calculus; if hepatolithiasis recurrence or a cholangitis flare up was found 3 months after surgery, it was defined as a recurrence.

Postoperative Follow-up

Patients were followed up by telephone interview and doctor visits in the outpatient department every 3 months; all follow-up examination data were collected until July 2014. Examinations included ultrasound, CT scanning, MRI, hepatobiliary contrast imaging, and 3D reconstruction. The rate of remnant calculus, the recurrence time and the rate of calculus, the incidence of cholangitis, and the cause of death were also recorded.

Statistical Analysis

SPSS software (version 19.0; SPSS Inc., Chicago, IL) was utilized in the current study. Quantitative data are presented as mean ± SD. Numeric data are presented as the rate or the ratio. Comparisons between 2 groups were performed by the Student t test, the χ^2 test, and the Fisher exact test for statistical analysis. Possible factors of postoperative outcomes were entered into a multiple logistic regression model, including age, sex, surgical history, the Child-Pugh score, DBIL, ALT, γ-GGT, the immediate clearance ratio, the final clearance ratio, hospital stays, and the postoperative hospital stay. $P < 0.05$ was considered as statistically significant.

RESULTS

Patient Characteristics and Preoperative Data

About 67 out of 118 patients received PTCSL and were classified into the PTCSL group, including 35 men and 35 women with an average age of 55.2 ± 13.5 years and a disease course that ranged between 3 months and 10 years. The other 51 patients, including 24 men and 27 women, with an average age of 58.8 ± 16.5 years and a disease course that ranged between 4 months and 9.5 years, underwent conventional PTCS and were classified into the PTCS group.

The comparison of patient characteristics and preoperative data are shown in Table 1. There was no difference between the patients in terms of their age, sex, and surgical history. However, there was a significant difference in the Child-Pugh grade score as the majority of the patients in both groups were grade 2, but this was much higher in the PTCSL group than in the PTCS group (86.6% vs. 58.8%, respectively) and more patients were grade 3 in the PTCS group than in the PTCSL group (39.2% vs. 11.9%, respectively). There were also some significant differences in the preoperative laboratory tests and in the number of patients with 6 and 7 biliary strictures, which was significantly higher in the PTCSL group. Significantly more patients had right-lobe stones in the PTCSL group (70.1%) compared with the PTCS group (49.0%).

Intraoperative Data

Intraoperative data of the 2 groups are shown in Table 2. No significant differences were found between the groups in terms of the immediate clearance ratio, the operation time, intraoperative blood infusion, or the intraoperative blood loss.

Outcomes

The postoperative hospital stay was similar in the 2 groups as shown in Table 2. The final clearance ratios and recurrence were also similar.

Both groups had no perioperative mortality. The complications are shown in Table 2 and were similar for both groups, with 6 cases of cholangitis in the PTCSL group compared with 2 in the PTCS group and 1 case of postoperative intrahepatic biliary stricture in the PTCSL group.

TABLE 1. Comparison of Preoperative Data Between the 2 Groups

	n (%)		
Variables	**PTCSL (N = 67)**	**PTCS (N = 51)**	***P***
Age	55 (21-84)	56 (21-94)	0.336
Sex (male)	33 (49.3)	24 (47.1)	0.813
Surgical history	56 (83.6)	43 (84.3)	0.915
Child-Pugh score			0.002*
1	1 (1.5)	1 (2.0)	
2	58 (86.6)	30 (58.8)	
3	8 (11.9)	20 (39.2)	
Preoperative laboratory tests			
TBIL	18.2 (5.1-295)	36.2 (8.5-529.2)	0.005*
ALB	34 (15-46)	34.5 (12.9-201)	0.883
PT	13.4 (1.7-106)	13.4 (1.17-20.6)	0.483
DBIL	4.2 (1-120.40)	17.1 (1.6-420.01)	< 0.001*
ALT	40 (9-252)	52 (11-831)	0.022*
γ-GGT	151 (0-1283.60)	310 (0-1441)	0.009*
HGB	121 (73-160)	112 (0-9910)	0.158
APTT	37.9 (0-127)	38 (28.4-54)	0.948
HBsAg	1 (1.5)	0	0.556
HCV negative	67 (100)	51 (100)	
Combined with Cholangiocarcinoma	2 (3.0)	1 (2.0)	0.723
Biliary stricture			
S1	5 (7.5)	1 (2.0)	0.155
S2	8 (11.9)	2 (3.9)	0.106
S3	7 (10.4)	1 (2.0)	0.051
S4	7 (10.4)	2 (3.9)	0.171
S5	9 (13.4)	2 (3.9)	0.065
S6	13 (19.4)	3 (5.9)	0.034*
S7	13 (19.4)	1 (2.0)	0.004*
S8	10 (14.9)	2 (3.9)	0.05
Location of stone			
Left lobe	43 (64.2)	25 (49.0)	0.099
Right lobe	47 (70.1)	25 (49.0)	0.02*
Bilateral	21 (31.3)	19 (37.3)	0.502
Common bile duct stones	41 (61.2)	24 (47.1)	0.126
Liver atrophy			
Left lobe	0	1 (2.0)	0.194
Right lobe	2 (3.0)	1 (2.0)	0.723
Bilateral	3 (4.5)	0	0.063
Percutaneous location			0.936
Bilateral	3 (4.5)	3 (5.9)	
Left	46 (68.7)	35 (68.6)	
Right	18 (26.9)	13 (25.5)	
Follow-up	18 (1-138)	44 (2-147)	< 0.001*

γ-GGT indicates γ-glutamyl transpeptidase; ALB, albumin; ALT, alanine aminotransferase; APTT, activated partial thromboplastin time; DBIL, direct bilirubin; HBsAg, surface antigen of the hepatitis B virus; HCV, hepatitis C virus; HGB, hemoglobin; PT, prothrombin time; PTCS, percutaneous transhepatic cholangioscopy; PTCSL, percutaneous transhepatic cholangioscopic lithotripsy; TBIL, total bilirubin.

Multivariate analysis revealed that the final clearance ratios and the postoperative hospital stay of the PTCSL group were significantly better than those for the PTCS group, even if DBIL was concerned, as shown in Table 3.

Follow-up Results

All enrolled patients were followed up for a period that ranged between 2 and 85 months (mean 31.1 mo). There were 17 patients with recurrence of calculus as diagnosed by ultrasound, CT scan, or cholangiography: 6 patients from the PTCSL group and 11 patients from the PTCS group; however, there was no significant difference in terms of the recurrence rate, with 9.0% and 21.6%, respectively ($P = 0.053$). All recurrent calculi were located in the right lobe of the liver, and one of the recurrent patients from the PTCSL group had hepatolithiasis recurrence at the right posterior hepatobiliary duct. In the PTCSL group, there were 3 recurrences within the first postoperative year, and 1 recurrence in the second, third, and fifth years, respectively. Two recurrent calculi were located in the right posterior hepatobiliary duct, 1 located in the right anterior common hepatobiliary duct, 2 located in both the right and the left lobes of the liver, and another one located in the right caudate lobe.

The recurrence of hepatolithiasis in 2 patients was revealed by a follow-up CT scan, and the patients were reluctant to receive further treatment because they experienced no symptoms. Three patients with recurrent hepatolithiasis had concurrent symptoms and underwent left hemihepatectomy and plastic cholangiojejunostomy. Another patient received liver transplantation. There was 1 patient from the PTCSL group who had concurrent cholangiocarcinoma, and died from multiple organ dysfunction syndrome 13 months after cholangiojejunostomy. No other

TABLE 2. Patient Outcomes

Variables	n (%) PTCSL (N = 67)	PTCS (N = 51)	P
Immediate clearance ratio	28 (41.8)	23 (45.1)	0.719
Final clearance ratio	57 (85.1)	36 (70.6)	0.056
Operation time (min)	100 (20-385)	75 (20-350)	0.06
Intraoperative blood infusion (mL)	0	0 (0-200)	0.104
Intraoperative blood loss (mL)	10 (0-150)	2 (0-200)	0.823
Hospital stay (d)	16 (5-36)	21 (6-67)	< 0.001*
Postoperative hospital stay (d)	10 (2-27)	15 (5-49)	< 0.001*
Recurrent hepatolithiasis	6 (9.0)	11 (21.6)	0.053
Perioperative mortality	0	0	
Complications			
Bile leakage	0	0	
Pulmonary infection	0	0	
Wound infection	0	0	
Intestinal leakage	0	0	
Pleural effusion	0	0	
Cholangitis	6 (9.0)	2 (3.9)	0.268
Peritoneal effusion	0	0	
Postoperative intrahepatic biliary stricture	1 (1.5)	0	0.286
Postoperative bleeding	0	0	

*$P < 0.05$.
PTCS indicates percutaneous transhepatic cholangioscopy; PTCSL, percutaneous transhepatic cholangioscopic lithotripsy.

deaths have been reported during the follow-up period and to date.

DISCUSSION

PTCSL demonstrated its clinical value on hepatobiliary duct stenosis, calculi with hepatic segment atrophy, diffused intrahepatic biliary calculi, calculi located within biliary branches of grades III and IV, calculi concurrent with cirrhosis or portal hypertension, and for patients who were intolerant to partial hepatectomy. More importantly, the preoperative CT, MRCP, and B-ultrasound images provided the accurate entrance route for PTCSL, which enabled a thorough cholangioscopic lithotripsy, while protecting the hepatic function from damage. In the current study, PTCSL demonstrated an advantage over PTCS on lithotripsy of calculus in the right hepatic lobe, bilateral lobes, or in patients with hepatic function at Child-Pugh stage C and intolerant to conventional surgery.

A critical measure of the success of hepatolithiasis treatment is the number of patients who have recurrence as this can generally be high and lead to the risk of complications.[7] Surgical resection is usually considered to be the optimal treatment for low recurrence rates of around 5% to 6%,[20,21] although these procedures often also involve other stone removal methods such as lithotripsy. The recurrence of calculus was reduced in the PTCSL group (9%) compared with the PTCS group (22%). Although the decrease in recurrence was not significant, this rate of recurrent calculus after PTCSL was also lower than that published in previous studies using PTCSL (29%,[3] 20%,[22,23] 18%,[24] 17%,[25] and 15%[26]). Those studies may have less success because methods have improved since they were published. We found that our method of individualized PTCSL could remove lesions thoroughly, get rid of calculi, and unblock stenosis. In the current study, the combination of a rigid choledochoscope and a protective sheath was utilized. The protective sheath was placed within the dilated fistulous tract, and all surgical operations were performed within the sheath and dilated biliary ducts; meanwhile, the biliary duct could be "straightened" by the sheath and formed an artificial channel to the outside. The shattered calculi were washed and sucked away by the rigid choloedochoscope from the sheath. Moreover, any stenosis or stricture of the biliary duct was corrected successfully by PTCSL at the same time, which can avoid multiple operations. Using CT, MRI, MRCP, and B-ultrasound, accurate locations of blood vessels and biliary ducts prevented accidental damage of the portal vein and hepatic vein during operation on a stenosis. The rigid percutaneous transhepatic choloedochoscope could reach the fragment of biliary duct stenosis from the dilated part, and as most of the stenoses were membrane type and short in length, they could be dilated directly by forceps. For severe stenosis, the biliary duct was dilated firstly by a balloon, and then guidewires with a series of diameters could be used if necessary. A stenosis with scar tissue could be opened by an electric or a laser knife, followed by a balloon for dilation; then, the

TABLE 3. Multivariate Analysis

Variables	P	OR	95% CI for OR Lower	Upper
Age	0.249	0.541	0.19	1.537
Sex	0.881	0.997	0.963	1.033
Surgical history	0.183	2.707	0.625	11.729
Child-Pugh score	0.818	0.833	0.176	3.948
DBIL	0.036*	1.015	1.001	1.028
ALT	0.136	1.007	0.998	1.015
γ-GGT	0.983	1	0.998	1.002
Immediate clearance ratio	0.205	2.178	0.653	7.257
Final clearance ratio	0.021*	0.201	0.051	0.785
Hospital stay	0.065	0.88	0.769	1.008
Postoperative hospital stay	0.001*	1.337	1.132	1.58

*$P < 0.05$.
γ-GGT indicates γ-glutamyl transpeptidase; ALT, alanine aminotransferase; CI, confidence interval; DBIL, direct bilirubin; OR, odds ratio.

placement of a supportive sheath helped avoid damage to blood vessels on the biliary duct wall and reduce hemobilia. Overall, our method of PTCSL reduced immediate and final remnant calculus in the PTCSL group effectively. The PTCSL group had a lower recurrence of cholangeitis compared with the PTCS group; however, it was not significant.

Although, unexpectedly, we found no significant difference in terms of the operation time between the 2 groups, there was a difference in postoperative hospitalization. The longer hospital stay for the patients in the PTCS group has the potential to cost more and indicate higher levels of pain and discomfort; although we did not measure the cost of treatment or pain experienced by the patients in this study, it would be worth considering in future studies.

Our method of percutaneous transhepatic operation through an expanded fistulous tract was performed under the guidance of CT or B-ultrasound. The puncture site at the dilated biliary duct with an optimal entrance angle was selected; the lateral abdominal wall close to the caudal of the xiphoid process was usually the primary entrance site; B2, B3a, and B3b, the dilated biliary ducts in the left lateral lobe, were usually used as puncture sites or the right midclavicular line was the entrance site, and the dilated biliary ducts B7a and B6c were used as puncture sites to avoid blood vessels, the intestine, and the chest cavity. The cholangioscopic lithotripsy was direct from the skin to targeted biliary ducts from an expanded fistulous tract. All PTCSL operations were successful in the current report. In our study, PTCSL shortened the whole lithotripsy period, the operation time, and the distance between skin entrance sites and targeted biliary ducts, although these differences were not significant in this population. Meanwhile, biliary duct dilation times and intraoperative blood losses were also slightly reduced, so that the minimal invasive treatment for cholangioscopic lithotripsy was realized by PTCSL.

There were some limitations in this study. First, this was a retrospective study of patients undergoing PTCS and PTCSL; hence, there was some inevitable selection bias between the groups that may impact the results. Second, the number of patients undergoing this treatment in this single-center study was quite small, and so the sample size was limited. These results should be confirmed in larger populations in multiple centers.

In summary, PTCSL demonstrated significant merits compared with PTCS, with reduced rates of immediate and final remnant calculus, a lower recurrence rate of hepatolithiasis, and a shorter postoperative hospitalization time, suggesting that PTCSL might be an ideal option for patients who are intolerant to conventional surgery or with postoperative remnant calculi.

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