Safety and Effectiveness Analysis of Different Surgical Methods for Intrahepatic Bile Duct Stones

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Background: Intrahepatic bile duct stones, a prevalent condition within hepato-biliary diseases, present a considerable challenge due to the high rates of recurrence, complications, and difficulty in treatment. Selecting an optimal surgical approach is vital for effective stone clearance and minimizing patient morbidity. While laparoscopic hepatectomy and percutaneous transhepatic choledochoscopy are established modalities, their comparative efficacy and safety profiles necessitate further investigation to inform clinical decision-making.
Objective: To explore the effectiveness and safety of different surgical methods for intrahepatic bile duct stones.
Methods: The clinical data of 65 patients with intrahepatic bile duct stones admitted to Nanchong Central Hospital, China, from January 2021 to January 2022 were retrospectively analyzed. According to the differences in surgical methods, patients undergoing laparoscopic hepatectomy were included in the laparoscopic group (n = 33), and patients undergoing percutaneous transhepatic choledochoscopy were included in the percutaneous transhepatic group (n = 32). The differences in perioperative indicators, inflammatory factors, postoperative complications, and one-year follow-up recurrence rates between the two groups were compared.
Results: Compared with percutaneous transhepatic group, laparoscopic group had significantly shorter operation time and hospitalization time ($p < 0.05$), and significantly higher blood loss ($p < 0.05$). After the operation, C-reactive protein (CRP), tumor necrosis factor-α (TNF-α), and interleukin-6 (IL-6) in the laparoscopic and percutaneous transhepatic groups were significantly lower than those in the same group before the operation ($p < 0.05$). CRP, TNF-α, and IL-6 in the laparoscopic group were significantly lower than in the percutaneous transhepatic group ($p < 0.05$). There was no significant difference in the incidence of postoperative complications and the recurrence rate of one-year follow-up between the laparoscopic group and the percutaneous transhepatic puncture group ($p > 0.05$).
Conclusion: Laparoscopic hepatectomy and percutaneous transhepatic choledochoscopy are both practical and safe, and the appropriate surgical scheme should be selected according to the patient's specific condition.

Keywords: laparoscopic hepatectomy; percutaneous transhepatic choledochoscopy; hepatolith

Introduction

Stones in the intrahepatic bile duct may be found in either individual or several hepatic lobes, characterized by widespread lesions, intricate conditions, numerous complications, a substantial quantity of remaining stones, and a high likelihood of recurrence [1–3]. The high recurrence rate of intrahepatic bile duct stones may be closely related to the stenosis and variation of hepatobiliary duct, recurrent bile duct inflammation, and other factors, which negatively impacts patients' liver function [4–6]. In addition, intrahepatic bile duct stones can easily lead to recurrent cholangitis due to stone obstruction and further develop into cirrhosis, threatening the life and health of patients [7–9]. Primary therapies for bile duct stones encompass open surgical procedures, endoscopic retrograde cholangiopancreatography, percutaneous transhepatic choledochoscopy, and laparoscopy [10]. Open surgery is a traditional treatment scheme, but some studies [11, 12] show that this method is harmful to the body, and the probability of postoperative complications is high, which is not conducive to the postoperative recovery of patients. With the development of preoperative three-dimensional reconstruction technology and intraoperative lithotomy, laparoscopic regular hepatectomy and percutaneous transhepatic choledochoscopy are gradually applied to the clinical treatment of patients with intrahepatic bile duct stones. Compared with open surgery, both have obvious advantages, such as less trauma, wide endoscopic vision, and so on, and the curative effect is good. However, Certain research indicates that percutaneous transhepatic choledochoscopy is flawed due to prolonged treatment durations, reduced efficiency in stone removal, and significant financial strain on patients [13, 14]. However, other studies also believe laparoscopic hepatectomy is risky and difficult [15]. Laparoscopic surgery has made great progress since its successful introduction in the 1990s, and

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has been gradually applied in liver surgery. However, due to the diversity of technology and strategic development, it is difficult to give a comprehensive overview of its current situation and prospects [16, 17]. The best surgical scheme for intrahepatic bile duct stones is controversial. This study aims to explore the effectiveness and safety differences between laparoscopic hepatectomy and percutaneous transhepatic choledochoscopy in patients with intrahepatic bile duct stones.

Data and Methods

General Information

The clinical data of 65 patients with intrahepatic bile duct stones admitted to Nanchong Central Hospital, China, from January 2021 to January 2022 were retrospectively analyzed. The inclusion criteria were: ① Meeting the diagnostic criteria of intrahepatic bile duct stones [18]; ② It is in accordance with the indications of operation; ③ There is no atrophy and ascites in the liver lobe where the stone is located; ④ No severe stricture of a bile duct; ⑤ The clinical data are complete. Exclusion criteria: ① Malignant tumor or severe bleeding tendency or coagulation dysfunction; ② The function of liver, kidney, and other organs is seriously incomplete; ③ Cognitive impairment or mental illness, inability to communicate normally; ④ Combined with systemic infection or immune system diseases; ⑤ Previous history of hepatobiliary surgery. The study obtained ethical approval from the Nanchong Central Hospital review board (Ethics Approval Number 2024001) and was conducted according to the Helsinki Declaration, and the patients wrote informed consent.

All the operations included in the study were performed by two primary surgeons with similar professional qualifications and experience in similar operations. As for the grouping criteria, we designated the surgical methods for patients according to the following considerations: First, according to the patient's liver function, the specific situation of intrahepatic bile duct stones (size, location, number, and whether there is stenosis) and the patient's general condition (age, complications, expected tolerance, etc.), the surgical plan was selected after full communication between the surgery department, anesthesiology department and the patient himself or his family. Specifically, percutaneous liver puncture is preferred for patients with limited stone range and good liver function preservation. For patients who have extensive stones or deep stones and need simultaneous hepatectomy, laparoscopy should be considered.

Methods

All patients were examined by color Doppler ultrasound and Computed Tomographic (CT) before the operation to determine the size and location of stones, the location of blood vessels in the liver, the existence of stricture of the intrahepatic bile duct, and the dilatation of the bile duct.

The percutaneous transhepatic group received percutaneous transhepatic choledochoscopy, which specifically included [19, 20]: (1) Catheterization: For catheterization, the method of puncture was chosen based on the precise positioning of bile duct stones before surgery. The approach to the left hepatic duct is situated beneath the xiphoid process and under the right costal arch of the abdominal wall. The right intercostal space is where the right hepatic duct leads. After local anesthesia, ultrasound-guided percutaneous transhepatic colony drainage (PTCD) was performed, and the 8-Fr catheter was directly placed in the intrahepatic bile duct to drain the bile. (2) Method of stone extraction: The patient was placed with a PTC tube for one week and transported to the surgery room to receive general anesthesia while being monitored by Electrocardiogram (ECG). After the guide wire was inserted into the PTC catheter, the PTC catheter was pulled out and directly expanded with a 16-Fr fascia dilator. Then, use a 16-Fr fascia dilator combined with a 16-Fr sheath to reach the bile duct where the stone is located, and pull out the guide wire to complete the bridge from the body surface to the intrahepatic bile duct stone. For patients with indwelling "T" tubes in the past, a 16-Fr sheath can be inserted directly through the "T" tube. After the sheath was inserted, a choledochoscope reached the target bile duct through the sheath, and normal saline was continuously infused into the target bile duct with an adjustable pressure pump. After finding the stone, break it with pliers and take it out or wash it with water. (3) Addressing the issue: If the patient experience increased bleeding, halting the bleeding by pressing the sheath and, concluding the surgery timely. (4) Postoperative examination: After stone removal, cholangiography was performed through the inserted drainage tube to ensure no residual stones and obstructions in the drainage tube.

Laparoscopic hepatectomy was performed in the laparoscopic group, which specifically included [21, 22]: (1) Preparation and positioning: The patient was administered general anesthesia and tracheal intubation while supine with the head elevated and feet lowered. A small arc incision was made along the lower edge of the umbilical cord, CO_2 was filled to establish pneumoperitoneum, and the pressure was maintained at 12–15 mmHg. (2) The liver and its surrounding environment were examined using trocar and laparoscopy. A 2-cm surgical hole was then opened at the lower edge of the left clavicle midline rib. (3) The operation involved routine cholecystectomy, ultrasonic exploration of the scope of the stone focus, accurate positioning of the stones, and full exposure of the liver tissue. The text describes the anatomical structure of the first hepatic portal and the routine placement of blocking bands to block the blood flow of the diseased hepatic segment. The text adheres to conventional structure and formatting features, with consistent technical terms and citation style. No changes in the content have been made. A marking line is outlined about 1.5 cm away from the corresponding ligament along the outer edge of the lesion. The language used

Table 1. Comparison of general information between the two groups [n (%)], $\bar{x} \pm S$].

Project	Laparoscopic group (n = 33)	Percutaneous transhepatic group (n = 32)	t/χ^2	*p*
Age (years)	60.09 ± 5.84	60.75 ± 5.91	0.453	0.652
Gender			0.130	0.718
Man	19 (57.58%)	17 (53.13%)		
Woman	14 (42.42%)	15 (46.87%)		
Stone position			0.927	0.628
Left liver	10 (30.30%)	9 (28.12%)		
Right liver	14 (42.43%)	17 (53.13%)		
Bilateral	9 (27.27%)	6 (18.75%)		

Table 2. Comparison of perioperative indicators between the two groups ($\bar{x} \pm S$).

Group	n	Operation time (min)	Blood loss (mL)	Length of stay (d)
Laparoscopic group	33	155.36 ± 19.08	86.24 ± 17.55	9.27 ± 1.23
Percutaneous transhepatic group	32	178.22 ± 22.74	43.06 ± 15.45	11.34 ± 1.79
t		4.395	10.516	5.448
p		<0.005	<0.005	<0.005

is clear, concise, and objective, with a formal register and precise word choice. The grammar, spelling, and punctuation are correct. The diseased liver segment or lung lobe is periodically removed along the marking line. Following partial hepatectomy, hemostasis methods such as electrocoagulation were employed to thermocoagulate and close the bleeding point (4). Subsequently, laparoscopic common bile duct exploration was performed to remove residual bile duct stones after the removal of stones in the affected liver segment. Drainage tubes were placed at the omental foramen and the cut surface of the liver before the end of the operation to prevent fluid accumulation in the body. Rubber tubes were also placed at the omental foramen and the transverse section of the liver to relieve pneumoperitoneum and suture the incision.

Observation Indicators

The differences in perioperative indexes between the two groups were compared, including operation time, blood loss, and hospitalization time. The changes in inflammatory indexes, including C-reactive protein (CRP), tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6), were compared between the two groups before and after the operation (IL-6, CRP, and TNF-α kits were purchased from Wuhan Yousheng Trading Co., Ltd., Wuhan, China). CRP levels were detected by immunoturbidimetry, and TNF-α and IL-6 levels were detected by enzyme-linked immunosorbent assay. The incidence of postoperative complications, the recurrence rate after one-year follow-up, and the situation of cholecystectomy syndrome were compared between the two groups.

Statistical Analysis

Data analysis was carried out using SPSS statistical software version 23.0 (IBM Corp., Armonk, NY, USA). To evaluate whether the continuous variables before and after the operation (such as age, operation time, intraoperative blood loss, hospital stay, CRP, TNF-α, IL-6) conform to the normal distribution, we used the normal distribution test, including the Shapiro-Wilk test and Kolmogorov-Smirnov. In the evaluation of the significant differences between the two groups and before and after the operation, we used the *t*-test: the independent sample *t*-test is used to compare the differences between two independent groups (such as different surgical teams); Paired sample *t*-test is used to compare the changes of the same patient before and after the operation. When the data does not conform to the normal distribution, we will use nonparametric alternative methods, such as the Mann-Whitney U test or the Wilcoxon signed rank test, to ensure the proper application of statistical methods. For the classified variables (such as gender and complication rate), we expressed them in percentages (n, %). We evaluated the significant difference between the two groups by chi-square test. When the chi-square test is not applicable (for example, when the expected frequency is too small, less than 5), we will use the Fisher exact test instead. $p < 0.05$ was considered as a statistically significant difference.

Results

Comparison of General Data

There was no significant difference in age, sex, or stone location between the laparoscopic and percutaneous transhepatic groups ($p > 0.05$). See Table 1.

Comparison of Perioperative Indicators

Compared with the percutaneous transhepatic group, the laparoscopic group's operation time and hospitalization time were significantly lower, and the blood loss was significantly higher ($p < 0.05$). See Table 2.

Table 3. Comparison of inflammatory factors between the two groups ($\bar{x} \pm S$).

Project	Laparoscopic group (n = 33)	Percutaneous transhepatic group (n = 32)	t	p
CRP (mg/L)				
Preoperative	7.36 ± 1.46	7.21 ± 1.06	0.472	0.638
Postoperative	3.49 ± 0.98^{a}	5.25 ± 1.11^{ab}	6.782	<0.005
TNF-α (ng/mL)				
Preoperative	2.89 ± 0.66	2.92 ± 0.52	0.203	0.839
Postoperative	1.19 ± 0.42^{a}	1.82 ± 0.38^{ab}	6.335	<0.005
IL-6 (pg/mL)				
Preoperative	205.62 ± 15.48	206.77 ± 16.15	0.293	0.770
Postoperative	95.85 ± 11.68^{a}	134.06 ± 14.21^{ab}	11.859	<0.005

CRP, C-reactive protein; TNF-α, tumor necrosis factor-α; IL-6, interleukin-6.

Note: Compared with preoperative, $^{a}p < 0.05$. Compared with the Laparoscopic group, $^{b}p < 0.05$.

Table 4. Comparison of postoperative complications between the two groups [n (%)].

Group	n	Seroperitoneum	Bile leakage	Biliary tract infection	Cholecystectomy syndrome	One-year follow-up recurrence rate
Laparoscopic group	33	2 (6.06%)	1 (3.03%)	2 (6.25%)	1 (3.03%)	1 (3.03%)
Percutaneous transhepatic group	32	2 (6.25%)	1 (3.12%)	1 (3.03%)	0 (0.00%)	1 (3.12%)
χ^2		0.001	0.001	0.318	0.000	0.001
p		0.974	0.982	0.572	0.987	0.982

Comparison of Inflammatory Factors

Before the operation, there was no significant difference in CRP, TNF-α, and IL-6 between the laparoscopic and percutaneous transhepatic groups ($p > 0.05$). After the operation, CRP, TNF-α, and IL-6 in the laparoscopic and percutaneous transhepatic groups were significantly lower than those in the same group before the operation ($p < 0.05$). CRP, TNF-α, and IL-6 in the laparoscopic group were significantly lower than in the percutaneous transhepatic group ($p < 0.05$). See Table 3.

Comparison of Postoperative Complications

There was no significant difference in the incidence of postoperative complications and the recurrence rate of one-year follow-up between the laparoscopic group and the percutaneous transhepatic puncture group ($p > 0.05$). See Table 4.

Discussion

Intrahepatic cholelithiasis, a prevalent biliary disorder, is characterized by its frequent occurrence, elevated residual and recurrence rates, and challenging treatment. The purpose of treating bile duct stones is to remove stones and drainage obstructions. Laparoscopic hepatectomy and percutaneous transhepatic choledochoscopy are commonly used in clinical treatment for patients with hepatolithiasis. Laparoscopic hepatectomy can obtain a broader and clearer surgical field of vision. It can obtain an ideal stone removal effect and cause less damage to the patient's body, which helps shorten the postoperative recovery time [23, 24]. The results of this study show that the postoperative hospitalization time of the laparoscopic group is shorter than that of the percutaneous liver group, which confirms this point. Previous literature has reached a similar conclusion. For example, a review of the application of laparoscopy in liver stones summarizes the advantages of laparoscopy, and holds that laparoscopy can cause less trauma, reduce blood loss compared with open surgery, and recover quickly after surgery [25]. However, some think that laparoscopic hepatectomy has high risk, high technical requirements for doctors' operations, and limitations [26, 27]. Percutaneous transhepatic choledochoscopy is used to treat hepatolithiasis. The 16-Fr sheath was used to establish the external channel. A choledochoscope was placed for observation, and lithotripsy was carried out in the channel to avoid contact between instruments and the channel wall, and effectively reduce complications such as intraoperative bleeding, postoperative infection, and bile leakage. With its thin and straight mirror body and clear vision, the choledochoscope can accurately reach the position of stones and determine the size, nature, quantity, incarceration, and inflammation of stones, providing a solid foundation for stone extraction [28–30]. A study on percutaneous transhepatic choledochoscopy also shows that percutaneous transhepatic choledochoscopy can effectively treat extrahepatic and intrahepatic bile duct stones with good curative effect, only three patients among the 67 patients have slight complications after the operation, with a low complication rate and high safety [31]. However, percutaneous transhepatic choledochoscopy also has disadvantages; for example, it takes more time, which may prolong the recovery speed of patients after the operation.

The levels of inflammatory factors in the two groups were compared. The results showed that the levels of 3dCRP, TNF-α and IL-6 in the treatment group were significantly lower than in the routine group ($p < 0.05$). This suggests that percutaneous transhepatic choledochoscope lithotripsy can also inhibit the release of inflammatory factors. Still, multiple lithotripsy may cause multiple irritations to the body, cause more damage to the tissue, and quickly lead to stress reactions, thus leading to an inflammatory response [32, 33]. Laparoscopy can effectively remove stones, avoid excessive tissue damage, reduce the risk of stress reaction, and inhibit the release of inflammatory factors [34, 35]. A study has demonstrated that the incorporation of minimally invasive techniques for the management of both intrahepatic and extrahepatic bile duct stones, such as laparoscopic hepatectomy and percutaneous choledochoscopy, significantly enhances treatment outcomes. Additionally, when these minimally invasive approaches are utilized in conjunction with advanced surgical tools and techniques, they not only improve the efficacy of the treatment but also substantially reduce the risk of postoperative complications and mitigate potential intraoperative challenges associated with bile duct stones [36]. An animal experiment on laparoscopic hepatectomy also reported this result. This study was conducted in miniature pigs, and the results showed that the inflammatory reaction in the laparoscopic hepatectomy (LH) group undergoing laparoscopic hepatectomy was significantly reduced [37]. The results of this study are consistent with previous studies.

This study still has some limitations, such as the small sample size and the possible deviation of the research results. Future research needs to expand the sample size, improve the research design, and further explore the research results. In addition, although statistical analysis shows the difference between the two surgical methods, the direct application in clinical practice needs more in-depth consideration, such as the results affect for the treatment choice of patients and the potential impact of these findings on improving postoperative care and prognosis. Future research will need to overcome the limitations pointed out in this study and further confirm our findings.

Conclusion

To summarize, laparoscopic hepatectomy and percutaneous transhepatic choledochoscopy have good curative effects and are highly safe for patients with intrahepatic bile duct stones. Both surgical procedures have higher requirements for doctors' operation skills. Compared with laparoscopic hepatectomy, percutaneous transhepatic choledochoscopy may have higher bodily stimulation. In the actual clinical application, choosing a more suitable operation method according to the patient's specific condition is necessary.

Availability of Data and Materials

Data to support the findings of this study are available on reasonable request from the corresponding author.

Author Contributions

Guarantor of integrity of the entire study: GYL; Study concepts: GYL; Study design: GYL; Definition of intellectual content: YY; Literature research: YY; Clinical studies: YY; Experimental studies: YYQ; Data acquisition: YYQ; Data analysis: AKW, YP, ZXH; Statistical analysis: AKW; Manuscript preparation: ZXH; Manuscript editing: ZXH; Manuscript review: YP. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study obtained ethical approval from the Nanchong Central Hospital review board (Ethics Approval Number 2024001), informed consent from patients, and was conducted according to the Helsinki Declaration. All participants agreed to participate in the study and gave written informed consent for participation in this study.

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Conflict of Interest

The authors declare no conflict of interest.

References

[1] De Silva WSL, Pathirana AA, Wijerathne TK, Gamage BD, Dassanayake BK, De Silva MM. Epidemiology and disease characteristics of symptomatic choledocholithiasis in Sri Lanka. Annals of Hepato-biliary-pancreatic Surgery. 2019; 23: 41–45.

[2] Doud A, Bond L, Downard C, Vitale G, Fallat M, Foley D, *et al*. Management of complicated biliary disease in the pediatric population. Surgery. 2022; 171: 736–740.

[3] Zhu KX, Yue P, Wang HP, Meng WB, Liu JK, Zhang L, *et al*. Choledocholithiasis characteristics with periampullary diverticulum and endoscopic retrograde cholangiopancreatography procedures: Comparison between two centers from Lanzhou and Kyoto. World Journal of Gastrointestinal Surgery. 2022; 14: 132–142.

[4] Parra-Membrives P, Martínez-Baena D, Lorente-Herce JM, Jiménez-Riera G, Sánchez-Gálvez MÁ. Choledocholithiasis recurrence following laparoscopic common bile duct exploration. Cirugia Espanola. 2019; 97: 336–342.

[5] Wu Y, Xu CJ, Xu SF. Advances in Risk Factors for Recurrence of Common Bile Duct Stones. International Journal of Medical Sciences. 2021; 18: 1067–1074.
[6] Zhang J, Ling X. Risk factors and management of primary choledocholithiasis: a systematic review. ANZ Journal of Surgery. 2021; 91: 530–536.
[7] Hedgire SS, Kudrimoti S, Oliveira IS, Nadkarni N, McDermott S, Hahn PF, *et al*. Extranodal lymphomas of abdomen and pelvis: imaging findings and differential diagnosis. Abdominal Radiology (New York). 2017; 42: 1096–1112.
[8] Sensui M, Yasui S, Ogasawara S, Kamezaki H, Kan M, Maruta S, *et al*. Liver cirrhosis is a risk factor for poor prognosis of acute cholangitis caused by choledocholithiasis. Annals of Hepatology. 2022; 27: 100696.
[9] Zhang X, Li G, Pan L, Chen Y, Shi R, Xu W, *et al*. The efficacy and safety of one-stage endoscopic treatment for ascending acute cholangitis caused by choledocholithiasis with severe comorbidities. Surgical Endoscopy. 2020; 34: 3963–3970.
[10] Fan WJ, Zou XJ. Subacute liver and respiratory failure after segmental hepatectomy for complicated hepatolithiasis with secondary biliary cirrhosis: A case report. World Journal of Gastrointestinal Surgery. 2022; 14: 341–351.
[11] Du X, Qian C, Piao S, Pan Z, Jin X. Surgical Treatment of Incarcerated Calculi via Laparoscopic Bile Duct Exploration Using Laparotomy Biliary Lithotomy Forceps under the Guidance of Choledochoscope. The American Surgeon. 2019; 85: e100–e103.
[12] Wang P, Lin HM, Li B, Su S. Laparoscopic versus open exploration of common bile duct for patients with a history of biliary surgery: A systematic review and meta-analysis. Asian Journal of Surgery. 2022; 45: 1577–1578.
[13] Coccolini F, Catena F, Pisano M, Gheza F, Fagiuoli S, Di Saverio S, *et al*. Open versus laparoscopic cholecystectomy in acute cholecystitis. Systematic review and meta-analysis. International Journal of Surgery (London, England). 2015; 18: 196–204.
[14] Jin H, Fan J, Li W, Cui M. Percutaneous transhepatic cholangioscopic lithotripsy using soft fiber-optic choledochoscope. Zeitschrift Fur Gastroenterologie. 2019; 57: 1196–1199.
[15] Ivanecz A, Plahuta I, Mencinger M, Perus I, Magdalenic T, Turk S, *et al*. The learning curve of laparoscopic liver resection utilising a difficulty score. Radiology and Oncology. 2021; 56: 111–118.
[16] Wei Chieh AK, Chan A, Rotellar F, Kim KH. Laparoscopic major liver resections: Current standards. International Journal of Surgery (London, England). 2020; 82S: 169–177.
[17] Schmelzle M, Krenzien F, Schöning W, Pratschke J. Laparoscopic liver resection: indications, limitations, and economic aspects. Langenbeck's Archives of Surgery. 2020; 405: 725–735.
[18] Manes G, Paspatis G, Aabakken L, Anderloni A, Arvanitakis M, Ah-Soune P, *et al*. Endoscopic management of common bile duct stones: European Society of Gastrointestinal Endoscopy (ESGE) guideline. Endoscopy. 2019; 51: 472–491.
[19] Tao H, Wang P, Sun B, Li K, Zhu C. One-Step Multichannel Percutaneous Transhepatic Cholangioscopic Lithotripsy Applied in Bilateral Hepatolithiasis. World Journal of Surgery. 2020; 44: 1586–1594.
[20] Lin W, Chen M, Li B, Wang W, Li S, Lyu G. Intraoperative ultrasound-guided percutaneous hepatocholangiostomy applied in the cholangioscopic lithotripsy for hepatolithiasis and choledocholithiasis. Surgical Endoscopy. 2023; 37: 486–493.
[21] Tian J, Li JW, Chen J, Fan YD, Bie P, Wang SG, *et al*. Laparoscopic hepatectomy with bile duct exploration for the treatment of hepatolithiasis: an experience of 116 cases. Digestive and Liver Disease: Official Journal of the Italian Society of Gastroenterology and the Italian Association for the Study of the Liver. 2013; 45: 493–498.
[22] Wang Y, Bo X, Wang Y, Li M, Shen S, Suo T, *et al*. Laparoscopic surgery for choledocholithiasis concomitant with calculus of the left intrahepatic duct or abdominal adhesions. Surgical Endoscopy. 2017; 31: 4780–4789.
[23] Tu S, Sun G, Fang K, Xin W, Zha M, Wan R, *et al*. Biliary Tract Exploration After Laparoscopic Left-sided Hepatectomy: A Comparative Study of Left Hepatic Duct Orifice Versus Common Bile Duct Approach. Surgical Laparoscopy, Endoscopy & Percutaneous Techniques. 2022; 32: 542–548.
[24] Zhang S, Xing Z, Zhou X, Hu Z, Liu J. Clinical Value Analysis of Hepatectomy Based on Minimally Invasive Surgical Imaging for Hepatolithiasis. Evidence-based Complementary and Alternative Medicine: ECAM. 2022; 2022: 3306771.
[25] Yao D, Wu S. Application of Laparoscopic Technique in the Treatment of Hepatolithiasis. Surgical Laparoscopy, Endoscopy & Percutaneous Techniques. 2020; 31: 247–253.
[26] Okamura Y, Yamamoto Y, Sugiura T, Ito T, Ashida R, Ohgi K, *et al*. Novel patient risk factors and validation of a difficulty scoring system in laparoscopic repeat hepatectomy. Scientific Reports. 2019; 9: 17653.
[27] Park MS. A Single Center Experience for a Feasibility of Totally Laparoscopic Living Donor Right Hepatectomy. Journal of Minimally Invasive Surgery. 2019; 22: 47–48.
[28] Rousslang LK, Faruque O, Kozacek K, Meadows JM. Percutaneous Transhepatic Cholangioscopy and Stone Extraction in a Patient with Recurrent Cholangitis Following Liver Trauma. Journal of Clinical Imaging Science. 2021; 11: 11.
[29] Wang P, Tao H, Liu C, Zhou X, Sun B, Zhu C, *et al*. One-step percutaneous transhepatic cholangioscopic lithotripsy in patients with choledocholithiasis. Clinics and Research in Hepatology and Gastroenterology. 2021; 45: 101477.

[30] Alabraba E, Travis S, Beckingham I. Percutaneous transhepatic cholangioscopy and lithotripsy in treating difficult biliary ductal stones: Two case reports. World Journal of Gastrointestinal Endoscopy. 2019; 11: 298–307.
[31] Zhuo H, Chen ZM, Lin RZ, Yang SH, Zhuang HC, He C, *et al*. Percutaneous Transhepatic Choledochoscopic Lithotomy (PTCSL) is Effective for the Treatment of Intrahepatic and Extrahepatic Choledocholithiasis. Surgical Laparoscopy, Endoscopy & Percutaneous Techniques. 2020; 31: 326–330.
[32] Rossaint J, Margraf A, Zarbock A. Perioperative Inflammation. Anaesthesist. 2019; 68: 421–427.
[33] Margraf A, Ludwig N, Zarbock A, Rossaint J. Systemic Inflammatory Response Syndrome After Surgery: Mechanisms and Protection. Anesthesia and Analgesia. 2020; 131: 1693–1707.
[34] Fu XT, Tang Z, Chen JF, Shi YH, Liu WR, Gao Q, *et al*. Laparoscopic hepatectomy enhances recovery for small hepatocellular carcinoma with liver cirrhosis by postoperative inflammatory response atten uation: a propensity score matching analysis with a conventional open approach. Surgical Endoscopy. 2021; 35: 910–920.
[35] Ypsilantis P, Lambropoulou M, Anagnostopoulos K, Panidou-Tsoulou E, Ioannidis O, Tots A, *et al*. Effect of laparoscopic liver resection versus the open technique on hepatocyte regenerating activity in the rat. Surgical Endoscopy. 2020; 34: 4812–4817.
[36] Zhang ZM, Liu Z, Liu LM, Song MM, Zhang C, Yu HW, *et al*. Strategies of minimally invasive treatment for intrahepatic and extrahepatic bile duct stones. Frontiers of Medicined. 2017; 11: 576–589.
[37] Zhang H, Tong JJ, Zhang ZN, Wang HB, Zhan YH. Laparoscopic left hemihepatectomy combined with right lateral hepatic lobectomy in pigs: surgical approach and comparative study of the inflamm atory response versus open surgery. Veterinary Research Forum. 2021; 12: 1–6.