

Analysis of Efficacy and Safety of Laparoscopy Plus Choledochoscopy Combined With Holmium Laser Lithotripsy for Choledocholithiasis and Hepatolithiasis

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Abstract

Background: With the advancement of laparoscopic technology, the combination of laparoscopy, choledochoscopy, and holmium laser lithotripsy has emerged as an effective treatment modality for both choledocholithiasis and hepatolithiasis. This study aimed to assess the efficacy and safety of this approach.

Methods: Retrospective analysis was conducted on the medical records of 76 patients diagnosed with choledocholithiasis and hepatolithiasis between April 2021 and March 2023. Patients were divided into two groups based on the treatment plan: the control group, which underwent traditional laparotomy and choledochoscopy lithotripsy (n = 38), and the experimental group, which underwent laparoscopy combined with choledochoscopy and holmium laser lithotripsy (n = 38). Comparative analysis was performed on various operation-related parameters, stone-free rate, complication rates, and changes in biochemical, liver function, inflammatory, stress response indicators, and pain scores between the two groups.

Results: The experimental group demonstrated significantly shorter stone removal time, reduced intraoperative bleeding, and shorter hospital stay compared to the control group (P < 0.05). Moreover, the experimental group exhibited lower incidence of postoperative complications and lower pain scores at 2 weeks to 3 months post-operation (P < 0.05). Biochemical indicators including total bile acid (TBA), total bilirubin (TBIL), alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), and gamma-glutamyl transpeptidase (GGT) were significantly lower in the observation

group compared to the control group (P < 0.05). Additionally, stress and inflammation indicators were also lower in the experimental group (P < 0.05).

Conclusions: The combination of laparoscopy, choledochoscopy, and holmium laser lithotripsy presents favorable therapeutic outcomes in the management of choledocholithiasis and hepatolithiasis, indicating its potential for widespread clinical application.

Keywords: Laparoscopy; Choledochoscopy; Holmium laser lithotripsy; Choledocholithiasis and hepatolithiasis; Safety; Bile biochemistry; Stress response

Introduction

Bile duct lithiasis, including both extrahepatic and intrahepatic types (choledocholithiasis and hepatolithiasis, respectively), is notably prevalent in clinical hepatobiliary surgery. Main clinical manifestations include epigastric pain, jaundice, and fever, among others. This condition is characterized by a high incidence and recurrence rate, with severe cases posing a threat to patient safety [1]. Traditional treatments like drug therapy, cholangiography, and surgery, particularly laparotomy, have been standard, though they often lead to large wounds and longer recovery times [2-5]. With advancements in medical technology, laparoscopic minimally invasive surgery is becoming more common [6]. Newer methods such as laparoscopy combined with choledochoscopy and holmium laser lithotripsy are proving effective in reducing surgery time, intraoperative bleeding, postoperative pain, and liver function damage, while also improving stone clearance rates [7-11]. This study aimed to evaluate the clinical efficacy of these combined approaches in treating bile duct lithiasis, assessing outcomes such as liver function, inflammation, stress, and postoperative complications and pain.

Materials and Methods

A total of 76 patients diagnosed with intrahepatic and extrahepatic bile duct lithiasis who were admitted to our hospital from April 2021 to March 2022, were enrolled in this study. The

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Table 1. Clinical Characteristics of Patients

	Control group (n = 38)	Experimental group (n = 38)	P
Gender			0.818
Male (n)	21	20	
Female (n)	17	18	
Age (years, mean ± SD)	48.95 ± 3.37	48.71 ± 3.40	0.758
Disease duration (months)	10.68 ± 1.19	10.84 ± 1.22	0.798
Localization			0.554
Intrahepatic stones (n)	30	32	
Extrahepatic stones (n)	8	6	

patients were divided into two groups based on the surgical interventions: the control group which underwent traditional laparotomy and choledochoscopy lithotripsy (n = 38), and the experimental group which underwent laparoscopy combined with choledochoscopy and holmium laser lithotripsy. Retrospective analysis of the medical records showed no significant differences between the two groups (Table 1).

The study included patients diagnosed with bile duct lithiasis confirmed by ultrasound or computed tomography (CT), with a bile duct diameter over 1 cm. Additionally, adherence to diagnostic criteria outlined in the “Guidelines for the Diagnosis and Therapy of Hepatobiliary Stones” was required. Patients who had difficulty to locate stones or unsuitable for extracorporeal lithotripsy were included. Exclusion criteria comprised suspicion of gallbladder or cholangiocarcinoma, presence of liver cirrhosis, portal hypertension, or varicose veins, abnormal coagulation function, prior biliary tract surgery, or autoimmune diseases/severe organic diseases.

The study was approved by the Ethical Committee of Xingguo Hospital Affiliated to Gannan Medical College (20210401) and was conducted in compliance with the ethical standards of the responsible institution on human subjects as well as with the Helsinki Declaration.

Methods

In the control group, all subjects underwent laparotomy and choledochoscopy for stone removal, following standard draping and disinfection protocols.

In the experimental group, subjects underwent laparoscopy combined with choledochoscopy and holmium laser lithotripsy.

Observation indicators

The operation-related indicators (time of stone removal, blood loss, length of stay) and stone removal outcomes of the patients included in the analysis were meticulously examined.

The frequency of related complications, including biliary fistula, incision infection, fever, and biliary tract bleeding, during the patients' recovery process was meticulously document-

ed between the groups.

For blood chemical tests and liver function assessment, fasting venous blood samples (5 mL) were collected both before and 1 week after the operation. After centrifugation at 3,000 r/min for 10 min, levels of total bile acid (TBA), total bilirubin (TBIL) alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), and glutamyl transpeptidase (GGT) were determined using an automatic biochemical analyzer.

To evaluate the levels of inflammatory and stress-related markers, venous blood samples (6 mL) were collected from patients before and 3 days post-surgery. Serum levels of epinephrine (EP) and cortisol (Cor) were determined by chemiluminescence immunoassay. Levels of C-reactive protein (CRP), interleukin-6 (IL-6), tumor necrosis factor- α (TNF- α) were determined by enzyme-linked immunosorbent assay, while neutrophil count (NEUT) levels were measured by an automatic hematology analyzer.

Pain scores were measured using the digital analog scoring method immediately after the operation, as well as at 2 weeks, 4 weeks, and 3 months post-operation.

Statistics

The data were analyzed using SPSS 21.0 statistical software. Independent samples *t*-test was utilized for numeric variables, while the Chi-square test was employed for categorical variables. $P < 0.05$ indicated statistical significance.

Results

Comparison of surgery-related indicators and stone clearance rate

The control group had a significantly longer stone extraction time (5.95 ± 0.23 vs. 4.05 ± 0.23 , $P = 0.001$) (Table 2). In addition, blood bleeding was also more in the control group, compared with the experimental group (70.34 ± 6.27 vs. 44.84 ± 3.38 , $P = 0.001$) (Table 2). The length of hospital stay in the experimental group was shorter than the control group (9.16 ± 0.68 vs. 6.95 ± 0.46 , $P = 0.001$) (Table 2). In terms of stone clearance,

Table 2. Analysis of Surgery-Related Indicators and Stone Clearance Rate

	Control group (n = 38)	Experimental group (n = 38)	P
Stone extraction time (min)	5.95 ± 0.23	4.05 ± 0.23	0.001
Bleeding volume (mL)	70.34 ± 6.27	44.84 ± 3.38	0.001
Length of stay (day)	9.16 ± 0.68	6.95 ± 0.46	0.001
Stone clearance rate, n (%)	26 (68.42)	35 (92.11)	0.009

Table 3. Analysis of Treatment-Related Complications

	Control group (n = 38)	Experimental group (n = 38)	P
Biliary fistula	1	0	
Incision infection	2	0	
Fever	3	1	
Biliary hemorrhage	1	0	
Total	18.42	2.63	0.025

the experimental group showed a significantly higher rate than the control group (68.42% vs. 92.11%, $P = 0.009$) (Table 2).

Analysis of treatment-related complications

The complications evaluated include biliary fistula, incision infection, fever, and biliary hemorrhage. The statistical analysis indicated a significant difference between the two groups ($P = 0.025$), suggesting that the experimental group had significantly fewer complications compared to the control group (Table 3).

Analysis of bile biochemical index

Changes in bile biochemical index levels between pre-opera-

tion and 1 week after surgery, specifically TBA and TBIL were evaluated.

For the control group, the preoperative TBA level dropped from 83.08 to 33.29 $\mu\text{mol/L}$, while the experimental group showed a more profound decrease from 83.24 to 9.87 $\mu\text{mol/L}$ (Fig. 1a). The reduction of TBIL level in the experimental group was also pronounced than the control group (Fig. 1b).

Analysis of liver function index levels

We also conducted detailed comparison of liver function index levels, specifically ALT, AST, ALP, and GGT between two groups of patients. At the outset, both the control and observation groups had nearly identical liver function index levels of ALT, AST, ALP, and GGT. However, 1 week after surgery, the

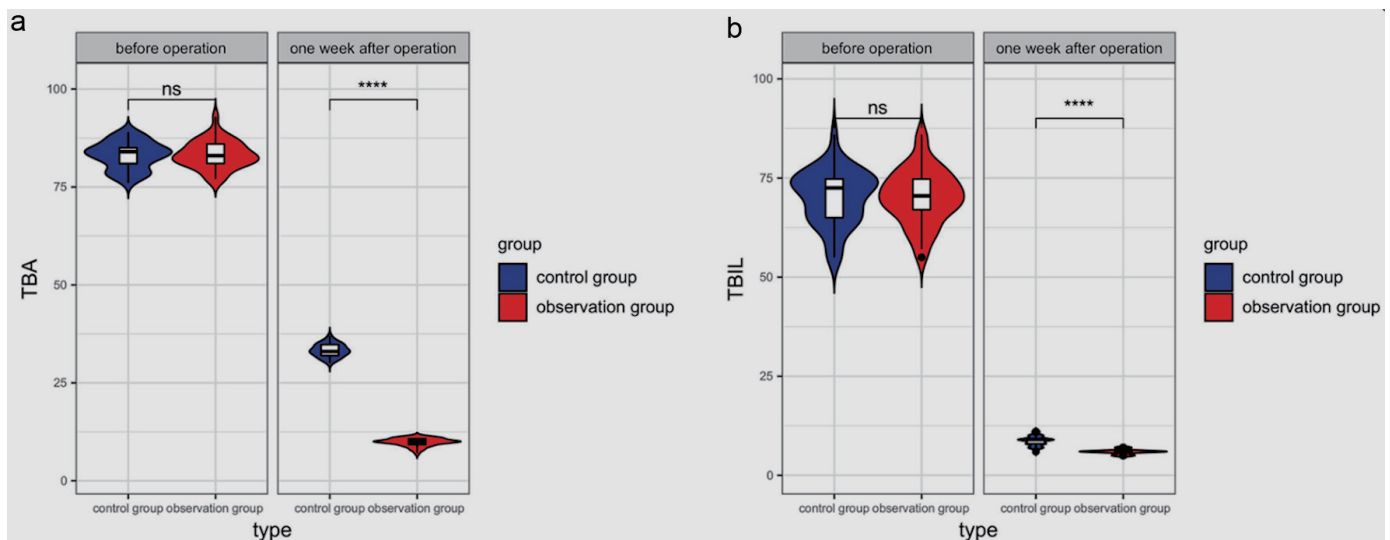


Figure 1. Analysis of bile biochemical index levels among groups. TBA (a) and TBIL (b) levels in patients before and 1-week post-surgery. **** $P < 0.0001$, ns: not significant. TBA: total bile acid; TBIL: total bilirubin.

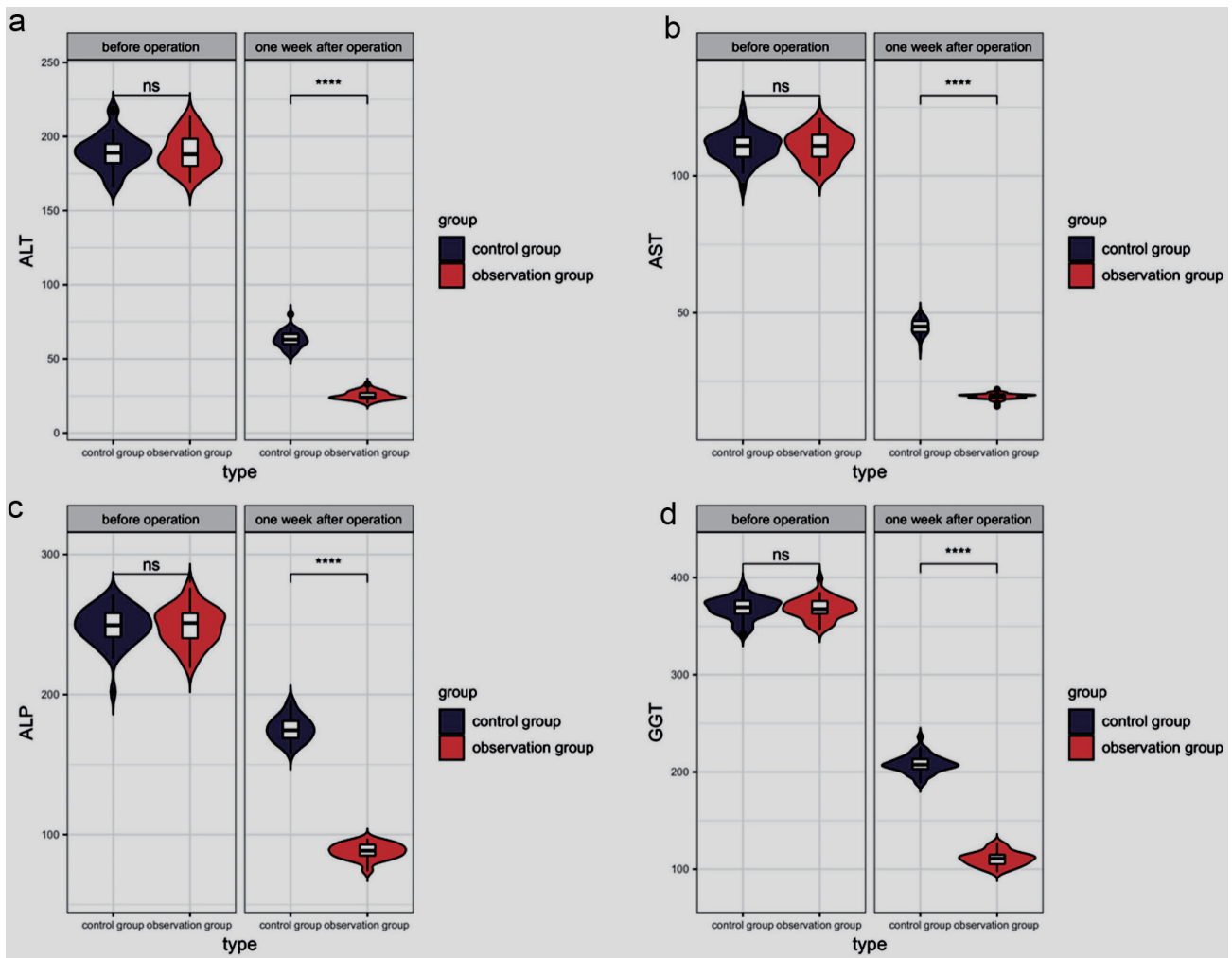


Figure 2. Analysis of liver function indicators between groups. Levels of ALT (a), AST (b), ALP (c), GGT (d) in patients from the control and experimental group before and after surgery. **** $P < 0.0001$, ns: not significant. ALT: alanine aminotransferase; AST: aspartate aminotransferase; ALP: alkaline phosphatase; GGT: glutamyl transpeptidase.

experimental group exhibited significantly greater improvements across all indices compared to the control group (Fig. 2).

Analysis of inflammatory index levels

Changes in inflammatory index levels, specifically CRP, IL-6, and TNF- α in the control group and the experimental group were measured preoperatively and 3 days post-surgery. There was no difference of the baseline levels of CRP, IL-6 and TNF- α in both groups, while their levels were significantly lower in the experimental group at 3 days post-surgery (Fig. 3).

Analysis of stress response

Next, we evaluated the stress response index including Cor, neutrophil percentage, and EP both pre-operation and 3 days post-surgery. No significant difference was observed in these

two groups before surgery, while the post-surgery levels of Cor, NEUT, and EP were significantly lower in the experimental group (Figure 4).

Analysis of pain levels

Pain levels in patients suffering between two groups of 38 patients were evaluated at various time points following surgery: immediately after surgery, 2-week, 4-week, and 3-month post-procedure. There was no difference of pain levels in the two groups after surgery, but it became significantly lower since 2 weeks post-operation (Table 4).

Discussion

The complexity of managing intrahepatic and extrahepatic bile duct stones, due to the intricate nature of pathological changes

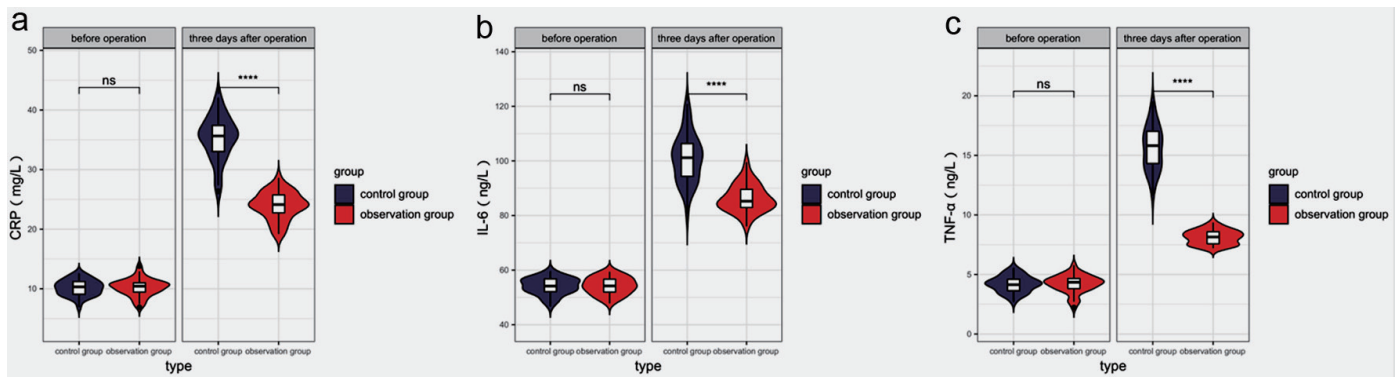


Figure 3. Analysis of inflammatory index levels between groups. Levels of CRP (a), IL-6 (b), and TNF- α (c) in patients from the control and experimental group before and 3 days after surgery. **** $P < 0.0001$, ns: not significant. CRP: C-reactive protein; IL-6: interleukin-6; TNF- α : tumor necrosis factor- α .

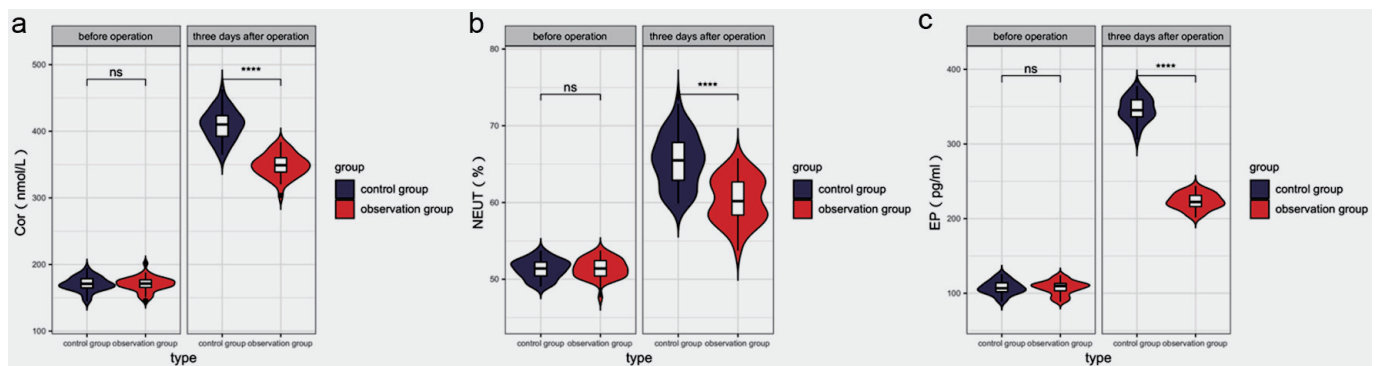


Figure 4. Analysis of stress response index levels between groups. Levels of Cor (a), NEUT (b), and EP (c) in patients from the control and experimental group before and 3 days after surgery. **** $P < 0.0001$, ns: not significant. Cor: cortisol; EP: epinephrine; NEUT: neutrophil count.

and the narrowness of bile ducts, poses a significant challenge in achieving complete stone removal in a single session, with clinical evidence pointing towards a high rate of postoperative residual stones and the need for repeat surgeries in a substantial fraction of cases [12, 13]. Historically, laparotomy was the primary treatment for bile duct lithiasis but was less effective for large or incarcerated stones, leading to longer surgery times and increased risks [14, 15]. The shift to minimally invasive techniques such as laparoscopy combined with choledochoscopy and holmium laser lithotripsy has reduced trauma, complications, and promoted faster recovery [16, 17]. Holmium laser lithotripsy enhances stone removal and success rates [18, 19]. It reduces blood loss and improves recovery, making the surgery less physically and psychologically impactful [20]. Studies show that laparoscopic and choledochoscopic

holmium laser lithotripsy leads to better outcomes in terms of surgery duration, hospital stay, bleeding, pain scores, and complication rates from 2 weeks to 3 months post-surgery, aligning with previous findings [21-25].

Our study also evaluated liver function biochemical markers, revealing significant improvements in the observation group compared to the control group postoperatively. This underscores the efficacy of the integrated surgical approach in managing bile duct lithiasis and enhancing liver function, contributing to a clearer operative field and improved liver environment.

The study found that the minimally invasive approach significantly reduces postoperative stress and inflammation by lowering EP and Cor levels [26-28]. This is attributed to the surgery's precise and minimally disruptive nature. In conclu-

Table 4. Analysis of Pain Score

	Control group (n = 38)	Experimental group (n = 38)	P
Immediately after surgery	6.21 \pm 0.47	6.08 \pm 0.36	0.512
2 weeks after surgery	4.97 \pm 0.16	4.05 \pm 0.23	0.001
4 weeks after surgery	3.89 \pm 0.39	3.03 \pm 0.37	0.001
3 months after surgery	2.84 \pm 0.44	2.05 \pm 0.40	0.001

sion, combining laparoscopy, choledochoscopy, and holmium laser lithotripsy offers a less invasive and effective treatment for bile duct lithiasis, enhancing liver function and reducing surgical stress.

Acknowledgments

None to declare.

Financial Disclosure

No funding was received for this study.

Conflict of Interest

The authors declare no conflict of interest.

Informed Consent

Informed consent was obtained from all participants.

Author Contributions

Study conception and design: QZ; data collection: HL, QL, QW, and WZ; analysis and interpretation of results: HL, QZ, QL, and GL; draft manuscript preparation: HL, QL and QW; manuscript editing and revision: QZ. All authors reviewed the results and approved the final version of the manuscript.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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