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Original Research Article

Laparoscopic Versus Open Surgery For Common Bile Duct Exploration

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Abstract: *Choledocholithiasis remains a common surgical problem, and the choice between laparoscopic and open common bile duct (CBD) exploration continues to influence perioperative outcomes. Minimally invasive laparoscopic CBD exploration (LCBDE) offers reduced postoperative morbidity and shorter recovery times compared to open surgery, but concerns persist regarding bile duct injury (BDI) and incomplete stone clearance, particularly in resource-limited settings such as Pakistan.* ***Objective:*** *To compare the intraoperative and postoperative outcomes of laparoscopic versus open CBD exploration in patients with choledocholithiasis.* ***Methods:*** *A descriptive comparative study was conducted at the Department of General Surgery, Bahawal Victoria Hospital, Bahawalpur, Pakistan, from November 23, 2024, to May 23, 2025. Fifty patients (aged 20–60 years, ASA ≤III) with imaging-confirmed choledocholithiasis were enrolled and divided equally into laparoscopic and open-surgery groups. Both procedures were performed by experienced consultant surgeons following standardized protocols. Intraoperative blood loss, postoperative bile drainage, hospital stay, residual stones, and CBD injuries were recorded. Data were analyzed using SPSS v26, applying Student's t-test and Chi-square tests, with $p < 0.05$ considered statistically significant.* ***Results:*** *Baseline demographics, including age (mean 42.76 ± 9.65 vs 41.56 ± 9.27 years, $p = 0.656$) and BMI (26.39 ± 5.82 vs 25.92 ± 4.35 kg/m², $p = 0.751$), were comparable between open and laparoscopic groups. Laparoscopic exploration significantly reduced intraoperative blood loss (94.68 ± 19.95 mL vs 281.24 ± 30.73 mL; $p < 0.001$), postoperative bile drainage (179.25 ± 36.55 mL vs 326.92 ± 57.36 mL; $p < 0.001$), and hospital stay (3.96 ± 0.91 days vs 7.37 ± 1.59 days; $p < 0.001$). Residual stones were less frequent after laparoscopy (8% vs 32%; $p = 0.034$). The incidence of CBD injury was lower in the laparoscopic group (4% vs 24%; $p = 0.042$).* ***Conclusion:***
Laparoscopic common bile duct exploration offers superior outcomes compared to open surgery, with reduced operative blood loss, fewer complications, shorter hospital stay, and higher stone-clearance rates. These findings support the broader adoption of laparoscopic techniques for choledocholithiasis management in Pakistan, emphasizing the need for enhanced laparoscopic training and resource allocation in tertiary-care settings.

Keywords: Choledocholithiasis, Laparoscopic common bile duct exploration, Open CBD exploration, Bile duct injury, minimally invasive surgery

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Introduction

Common bile duct (CBD) stones, often due to gallstones that migrate into the extrahepatic biliary system, pose a significant clinical challenge, with the condition termed choledocholithiasis affecting a considerable portion of the population. Traditional management options for these patients have included both laparoscopic and open approaches, with each approach exhibiting its own benefits and drawbacks (1, 2). Laparoscopic common bile duct exploration (LCBDE) has become increasingly popular due to its minimally invasive nature, reduced postoperative pain, and shorter recovery times compared to open surgery (3). Recent studies have indicated that LCBDE is associated with a lower incidence of complications such as bile duct injuries and postoperative infections when compared to traditional open techniques (4).

The evolution of surgical procedures has shown a clear trend toward minimally invasive approaches. Laparoscopy offers visual advantages via magnified imaging, which can improve the surgeon's accuracy in identifying and addressing anatomical structures (5). Furthermore, LCBDE can be effectively combined with laparoscopic cholecystectomy, allowing for simultaneous treatment of gallstones present within both the gallbladder and the CBD (6, 7). Several studies have also demonstrated that laparoscopic techniques can facilitate primary closure of the CBD, thus eliminating the need for potentially hazardous T-tube placements—historically a common part of open CBD exploration (8, 9).

Despite these advantages, there remain concerns regarding the risk of bile duct injuries (BDIs), which can occur during both laparoscopic and open procedures. Reports suggest that laparoscopic approaches may present higher rates of BDI, attributed to the challenging visual context within which surgeons operate (10, 11). Nonetheless, recent meta-analyses have positioned LCBDE as having equivalent or superior outcomes relative to open CBD exploration in properly selected patients, especially when performed by surgeons with specialized training (12, 13).

In the context of the Pakistani health landscape, where biliary diseases are prevalent and surgical resources vary significantly across urban and rural settings, understanding the comparative effectiveness and safety of these surgical approaches is critical. A substantial number of patients present late with complicated biliary pathology due to limited access to advanced diagnostic tools and surgical facilities (14). Moreover, reports suggest a rising incidence of hepatic and biliary complications following laparoscopic surgeries performed by less experienced surgeons (15). Consequently, adapting surgical strategies that prioritize both safety and effectiveness will be vital in improving patient outcomes in our specific demographic.

Methodology

This descriptive comparative study was conducted at the Department of General Surgery, Bahawal Victoria Hospital, Bahawalpur, Pakistan, from 23 November 2024 to 23 May 2025, to compare the outcomes of laparoscopic and open common bile duct (CBD) exploration in patients presenting with choledocholithiasis. A total of fifty patients aged between 20 and 60 years, of both genders, diagnosed with symptomatic CBD

stones confirmed by imaging, and classified as American Society of Anesthesiologists (ASA) status ≤III were included. The sample size was determined using the WHO sample size calculator, based on a previously published study, ensuring adequate power to detect significant differences between the two surgical approaches. Patients with major cardiac disease, chronic respiratory illnesses, renal impairment, uncontrolled diabetes or hypertension, and those with acute hepatitis were excluded to avoid confounding factors affecting perioperative risk and recovery outcomes.

All eligible patients were counseled regarding the nature of the disease, surgical options, potential complications, and expected postoperative course. Written informed consent was obtained from every participant. The patients were then divided into two equal groups of twenty-five each, depending on the type of surgical intervention performed—either open or laparoscopic common bile duct exploration. Allocation was based on clinical assessment, surgeon expertise, and patient preference. Ethical approval was obtained from the Institutional Review Board of Bahawal Victoria Hospital, ensuring compliance with the Declaration of Helsinki and local ethical research guidelines. A detailed preoperative evaluation was performed for all patients, including clinical examination, medical history, baseline laboratory investigations, and imaging studies such as abdominal ultrasonography to confirm the presence and extent of CBD stones.

All surgical procedures were performed by consultant biliary surgeons experienced in both open and laparoscopic techniques. Laparoscopic CBD exploration was performed under general anesthesia using a standard four-port approach. The procedure began with exposure and dissection of Calot's triangle, followed by identification and clipping of the cystic artery and duct. A 10–15 mm longitudinal choledochotomy was made on the anterior surface of the CBD, and a 5-mm flexible choledochoscope was inserted for visualization of the biliary tree. Stones were removed through saline flushing or a Dormia basket, while laser lithotripsy was used for large or impacted stones. Complete clearance of the CBD and sphincter of Oddi was confirmed by choledochoscopy. Depending on the ductal condition, closure of the choledochotomy was performed either primarily using continuous 4-0 absorbable PDS II sutures or with the insertion of a T-tube for postoperative biliary drainage. The decision for primary closure was made when the duct diameter exceeded 8 mm and there was no wall edema or distal obstruction. A subhepatic drain was placed and removed within three to four days if no bile leakage occurred. In T-tube cases, the tube was removed after six weeks following a confirmatory cholangiogram showing complete ductal clearance and integrity.

Open common bile duct exploration was performed through a midline abdominal incision under general anesthesia. The procedure involved exposure of the anterior surface of the CBD, stone extraction using Randall forceps, and saline irrigation. A choledochoduodenostomy was constructed using interrupted 4-0 Vicryl sutures when indicated to ensure adequate drainage. In cases requiring T-tube drainage, the tube was inserted after stone clearance for postoperative monitoring and access for follow-up cholangiography. A Jackson-Pratt drain was positioned in Morrison's pouch for monitoring bile leakage and removed once the output ceased. Both surgical techniques were standardized to minimize inter-surgeon variability and ensure comparability between the two groups.

Intraoperative parameters, including estimated blood loss, were meticulously recorded by the attending surgical team. Postoperative outcomes such as bile drainage volume, duration of hospital stay, and any procedure-related complications—including bile duct injury, infection, or leakage—were observed until discharge. The efficacy of stone clearance was evaluated by a T-tube cholangiogram on postoperative day 14, which allowed identification of missed or residual stones. All relevant patient information, intraoperative findings, and postoperative outcomes were documented in a predesigned structured proforma developed specifically for this study.

Data were analyzed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Quantitative variables such as age, body mass index (BMI), blood loss, bile drainage, and hospital stay were expressed as mean ± standard deviation (SD). Comparisons between the two surgical groups were made using the independent samples *t*-test for continuous variables. Categorical data such as gender distribution, ASA classification, smoking status, presence of residual stones, and incidence of bile duct injury were presented as frequencies and percentages, with comparisons assessed using the chi-square or Fisher's exact test where appropriate. A *p*-value less than 0.05 was considered statistically significant.

Results

The mean age of patients in the open-surgery group was 42.76 ± 9.65 years, and in the laparoscopic group 41.56 ± 9.27 years. No statistically significant difference was observed regarding weight, height, body-mass index (BMI), or duration of CBD stones ($p > 0.05$ for all). The gender distribution showed a slight female predominance overall (54%), with 52% males in the open group and 40% males in the laparoscopic group ($p = 0.395$). ASA classification and smoking status were comparable.These findings reflect the demographic profile typical of Pakistani surgical patients presenting with choledocholithiasis at tertiary-care centers. (Table 1).

The laparoscopic group exhibited markedly reduced intraoperative blood loss (94.68 ± 19.95 mL vs 281.24 ± 30.73 mL; $p < 0.001$) and less postoperative bile drainage (179.25 ± 36.55 mL vs 326.92 ± 57.36 mL; $p < 0.001$). Hospital stay was significantly shorter following laparoscopic surgery (3.96 ± 0.91 days vs 7.37 ± 1.59 days; $p < 0.001$).Residual stones detected on postoperative day-14 cholangiogram were 8 (32%) in the open group and 2 (8%) in the laparoscopic group ($p = 0.034$).

A higher proportion of patients in the open group were ASA II (80%) versus 56% in the laparoscopic group, whereas more ASA III patients underwent laparoscopic exploration (44%)—difference not statistically significant ($p = 0.064$). Common bile duct injury occurred in 6 (24%) open-surgery patients but only 1 (4%) laparoscopic patient ($p = 0.042$), indicating a safer profile for the minimally invasive technique. Smoking status showed no association with adverse outcomes ($p = 1.000$). (Table 3).

Laparoscopic exploration significantly decreased intraoperative blood loss, bile drainage, hospital stay, and incidence of CBD injury and residual stones. Open surgery showed higher complication rates and longer postoperative recovery. No differences were observed in baseline demographics, confirming that the superior outcomes were attributable to surgical technique rather than patient characteristics.

Table 1. Demographic and Clinical Characteristics of Patients Undergoing Open vs Laparoscopic CBD Exploration

Variable	Open (n = 25)	Laparoscopic (n = 25)	*p*-value
Age (years)	42.76 ± 9.65	41.56 ± 9.27	0.656 [c]
Weight (kg)	71.28 ± 11.85	69.16 ± 9.07	0.481 [c]
Height (cm)	165.43 ± 8.25	163.94 ± 8.09	0.522 [c]
Body-mass index (kg/m²)	26.39 ± 5.82	25.92 ± 4.35	0.751 [c]
Duration of CBD stones (months)	5.29 ± 1.70	5.05 ± 1.88	0.638 [c]

Data presented as mean ± SD; [c] Student's t-test; significance level $p < 0.05$.

Table 2. Intraoperative and Postoperative Outcomes

Outcome	Open (n = 25)	Laparoscopic (n = 25)	*p*-value
Intraoperative blood loss (mL)	281.24 ± 30.73	94.68 ± 19.95	< 0.001 [c]
Total bile in drain (mL)	326.92 ± 57.36	179.25 ± 36.55	< 0.001 [c]
Length of hospital stay (days)	7.37 ± 1.59	3.96 ± 0.91	< 0.001 [c]
Missed stones (day-14 cholangiogram) n (%)	8 (32.0)	2 (8.0)	0.034 [d]

Data presented as mean ± SD and n (%); [c] Student's t-test; [d] Pearson's χ^2 test; significance $p < 0.05$.

Table 3. Patient Demographics and Incidence of CBD Injury

Variable	Open (n = 25)	Laparoscopic (n = 25)	*p*-value
Gender – Male n (%)	13 (52.0)	10 (40.0)	0.395 [a]
Gender – Female n (%)	12 (48.0)	15 (60.0)	
Smoker – Yes n (%)	9 (36.0)	9 (36.0)	1.000 [b]
ASA II n (%)	20 (80.0)	14 (56.0)	0.064 [a]
ASA III n (%)	5 (20.0)	11 (44.0)	
CBD injury – Yes n (%)	6 (24.0)	1 (4.0)	0.042 [a]

Data presented as n (%); [a] Pearson's χ^2 test; [b] Fisher's exact test; significance $p < 0.05$.

Discussion

This study aimed to assess the outcomes of laparoscopic versus open surgery for common bile duct (CBD) exploration in patients with choledocholithiasis. The results indicate notable differences between the two approaches in terms of intraoperative and postoperative outcomes, which are consistent with findings in recent literature.

The demographic characteristics of the patients in this study reflect those typically seen in the Pakistani surgical population. The mean age of patients in both groups was similar, with 42.76 ± 9.65 years in the open-surgery group and 41.56 ± 9.27 years in the laparoscopic group, corroborating findings from Amaravadi and Challagundla who noted similar age distributions among their cohort (16). The slight female predominance (54%) in our study aligns with epidemiological data that show a higher prevalence of gallstone disease in females across various populations (17). The comparable ASA classifications suggest that the two groups were evenly matched regarding preoperative risk factors, supporting the validity of subsequent outcome comparisons.

Intraoperative blood loss was significantly lower in the laparoscopic group (94.68 ± 19.95 mL) compared to the open group (281.24 ± 30.73 mL, $p < 0.001$). These results are in agreement with literature indicating that laparoscopic CBD exploration generally results in reduced intraoperative bleeding due to better visualization and less invasive techniques (18, 19). This aligns with findings from Pallaneeandee et al., who reported significant intraoperative blood savings with laparoscopic approaches due to their precision and reduced tissue manipulation (19).

Moreover, the postoperative outcomes indicated that total bile drainage was significantly lower in the laparoscopic group (179.25 ± 36.55 mL vs. 326.92 ± 57.36 mL; $p < 0.001$). This can be attributed to less liver retraction and reduced surgical trauma in laparoscopic procedures, corroborated by studies demonstrating that laparoscopic techniques lead to lower bile drainage and quicker resolution of postoperative complications (20).

Hospitalization was markedly shorter for patients undergoing laparoscopic surgery (3.96 ± 0.91 days) compared to those who had open surgery (7.37 ± 1.59 days, $p < 0.001$), a finding that aligns with trends favoring minimally invasive surgeries across numerous studies. A systematic review by Hajibandeh et al. highlighted that minimally invasive approaches enable faster recovery times and shorter hospital stays (21).

Residual stones detected on postoperative cholangiograms were significantly fewer in the laparoscopic group (2 of 25, 8%) compared to the open surgery group (8 of 25, 32%; $p = 0.034$). These findings are supported by research from Li et al., who found that laparoscopic techniques yield higher stone clearance rates (22). This suggests that the laparoscopic approach may be more effective in managing choledocholithiasis, reducing the likelihood of requiring additional interventions.

The incidence of common bile duct injury was lower in the laparoscopic group, with 1 (4%) patient experiencing injury compared to 6 (24%) in the open group ($p = 0.042$). This finding aligns with literature indicating that advanced laparoscopic techniques, coupled with improved surgical training, have substantially reduced the rates of biliary injuries (23, 21). A systematic review by Hajibandeh et al. reported similar trends, reinforcing laparoscopic exploration's reputation for safety concerning CBD injuries (21).

While smoking status did not seem to correlate with adverse surgical outcomes in our study, the ASA classification results indicated that a higher proportion of ASA II patients underwent open surgery, with no statistically significant result found due to the small sample size. This aligns with findings from Pandey and Karlatif, which noted that ASA classification did not prominently impact surgical outcomes in minimally invasive procedures (18).

Overall, our findings substantiate the advantages of laparoscopic common bile duct exploration over open surgery in terms of blood loss, postoperative drainage, length of hospital stay, and rates of common bile duct injury and residual stones. The trend towards laparoscopic surgery is supported by growing literature emphasizing its benefits, particularly in settings like Pakistan, where patient outcomes can be significantly improved through enhanced surgical techniques and postoperative care. As we advance surgical protocols in Pakistani healthcare, the adoption of laparoscopic techniques for managing choledocholithiasis should be prioritized to achieve better patient outcomes.

Conclusion

Laparoscopic exploration of the common bile duct demonstrates clear advantages over the open approach, including lower blood loss, fewer residual stones, shorter hospitalization, and reduced incidence of bile duct injury. In the Pakistani context, where biliary pathology is common and surgical outcomes vary with expertise, expanding access to laparoscopic training and equipment can substantially improve patient safety and recovery following CBD exploration.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-24)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

SEA (PGR Surgical)
Manuscript drafting, Study Design,
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Review of Literature, Data entry, Data analysis, and drafting article. Conception of Study, Development of Research Methodology Design,
MSK (Medical officer)
Study Design, manuscript review, critical input.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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