



## Comparative Evaluation of Different Treatment Modalities for Choledocholithiasis: A Retrospective Clinical Study

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### Abstract

**Background:** Choledocholithiasis is a common complication of gallstone disease and may lead to significant morbidity if not managed appropriately. Multiple treatment modalities including endoscopic, laparoscopic, and open surgical approaches are available, and the optimal choice depends on patient and stone characteristics.

**Objectives:** To compare the effectiveness, ductal clearance rates, postoperative outcomes, and complications associated with ERCP, laparoscopic CBD exploration, and open CBD exploration in the management of choledocholithiasis.

**Materials and Methods:** This Retrospective clinical study included 71 patients diagnosed with choledocholithiasis and treated using ERCP (n = 38), laparoscopic CBD exploration (n = 16), or open CBD exploration (n = 17). Patients were evaluated for baseline clinical parameters, stone characteristics, ductal clearance, postoperative outcomes, and complications. Statistical analysis was performed using appropriate tests, with a p-value <0.05 considered statistically significant. **Results:** Complete ductal clearance was achieved in 86.8% of patients undergoing ERCP, 93.8% undergoing laparoscopic CBD exploration, and 100% undergoing open CBD exploration (p = 0.048). Residual stones and need for repeat procedures were significantly higher in the ERCP group. ERCP was associated with post-procedure pancreatitis, while bile leak and wound infection were more common following open surgery. Hospital stay was shortest in the ERCP group and longest in the open CBD exploration group (p < 0.001). Larger stone size, multiple stones, and dilated CBD were significantly associated with surgical exploration. **Conclusion:** All three modalities are effective for the management of choledocholithiasis when appropriately selected. ERCP is suitable for selected uncomplicated cases, laparoscopic CBD exploration offers excellent outcomes with reduced morbidity, and open CBD exploration remains indispensable for complex stone disease. An individualized treatment approach ensures optimal outcomes.

**Keywords:** Choledocholithiasis. Endoscopic retrograde cholangiopancreatography. Common bile duct exploration.



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### INTRODUCTION

Choledocholithiasis, defined as the presence of stones within the common bile duct (CBD), represents a common and clinically significant complication of gallstone disease. The incidence of CBD stones has been reported to range between 3% and 15% among patients undergoing cholecystectomy, with higher prevalence observed in elderly patients and those with longstanding gallstone disease. CBD stones may be classified as primary stones, which originate de novo within the bile duct, or secondary stones, which migrate from the gallbladder into the CBD. In the Indian population, secondary cholesterol stones constitute the majority of cases.[1]

Clinically, choledocholithiasis presents with a wide spectrum of manifestations ranging from asymptomatic disease to biliary colic, obstructive jaundice, acute cholangitis, and acute pancreatitis. Persistent biliary obstruction can lead to progressive hepatic dysfunction, secondary biliary cirrhosis, and increased perioperative morbidity. Hence, early diagnosis and appropriate intervention are essential to prevent serious complications and mortality.[2]

Over the past few decades, management strategies for choledocholithiasis have evolved considerably with advancements in endoscopic, laparoscopic, and open surgical techniques. Endoscopic retrograde cholangiopancreatography (ERCP) with sphincterotomy

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and stone extraction has become a widely accepted first-line modality for CBD stone clearance, particularly in high-risk surgical candidates and patients presenting with cholangitis or pancreatitis. Reported success rates of ERCP range from 85% to 97%; however, it is associated with complications such as pancreatitis, bleeding, perforation, and the need for repeat procedures in a subset of patients.[3]

Laparoscopic common bile duct exploration (LCBDE) has emerged as an effective single-stage treatment option, allowing simultaneous management of gallbladder and CBD stones. It offers advantages such as shorter hospital stay, reduced overall morbidity, and avoidance of sphincter damage. Nevertheless, LCBDE requires advanced laparoscopic expertise and may not be feasible in all patients, particularly those with multiple large or impacted stones.[4]

## AIM

To compare the effectiveness and outcomes of different treatment modalities for choledocholithiasis.

## OBJECTIVES

1. To evaluate and compare ERCP, laparoscopic CBD exploration, and open CBD exploration in terms of ductal clearance.
2. To assess postoperative outcomes and complications associated with each treatment modality.
3. To determine the most appropriate treatment modality based on clinical presentation and stone characteristics.

## MATERIALS AND METHODS

### Source of Data

The study data were obtained from patients diagnosed with choledocholithiasis who were admitted and treated in the Department of General Surgery at a tertiary care teaching hospital.

### Study Design

This was a Retrospective clinical comparative study.

### Study Location

The study was conducted at a tertiary care hospital attached to a teaching medical institution.

### Study Duration

The study was carried out over 2017 to 2019.

### Sample Size

A total of 71 patients with confirmed choledocholithiasis were included and distributed as follows:

- ERCP group: 38 patients
- Laparoscopic CBD exploration group: 16 patients
- Open CBD exploration group: 17 patients

### Inclusion Criteria

- Patients aged  $\geq 18$  years.
- Radiologically confirmed choledocholithiasis (USG/MRCP/CT).
- Patients fit for endoscopic or surgical intervention.
- Patients who provided informed written consent.

### Exclusion Criteria

- Patients with malignant biliary obstruction.
- Patients with severe cardiopulmonary illness unfit for intervention.
- Pregnant women.
- Patients refusing consent or lost to follow-up.

### Procedure and Methodology

All patients underwent detailed clinical evaluation including history, physical examination, and laboratory investigations. Imaging studies were used to confirm CBD stones and assess stone size, number, and ductal anatomy. Treatment modality was decided based on clinical condition, stone characteristics, and institutional expertise. ERCP with sphincterotomy and stone extraction was performed for selected patients. Laparoscopic CBD exploration or open CBD exploration was undertaken in cases unsuitable for or failed ERCP. Postoperative monitoring included assessment for complications, duration of hospital stay, and clinical recovery.

### Sample Processing

Blood samples were collected pre- and post-procedure for routine hematological and biochemical investigations. Imaging findings and operative details were documented systematically.

### Data Collection

Data were recorded using a predesigned proforma including demographic details, clinical features, imaging findings, type of intervention, intraoperative details, postoperative outcomes, and complications.

### Statistical Methods

Data were entered into Microsoft Excel and analyzed using statistical software. Categorical variables were expressed as frequencies and percentages, while continuous variables were expressed as mean  $\pm$  standard deviation. Appropriate statistical tests such as Chi-square test and ANOVA were applied, with a p-value  $<0.05$  considered statistically significant.

## RESULTS

**Table 1: Baseline Clinical and Procedural Characteristics of Patients Undergoing Different Treatment Modalities for Choledocholithiasis**

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| Parameter                                 | ERCP<br>(n=38)  | Lap CBDE<br>(n=16) | Open CBDE<br>(n=17) | Test of<br>Significance | 95% CI         | p-value |
|-------------------------------------------|-----------------|--------------------|---------------------|-------------------------|----------------|---------|
| Age (years), Mean $\pm$ SD                | 54.6 $\pm$ 11.2 | 48.3 $\pm$ 9.6     | 56.9 $\pm$ 10.8     | One-way<br>ANOVA        | -2.1 to<br>7.8 | 0.041*  |
| Male sex, n (%)                           | 15 (39.5)       | 7 (43.8)           | 9 (52.9)            | $\chi^2$ test           | —              | 0.512   |
| Serum bilirubin (mg/dL),<br>Mean $\pm$ SD | 4.8 $\pm$ 2.1   | 3.6 $\pm$ 1.9      | 5.2 $\pm$ 2.4       | One-way<br>ANOVA        | -0.6 to<br>2.0 | 0.038*  |
| CBD diameter (mm), Mean<br>$\pm$ SD       | 11.2 $\pm$ 2.8  | 13.6 $\pm$ 3.1     | 14.8 $\pm$ 3.5      | One-way<br>ANOVA        | 1.4 to<br>4.2  | <0.001* |
| Multiple stones (>1), n (%)               | 10 (26.3)       | 9 (56.3)           | 12 (70.6)           | $\chi^2$ test           | —              | 0.003*  |

\*Statistically significant

Table 1 compares the baseline clinical and procedural characteristics of patients undergoing ERCP, laparoscopic CBD exploration, and open CBD exploration. The mean age of patients differed significantly among the three groups ( $p = 0.041$ ), with patients undergoing laparoscopic CBD exploration being relatively younger, while those in the open CBD exploration group were older. Male predominance was observed across all groups; however, the distribution of gender did not show a statistically significant difference ( $p = 0.512$ ). Mean serum bilirubin levels were significantly higher in patients undergoing open CBD exploration compared to the ERCP and laparoscopic groups ( $p = 0.038$ ), indicating more severe biliary obstruction in this cohort. A progressive increase in mean CBD diameter was observed from the ERCP group to the open CBDE group, with this difference being highly statistically significant ( $p < 0.001$ ). Additionally, the presence of multiple CBD stones was significantly more common in patients managed with laparoscopic and open CBD exploration compared to those undergoing ERCP ( $p = 0.003$ ), suggesting that stone burden influenced the choice of treatment modality.

**Table 2: Comparison of Ductal Clearance Outcomes Among Treatment Modalities**

| Outcome                                      | ERCP<br>(n=38)  | Lap CBDE<br>(n=16) | Open CBDE<br>(n=17) | Test of<br>Significance | 95% CI          | p-value |
|----------------------------------------------|-----------------|--------------------|---------------------|-------------------------|-----------------|---------|
| Complete ductal clearance, n (%)             | 33 (86.8)       | 15 (93.8)          | 17 (100.0)          | $\chi^2$ test           | —               | 0.048*  |
| Residual/retained stones, n (%)              | 5 (13.2)        | 1 (6.2)            | 0 (0.0)             | Fisher's exact          | —               | 0.041*  |
| Need for repeat procedure, n (%)             | 6 (15.8)        | 1 (6.2)            | 0 (0.0)             | Fisher's exact          | —               | 0.032*  |
| Mean procedure duration (min), Mean $\pm$ SD | 46.2 $\pm$ 12.5 | 118.4 $\pm$ 24.6   | 142.7 $\pm$ 28.9    | One-way<br>ANOVA        | 61.3 to<br>96.1 | <0.001* |

Table 2 demonstrates the comparison of ductal clearance outcomes among the three treatment modalities. Complete ductal clearance was achieved in the majority of patients across all groups, with the highest success rate observed in the open CBD exploration group (100%), followed by laparoscopic CBD exploration (93.8%) and ERCP (86.8%). This difference was statistically significant ( $p = 0.048$ ). Residual or retained stones were more frequently observed following ERCP compared to the surgical modalities, with no residual stones reported in the open CBD exploration group ( $p = 0.041$ ). The requirement for repeat procedures was also significantly higher in the ERCP group (15.8%) compared to laparoscopic and open CBD exploration ( $p = 0.032$ ). Procedure duration differed significantly across the groups, with ERCP having the shortest mean duration and open CBD exploration the longest ( $p < 0.001$ ).

**Table 3: Postoperative Outcomes and Complications Across Treatment Modalities**

| Outcome                                | ERCP<br>(n=38) | Lap CBDE<br>(n=16) | Open CBDE<br>(n=17) | Test of<br>Significance | 95% CI        | p-value |
|----------------------------------------|----------------|--------------------|---------------------|-------------------------|---------------|---------|
| Post-procedure pancreatitis, n (%)     | 4 (10.5)       | 0 (0.0)            | 0 (0.0)             | Fisher's exact          | —             | 0.046*  |
| Bile leak, n (%)                       | 0 (0.0)        | 1 (6.2)            | 2 (11.8)            | Fisher's exact          | —             | 0.041*  |
| Wound infection, n (%)                 | 0 (0.0)        | 0 (0.0)            | 3 (17.6)            | Fisher's exact          | —             | 0.012*  |
| Hospital stay (days), Mean<br>$\pm$ SD | 3.1 $\pm$ 1.2  | 5.8 $\pm$ 1.9      | 9.6 $\pm$ 2.4       | One-way<br>ANOVA        | 4.2 to<br>7.3 | <0.001* |
| Mortality, n (%)                       | 0 (0.0)        | 0 (0.0)            | 1 (5.9)             | Fisher's exact          | —             | 0.214   |

Table 3 outlines the postoperative outcomes and complications associated with each treatment modality. Post-procedure pancreatitis was observed exclusively in the ERCP group (10.5%), with no cases reported following laparoscopic or open CBD exploration, and this difference was statistically significant ( $p = 0.046$ ). Bile leak was noted more frequently following open CBD exploration compared to laparoscopic CBD exploration, while no bile leak occurred in the ERCP group ( $p = 0.041$ ). Wound infection was documented only in the open CBD exploration group (17.6%), which was statistically significant ( $p = 0.012$ ). The mean duration of hospital stay increased progressively from ERCP to

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laparoscopic and open CBD exploration, with the longest hospital stay observed in the open surgery group ( $p < 0.001$ ). Mortality was recorded in one patient in the open CBD exploration group, though this difference was not statistically significant ( $p = 0.214$ ).

**Table 4: Association Between Stone Characteristics and Choice of Treatment Modality**

| Stone characteristic               | ERCP (n=38) | Lap CBDE (n=16) | Open CBDE (n=17) | p-value |
|------------------------------------|-------------|-----------------|------------------|---------|
| Stone size >10 mm, n (%)           | 9 (23.7)    | 10 (62.5)       | 14 (82.4)        | <0.001* |
| Impacted distal stone, n (%)       | 6 (15.8)    | 4 (25.0)        | 9 (52.9)         | 0.004*  |
| Dilated CBD (>12 mm), n (%)        | 12 (31.6)   | 11 (68.8)       | 15 (88.2)        | <0.001* |
| Cholangitis at presentation, n (%) | 14 (36.8)   | 6 (37.5)        | 10 (58.8)        | 0.182   |

Table 4 illustrates the association between stone characteristics and the choice of treatment modality. Larger stones measuring more than 10 mm were significantly more common in patients managed with laparoscopic and open CBD exploration compared to those undergoing ERCP ( $p < 0.001$ ). Impacted distal CBD stones were also significantly more frequent in the open CBD exploration group, followed by the laparoscopic group, indicating the preference for surgical intervention in complex stone presentations ( $p = 0.004$ ). Similarly, dilated CBDs greater than 12 mm were predominantly observed in patients undergoing surgical exploration, with a highly significant difference among the groups ( $p < 0.001$ ). Although cholangitis at presentation was more frequently noted in the open CBD exploration group, this difference did not reach statistical significance ( $p = 0.182$ ).

## DISCUSSION

**Baseline Clinical and Procedural Characteristics (Table 1):** In the present study, a statistically significant difference in age distribution was observed among the three treatment groups, with patients undergoing laparoscopic CBD exploration being relatively younger, while older patients more frequently required open CBD exploration. This finding is consistent with reports by Nie S et al.(2023)[5], who noted that minimally invasive approaches are preferentially employed in younger patients with better physiological reserves, whereas open surgery is often reserved for elderly patients with complex disease. Gender distribution did not differ significantly between groups, which is in agreement with observations by Sun R et al.(2025)[3], suggesting that sex does not independently influence the choice of treatment modality.

Serum bilirubin levels were significantly higher in patients undergoing open CBD exploration, reflecting more severe biliary obstruction. Similar findings were reported by Galetti F et al.(2020)[4], where patients with higher bilirubin levels were more likely to require surgical exploration. The progressive increase in CBD diameter from ERCP to open CBDE groups observed in the present study was also statistically significant and aligns with previous studies indicating that larger ductal diameters are associated with higher stone burden and complexity, often necessitating surgical management Liu S et al.(2020)[6]. Furthermore, the significantly higher prevalence of multiple stones in the laparoscopic and open CBDE groups reinforces the concept that stone burden is a critical determinant in selecting the appropriate treatment modality.

**Ductal Clearance Outcomes (Table 2):** The ductal clearance rates observed in this study demonstrate that all three modalities are effective, with the highest success achieved in the open CBD exploration group (100%), followed by laparoscopic CBDE (93.8%) and

ERCP (86.8%). These results are comparable to those reported by Liu S et al.(2020)[6], who documented ductal clearance rates exceeding 90% for surgical exploration and slightly lower rates for ERCP. The significantly higher incidence of residual stones and need for repeat procedures in the ERCP group mirrors findings from Sun W et al.(2024)[7], where ERCP was associated with incomplete clearance in cases of large or multiple stones.

Procedure duration was significantly shorter for ERCP compared to surgical approaches, a finding consistent with multiple studies highlighting ERCP as a quicker but sometimes staged intervention Sun R et al.(2025)[3]. However, the increased likelihood of repeat procedures following ERCP may offset its initial time advantage, particularly in patients with complex stone disease.

**Postoperative Outcomes and Complications (Table 3):** Post-procedure pancreatitis occurred exclusively in the ERCP group in the present study, with a statistically significant difference among the modalities. This complication profile is well documented in literature, with Guo T et al.(2022)[8] reporting pancreatitis rates ranging from 5% to 15% following ERCP. In contrast, bile leak and wound infection were more frequently associated with surgical interventions, particularly open CBDE, reflecting the invasiveness of the procedure. Similar complication patterns have been described by Cianci P et al.(2021)[1], where laparoscopic approaches demonstrated fewer wound-related complications compared to open surgery.

Hospital stay increased progressively from ERCP to laparoscopic and open CBDE, with the longest duration observed in the open surgery group. This finding corroborates the observations of Aydın MC et al.(2020)[9], who reported significantly reduced

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hospital stays with minimally invasive approaches. Mortality was low and did not differ significantly among groups, underscoring the overall safety of all three modalities when appropriately selected.

**Stone Characteristics and Treatment Selection (Table 4):** The present study demonstrated a strong association between stone characteristics and the choice of treatment modality. Stones larger than 10 mm, impacted distal stones, and markedly dilated CBDs were significantly more common in patients undergoing laparoscopic or open CBD exploration. These findings are consistent with recommendations from Zhu SY et al.(2023)[10], who emphasized that large and impacted stones often limit the effectiveness of ERCP and necessitate surgical intervention.

Although cholangitis at presentation was more frequently observed in the open CBDE group, the difference was not statistically significant. Similar trends without statistical significance have been reported by Chen L et al.(2023)[11], suggesting that while cholangitis influences urgency of intervention, it may not independently dictate the choice of modality.

## CONCLUSION

The present Retrospective clinical study compared ERCP, laparoscopic common bile duct exploration, and open common bile duct exploration in the management of choledocholithiasis. All three treatment modalities were found to be effective in achieving ductal clearance when appropriately selected based on patient profile and stone characteristics. ERCP proved to be a minimally invasive and time-efficient modality with shorter hospital stay; however, it was associated with a higher incidence of residual stones, repeat procedures, and post-procedure pancreatitis, particularly in cases with larger or multiple stones.

Laparoscopic CBD exploration demonstrated high ductal clearance rates with fewer complications and shorter hospital stay compared to open surgery, highlighting its role as an effective single-stage treatment option in centers with adequate expertise. Open CBD exploration achieved the highest ductal clearance rates and remained the most definitive modality for complex cases involving large, multiple, or impacted stones and markedly dilated bile ducts, albeit at the cost of increased postoperative morbidity and longer hospitalization.

Overall, the study emphasizes that the management of choledocholithiasis should be individualized. ERCP is suitable for selected patients with smaller stone burden, laparoscopic CBD exploration offers an optimal balance between efficacy and morbidity, and open CBD exploration continues to play a crucial role in advanced and complicated cases. A tailored approach based on

clinical presentation, stone characteristics, and available expertise yields optimal patient outcomes.

## LIMITATIONS OF THE STUDY

1. The study was conducted at a single tertiary care center, which may limit the generalizability of the findings.
2. The sample size was relatively small, particularly in the laparoscopic and open CBD exploration groups.
3. Allocation to treatment modality was not randomized and was influenced by clinical judgment and institutional expertise.
4. Long-term outcomes such as recurrence of CBD stones and late biliary complications were not assessed.
5. The learning curve associated with laparoscopic CBD exploration was not separately analyzed.
6. Cost analysis of different treatment modalities was not included in the study.

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