



RESEARCH ARTICLE

Comparative Study of Primary Closure Versus T-Tube Drainage Following Common Bile Duct Exploration in Patients with Choledocholithiasis

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ABSTRACT

Background: Choledocholithiasis is a common biliary disorder that frequently requires common bile duct (CBD) exploration when endoscopic management is unsuccessful or unavailable. Traditionally, T-tube drainage has been employed following CBD exploration to facilitate biliary decompression and postoperative cholangiography. However, primary closure of the CBD has emerged as an alternative approach that may reduce postoperative morbidity, shorten hospital stay, and improve patient comfort. This study compares the outcomes of primary closure and T-tube drainage following CBD exploration in patients with choledocholithiasis.

Objectives: To compare the safety and efficacy of primary closure versus T-tube drainage following common bile duct exploration in patients with choledocholithiasis, with respect to postoperative complications, biliary leakage, operative time, duration of hospital stay, and overall patient outcomes.

Materials and Methods: A comparative study was conducted on patients diagnosed with choledocholithiasis who underwent common bile duct exploration. Patients were allocated into two groups: Group A underwent primary closure of the CBD, while Group B underwent T-tube drainage after exploration. Demographic characteristics, operative findings, postoperative complications, duration of hospital stay, biliary leakage, wound infection, and need for re-intervention were recorded and analyzed using appropriate statistical methods. A p-value of <0.05 was considered statistically significant.

Results: Both techniques achieved successful ductal clearance. The primary closure group demonstrated a significantly shorter postoperative hospital stay and earlier recovery compared with the T-tube drainage group. The incidence of postoperative biliary leakage and other complications was comparable between the two groups, with no significant difference in retained stones or mortality. Overall, primary closure was associated with improved postoperative recovery and reduced morbidity without compromising patient safety.

Conclusion: Primary closure following common bile duct exploration is a safe and effective alternative to T-tube drainage in selected patients with choledocholithiasis. It offers the advantages of reduced hospital stay, faster postoperative recovery, and avoidance of T-tube-related complications while maintaining comparable surgical outcomes. Careful patient selection and meticulous surgical technique are essential for achieving optimal results.

Keywords: Choledocholithiasis; Common bile duct exploration; Primary closure; T-tube drainage; Biliary surgery; Common bile duct stones; Postoperative complications; Hospital stay.

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INTRODUCTION

Choledocholithiasis, defined as the presence of stones in the common bile duct (CBD), is a common complication of gallstone disease, occurring in approximately 10–15% of patients with cholelithiasis. It is an important cause of biliary obstruction and may present with obstructive jaundice, acute cholangitis, biliary colic, or gallstone pancreatitis. The incidence increases with advancing age and is particularly high among patients undergoing cholecystectomy. In India, the prevalence varies across different regions, with higher rates reported in northern parts of the country due to dietary, genetic, and environmental factors [1–4].

The primary goal of treatment is complete clearance of CBD stones while maintaining adequate biliary drainage and minimizing postoperative complications. Common bile

duct exploration (CBDE), performed by either an open or laparoscopic approach, remains an effective method for managing choledocholithiasis, particularly in patients with large, multiple, or impacted stones and where endoscopic facilities are unavailable or unsuccessful [5,6].

Following choledochotomy, closure of the CBD can be achieved either by primary closure (PC) or T-tube drainage (TTD). Traditionally, T-tube drainage has been considered the standard approach because it decompresses the biliary tree, allows postoperative cholangiography, and facilitates the detection of retained stones. However, its use is associated with several disadvantages, including bile leakage, tube dislodgement, tract infection, electrolyte loss, patient discomfort, prolonged hospitalization, and delayed recovery [7,8].

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Advances in surgical techniques, choledochoscopy, intraoperative imaging, and improved suture materials have led to increasing acceptance of primary closure as a safe alternative. Several randomized controlled trials and meta-analyses have demonstrated that primary closure significantly reduces operative time, postoperative hospital stay, and overall morbidity without increasing the incidence of bile leakage, retained stones, biliary strictures, or stone recurrence when complete ductal clearance is achieved [9–12]. Consequently, recent surgical guidelines advocate primary closure in carefully selected patients following successful CBD exploration [13,14].

Despite accumulating evidence favoring primary closure, T-tube drainage continues to be widely practiced, particularly in resource-limited settings and in patients with uncertain ductal clearance or severe biliary inflammation. Therefore, comparative evaluation of these two techniques remains clinically relevant.

The present study was undertaken to compare primary closure and T-tube drainage following common bile duct exploration in patients with choledocholithiasis with respect to operative time, postoperative complications, duration of hospital stay, and overall surgical outcomes.

MATERIALS AND METHODS

Study Design and Setting

This prospective interventional study will be conducted in the Department of General Surgery, Eras Lucknow Medical

College and Hospital, Lucknow, over a period of 24 months. The study population will include patients attending the outpatient and inpatient departments diagnosed with choledocholithiasis and scheduled for common bile duct (CBD) exploration.

Sample Size

A total of 66 patients will be enrolled and randomly allocated into two equal groups:

- Group A (n = 33): Primary Closure
- Group B (n = 33): T-tube Drainage

The sample size was calculated using the expected proportion of wound infection in the two groups ($p_1 = 0.4285$; $p_2 = 0.1111$), with a 95% confidence level ($\alpha = 0.05$) and 90% study power ($\beta = 0.10$), yielding a minimum requirement of 33 patients per group.

Eligibility Criteria

Patients aged >18 years with confirmed choledocholithiasis undergoing CBD exploration will be included. Patients with multiple hepatolithiasis, CBD stricture, acute pancreatitis, acute cholangitis, malignant biliary tumors, immunocompromised status, or those with CBD diameter >2.5 cm (for primary closure) will be excluded.

METHODOLOGY

After obtaining Institutional Ethics Committee approval and written informed consent, eligible patients will be randomized using the Sequentially Numbered, Opaque, Sealed Envelope (SNOSE) technique in a 1:1 ratio.

A detailed preoperative assessment including demographic profile, clinical presentation, comorbidities, BMI, and radiological evaluation (ultrasonography, MRCP, and CECT abdomen where indicated) will be performed.

All procedures will be carried out under general anesthesia. Following cholecystectomy, supra duodenal choledochotomy and CBD exploration will be performed with complete stone clearance confirmed by saline irrigation and/or choledochoscopy.

Group A

The choledochotomy will be closed primarily using continuous absorbable sutures (3-0/4-0 Vicryl or PDS).

Group B

An appropriately sized (12–14 F) latex T-tube will be inserted into the CBD, and the duct closed around the tube using absorbable sutures.

Intraoperative parameters including operative time and estimated blood loss will be recorded.

Postoperatively, all patients will receive standardized antibiotic and analgesic therapy. Subhepatic drains will be managed according to clinical status. In the T-tube group, postoperative management will include T-tube clamping trials and cholangiography before tube removal as per institutional protocol.

Outcome Measures

The primary outcomes will include:

- Operative time
- Duration of postoperative hospital stay
- Time to return to normal daily activities
- Postoperative complications (bile leak, wound infection, biliary peritonitis, and retained stones)

Statistical Analysis

Data will be entered into Microsoft Excel and analyzed using SPSS version 26.0. Continuous variables will be expressed as mean $\pm$ standard deviation (SD) or median (IQR), while categorical variables will be presented as frequencies and percentages. Comparisons between groups will be performed using the Independent Student's t-test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables. A p-value <0.05 will be considered statistically significant.

RESULTS

Table 1: Baseline Characteristics of the Study Population

Variable	T-tube (n=33)	Primary Closure (n=33)	p-value
Mean Age (years)	Comparable	Comparable	>0.05
Female, n (%)	25 (75.8)	28 (84.8)	0.36
Comorbidities, n (%)	17 (51.5)	12 (36.4)	0.32

Interpretation

Both groups were comparable with respect to demographic characteristics and comorbidities. No statistically significant difference was observed ($p > 0.05$), indicating adequate baseline comparability.

Table 2: Comparison of Intraoperative Outcomes

Parameter	T-tube (n=33)	Primary closure (n=33)	p-value
Operative time (min)	112.4 $\pm$ 18.2	105.7 $\pm$ 15.6	0.051
Blood loss (mL)	196.91 $\pm$ 68.28	175.91 $\pm$ 54.92	0.173

Interpretation

The primary closure group had a shorter operative time and lower intraoperative blood loss; however, these differences were not statistically significant ($p > 0.05$).

Table 3: Comparison of Postoperative Recovery

Parameter	T-tube (n=33)	Primary closure (n=33)	p-value
Hospital stay (days)	9.76 $\pm$ 2.81	7.85 $\pm$ 2.00	0.002
Recovery time (days)	13.15 $\pm$ 2.48	11.15 $\pm$ 2.92	0.004
Return to normal activities (days)	22.67 $\pm$ 4.36	14.85 $\pm$ 4.89	<0.001

Interpretation

Patients undergoing primary closure demonstrated significantly shorter hospital stay, faster recovery, and earlier return to normal activities compared with the T-tube group ($p < 0.05$ for all parameters).

Table 4: Comparison of Postoperative Complications

Complication	T-tube (n=33)	Primary closure (n=33)	p-value
Bile leak	1 (3.0%)	3 (9.1%)	0.613
Wound infection	8 (24.2%)	5 (15.2%)	0.537
Retained stone	0	0	—
Reintervention	0	0	—

Interpretation

The incidence of postoperative complications was comparable between the two groups. Although wound infection was more frequent in the T-tube group and bile leak was numerically higher in the primary closure group, these differences were not statistically significant ($p > 0.05$). No retained stones or reinterventions were observed.

Table 5: Summary of Surgical Outcomes

Outcome	Better group	Statistical significance
Operative time	Primary closure	No ($p=0.051$)
Blood loss	Primary closure	No ($p=0.173$)
Hospital stay	Primary closure	Yes ($p=0.002$)
Recovery time	Primary closure	Yes ($p=0.004$)
Return to normal activities	Primary closure	Yes ($p<0.001$)
Overall complications	Comparable	No ($p>0.05$)

Interpretation

Primary closure provided superior postoperative recovery, significantly reducing hospital stay, recovery time, and time to resume normal activities, while maintaining a complication profile comparable to T-tube drainage.

DISCUSSION

The present prospective interventional study compared the surgical outcomes of primary closure (PC) and T-tube drainage (TTD) following common bile duct (CBD) exploration in patients with choledocholithiasis. The baseline demographic characteristics, including age, sex, and comorbidities, were comparable between the two groups, indicating that the observed postoperative outcomes were attributable to the intervention rather than differences in patient characteristics.

The present study demonstrated that primary closure was associated with a shorter operative time compared with T-tube drainage, although the difference did not achieve statistical significance ($p=0.051$). The additional operative steps required for insertion and fixation of the T-tube may account for the longer duration. Similar observations have been reported by Zhu *et al.*, and the Cochrane review by Gurusamy *et al.*, who concluded that primary closure reduces operative time without compromising surgical safety [9,11].

Intraoperative blood loss was slightly lower in the primary closure group but was not statistically significant ($p=0.173$), indicating that both techniques are equally safe with respect to intraoperative hemorrhage. Comparable findings have been reported in previous studies, suggesting that the method of duct closure does not significantly influence blood loss during CBD exploration [9,10].

A major finding of the present study was the significantly shorter postoperative hospital stay in patients undergoing primary closure (7.85 ± 2.00 days) compared with T-tube drainage (9.76 ± 2.81 days; $p=0.002$). Similarly, recovery time and return to normal daily activities were significantly faster in the primary closure group ($p=0.004$ and $p<0.001$, respectively). These findings are consistent with the reports of El-Geidie *et al.*, Yi *et al.*, and Zhu *et al.*, who demonstrated that primary closure facilitates earlier recovery, shorter hospitalization, reduced healthcare costs, and improved patient comfort by eliminating the need for prolonged external biliary drainage [9,10,12].

The incidence of postoperative complications, including bile leak and wound infection, was comparable between the two groups. Although bile leak occurred slightly more frequently after primary closure and wound

infection was more common in the T-tube group, neither difference reached statistical significance. Furthermore, no retained stones or reinterventions were observed in either group, indicating complete duct clearance and satisfactory surgical outcomes. These results agree with the findings of Gurusamy *et al.*, Zhu *et al.*, and current ESGE and SAGES recommendations, which suggest that primary closure is a safe alternative to routine T-tube drainage when complete stone clearance has been achieved [9,11,13].

Overall, the findings of the present study support the growing body of evidence that primary closure is an effective and safe alternative to T-tube drainage following CBD exploration. It offers significant advantages in terms of postoperative recovery and duration of hospitalization without increasing postoperative morbidity. These findings are in accordance with contemporary international guidelines, which increasingly recommend primary closure in appropriately selected patients undergoing CBD exploration [13,14].

CONCLUSION

Primary closure following common bile duct exploration is a safe and effective alternative to T-tube drainage in patients with uncomplicated choledocholithiasis. It is associated with significantly shorter hospital stay, faster recovery, and earlier return to normal activities without increasing postoperative complications such as bile leak or wound infection. These findings support primary closure as a preferred, patient-centered approach after successful CBD stone clearance.

Ethical Committee Clearance

Obtained from the Institutional Ethics Committee, Era's Lucknow Medical College and Hospital, Lucknow, prior to commencement of the study.

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