

Role of laparoscopic common bile duct exploration in the management of choledocholithiasis

Nikhil Gupta

Nikhil Gupta, Department of Surgery, PGIMER Dr RML Hospital, Delhi 110001, India

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Correspondence to: Dr. Nikhil Gupta, MS, MRCSEd, FAIS, FMAS, FIAGES, MNAMS, Assistant Professor, Department of Surgery, PGIMER Dr RML Hospital, B-406 Panchsheel Apartments, Plot-9, Sector-10, Dwarka, Delhi 110001, India. nikhil_ms26@yahoo.co.in
Telephone: +91-011-45526090
Fax: +91-011-45526090

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Abstract

Surgical fraternity has not yet arrived at any consensus for adequate treatment of choledocholithiasis. Sequential treatment in the form of pre-operative endoscopic retrograde cholangio-pancreatography followed by laparoscopic cholecystectomy (LC) is considered as

optimal treatment till date. With refinements in technique and expertise in field of minimal access surgery, many centres in the world have started offering one stage management of choledocholithiasis by LC with laparoscopic common bile duct exploration (LCBDE). Various modalities have been tried for entering into concurrent common bile duct (CBD) [transcystic (TC) vs transcholedochal (TD)], for confirming stone clearance (intraoperative cholangiogram vs choledochoscopy), and for closure of choledochotomy (T-tube vs biliary stent vs primary closure) during LCBDE. Both TC and TD approaches are safe and effective. TD stone extraction is involved with an increased risk of bile leaks and requires more expertise in intra-corporeal suturing and choledochoscopy. Choice depends on number of stones, size of stone, diameter of cystic duct and CBD. This review article was undertaken to evaluate the role of LCBDE for the management of choledocholithiasis.

Key words: Laparoscopic common bile duct exploration; Choledochoscopy; Cholangiogram; Choledocholithiasis; Primary closure

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Core tip: Various treatment modalities are available for management of choledocholithiasis. Laparoscopic common bile duct exploration offers one stage management of cholelithiasis with choledocholithiasis. This review article was undertaken to evaluate this technique and its various aspects.

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INTRODUCTION

The incidence of gallstones varies from 6%-10% in adult population^[1]. Three percent to 14.7% of patients of gallstones have concurrent common bile duct (CBD) stones as well^[2]. "Gold Standard" for management of gallstones is laparoscopic cholecystectomy (LC) but there is no consensus for treatment of CBD stones. In the era of open surgery, treatment was straight-forward; open cholecystectomy with open CBD exploration though it carried high morbidity and mortality. With the advent of non invasive and minimal invasive techniques, option of pre-operative endoscopic retrograde cholangiopancreatography (ERCP) followed by LC emerged as adequate treatment. Major disadvantages of ERCP are that it is a two stage procedure and is associated with life threatening complications like pancreatitis, bleeding and duodenal perforation. It has also been reported that sphincterotomy may cause papillary stenosis and increased risk of bile duct cancer^[2,3].

With refinements in technique and expertise in field of minimal access surgery, many centres in the world have started offering one stage management of choledocholithiasis by LC with laparoscopic CBD exploration (LCBDE). Only few randomized trials are available comparing pre-operative ERCP followed by LC with single stage LC and LCBDE^[4,5]. There is no consensus even for the technique of LCBDE. Various modalities have been tried for entering into CBD [transcystic (TC) vs transcholedochal (TD)], for confirming stone clearance [intraoperative cholangiogram (IOC) vs choledochoscopy], and for closure of choledochotomy (T-tube vs biliary stent vs primary closure).

REVIEW OF LITERATURE

Literature search was performed to answer these questions. Online search engines like PubMed, Google, springer link library and Cochrane database systematic review were utilized and review articles, prospective and retrospective studies which detailed or compared the various treatment strategies for CBD stones were selected and analyzed.

Sequential vs one stage management

Two randomized trials have compared pre-operative ERCP followed by LC with one stage LC and LCBDE^[4,5]. Results of the two modalities were comparable in terms of stone clearance and complications but duration of hospitalization was shorter with LCBDE in both studies^[4,5]. In a study done by Rogers *et al*^[5], 122 patients were randomized into either group. Hospital stay was significantly shorter for LC + LCBDE [mean (SD), 55 (45) h vs 98 (83) h; $P < 0.001$]. There was no difference in patient acceptance and quality of life scores among the two groups. A prospective analysis done ($n = 150$) by Mohamed *et al*^[6] showed that the laparoscopic management of CBD stones is as safe and effective as the sequential ERCP followed by LC with nearly the same

stone clearance rate, hospital stay, and complications.

Liu *et al*^[7] did a meta-analysis and found that there was no significant difference between laparoscopic CBD exploration group and pre-operative endoscopic sphincterotomy group in terms of complications or retained stones ($P > 0.05$). Success rate was higher in LCBDE group with reduced hospital expenses, mean operative time and duration of hospitalization ($P < 0.05$)^[7].

Another meta-analysis done by Nagaraja *et al*^[8], reported higher incidence of ERCP related complications in patients undergoing pre-operative ERCP [odds ratio (OR) = 2.40, 95%CI: 1.21-4.75].

Costi *et al*^[9] performed a case-control study comparing a single stage laparoscopic approach ($n = 22$) with sequential treatment ($n = 15$). They found two groups to be similar in terms of early and late complications. The postoperative hospitalization was significantly less in the single stage group^[9]. Bansal *et al*^[10] conducted a prospective randomized trial comparing single stage laparoscopic treatment with sequential treatment of CBD stones. Fifteen patients were randomized to each group. Stone clearance rates and complications were similar in both groups. They concluded that single stage approach seems to be better due to smaller number of procedures and hospital visits^[10].

Cochrane systematic review was done by Dasari *et al*^[11] in 2013. They included five trials ($n = 580$). Two hundred and eighty-five patients underwent LC + LCBDE and 295 patients received sequential treatment in the form of ERCP + LC. There was no significant difference among two groups in terms of mortality (0.7% vs 1%), morbidity (15% vs 13%) or incidence of retained stones (8% vs 11%).

A meta-analysis of single-stage vs sequential treatment for cholelithiasis with common bile duct stones was carried out by Zhu *et al*^[12] recently. Eight randomized controlled trials, which involved 1130 patients, were included in this study. The meta-analysis revealed that the CBD stone clearance rate in the single-stage group was higher (OR = 1.56, 95%CI: 1.05-2.33, $P = 0.03$). The lengths of hospitalization (MD = -1.02, 95%CI: -1.99 to -0.04, $P = 0.04$) and total operative times (MD = -16.78, 95%CI: -27.55 to -6.01, $P = 0.002$) were also shorter in the single-stage group. There was no statistically significant difference among the two groups regarding postoperative morbidity (OR = 1.12, 95%CI: 0.79-1.59, $P = 0.52$), mortality (OR = 0.29, 95%CI: 0.06-1.41, $P = 0.13$) and conversion to other procedures (OR = 0.82, 95%CI: 0.37-1.82, $P = 0.62$).

TC vs TD

Hongjun *et al*^[13] compared TC approach ($n = 80$) with TD approach ($n = 209$) and found that there was no significant difference between the two approaches for cystic duct diameter (0.47 ± 0.09 cm vs 0.47 ± 0.08 cm), procedure time (91.94 ± 34.21 min vs 96.13 ± 32.15 min), complications (2.5% vs 2.87%) and

duration of hospitalization (9.82 ± 3.48 d vs 10.74 ± 5.34 d) (all $P > 0.05$). A significant difference was noticed in terms of the common bile duct diameter (1.18 ± 0.29 cm vs 1.04 ± 0.24 cm, $P < 0.05$)^[13].

Wang *et al*^[14] reported that TC LCBDE is safe and effective in elderly population. TC approach was successful in 157 of 165 patients (95.15%). Five patients were converted to laparoscopic TD approach and T-tube drainage whereas three patients were managed by laparotomy and open CBD exploration. No significant complications were reported in the study. The mean blood loss was 43 ± 20 mL and mean operative time was 102 ± 35 min. The postoperative hospitalization was 3 ± 0.5 d^[14].

A systematic review done by Reinders *et al*^[15] included eight randomized trials with 965 patients. Successful bile duct clearance varied between 80.4% and 100% in the TC groups and 58.3% and 100% in the TD groups. There were more bile leaks after TD stone extraction (11%) than after TC stone extraction (1.7%). They concluded that TD stone extraction is associated with an increased risk of bile leaks and should only be done by highly experienced surgeons; TC stone extraction seems a more accessible technique with lower complication rates^[4,5,10,16-20].

Chander *et al*^[21] have concluded that TD route is better in Asian patients with multiple, large stones and dilated CBD.

IOC vs choledochoscopy

Only two studies were found comparing IOC with choledochoscopy for confirming stone clearance. Topal *et al*^[22] found similar results with both techniques, though operative time was longer in IOC group. Vindal *et al*^[23] in a prospective randomized study compared IOC ($n = 65$) with intra-operative choledochoscopy ($n = 67$). Mean operative time was 170 min in group A and 140 min in group B ($P < 0.001$). There was no significant difference in complications among the two groups^[23]. They found choledochoscopy to be better and less time consuming than IOC for determining bile duct clearance after TD LCBDE.

Primary closure vs T-tube vs biliary stent

In a retrospective study done by Yi *et al*^[24], long term results of primary closure (group P, $n = 91$) after LCBDE were compared with T-tube drainage (group T, $n = 51$). The mean operative time was significantly less in group P than group T (168.9 ± 50.1 min vs 198.0 ± 59.6 min, $P = 0.002$). The duration of hospitalization was significantly less in group P than in group T (8.59 ± 6.0 d for group P vs 14.96 ± 5.4 d for group T, $P = 0.001$). The stone recurrence rates in group P and group T were 4.4% and 5.9%, respectively ($P = 0.722$) (mean follow-up 48.8 mo). There was no sign of biliary stricture or other biliary complications in follow-up in either group. They concluded that primary closure after LCBDE with choledochoscopy is as safe and effective as T-tube drainage in terms of long-term results^[24].

Dong *et al*^[25] compared primary closure (group A, $n = 101$) with T-tube drainage (group B, $n = 93$) after LCBDE. The mean operative time was less in group A than in group B (102.6 ± 15.2 min vs 128.6 ± 20.4 min, $P < 0.05$). Postoperative hospitalization was longer in group B (4.9 ± 3.2 d) than in group A (3.2 ± 2.1 d). The hospital expenses were also significantly less in group A. Three patients experienced complications in postoperative period, which were related to T-tube usage in group B^[25].

In other study, Leida *et al*^[26] showed that patients with primary closure of the CBD returned to work faster (12.6 ± 5.1 d vs 20.4 ± 13.2 d). This group also showed advantages of significantly lower hospital expenses and less postoperative complications than T-tube drainage group (15% vs 27.5%)^[26].

Lyon *et al*^[27] compared use of biliary stent ($n = 82$) with T-tube drainage ($n = 34$) after LCBDE in a prospective non-randomized study. The duration of hospitalization for patients who underwent biliary stent or T-tube insertion after LCBDE were 1 and 3.4 d, respectively ($P < 0.001$). In the T-tube group, two patients required laparoscopic washout due to bile leaks. They concluded that ante-grade biliary stent insertion is associated with low hospital expenses and increased patient satisfaction^[27].

Dietrich *et al*^[28] compared biliary stent with T-tube drainage in a series of 48 patients who underwent LCBDE. Patients with T-tube drainage had more procedure-related complications ($P < 0.0001$) and a prolonged hospital stay ($P = 0.03$).

A retrograde study done by Abellán Morcillo *et al*^[29], compared T-tube closure ($n = 36$), biliary stent ($n = 133$) and primary closure ($n = 16$). In the stented group, they found an 11.6% incidence of pancreatitis and a 26.1% incidence of hyperamylasemia whereas in the primary closure group, a clear improvement of complications and hospital stay was observed^[29].

Chen *et al*^[30] in their study observed that primary closure is safe after LCBDE ($n = 194$).

Estellés Vidagany *et al*^[31] did primary closure after LCBDE in 160 patients. Bile leakage was reported in 11 patients (6.8%). In 7 out of 11 patients (63.6%), no further intervention was needed and the leak closed on its own. Six patients were reoperated (3.75%), two for biliary peritonitis and four for haemoperitoneum. The success rate for stone clearance was 96.2%. No mortality or CBD stricture was reported in the study. They concluded that primary closure after LCBDE is a safe technique with excellent results^[31].

Hua *et al*^[32] studied rate of bile leak following primary closure in LCBDE *via* TD approach. Of 157 LCBDE procedures, 138 (87.9%) were successfully managed with primary closure of the choledochotomy. Eight patients (5.1%) underwent closure over a T-tube after LCBDE and 11 patients (7.0%) were converted to open surgery. The success rate for CBD stone clearance was 98.1%. Postoperative bile leak was seen in 6 patients (3.8%).

Table 1 Effective and important factors in common bile duct stones approach

Factor	Trans-cystic approach	Trans-ductal approach
Single stone	Yes	Yes
Multiple stones	Yes	Yes
Stones < 6 mm diameter each	Yes	Yes
Stones > 6 mm diameter each	No	Yes
Intrahepatic stones	No	Yes
Diameter of cystic duct < 4 mm	No	Yes
Diameter of cystic duct > 4 mm	Yes	Yes
Diameter of common bile duct < 6 mm	Yes	No
Diameter of common bile duct > 6 mm	Yes	Yes
Suturing ability-poor	Yes	No

Gurusamy *et al*^[33] published a cochrane systematic review comparing T-tube with primary closure after LCBDE. They included three trials randomizing 295 participants: 147 to T-tube drainage vs 148 to primary closure. The operative time was significantly more in the T-tube drainage group compared with the primary closure group (MD 21.22 min; 95%CI: 12.44 to 30.00 min). The duration of hospitalization was significantly more in the T-tube drainage group compared with the primary closure group (MD 3.26 d; 95%CI: 2.49 to 4.04 d). According to one trial, the participants randomized to T-tube drainage took approximately eight days more to return to work than the participants randomized to the primary closure group ($P < 0.005$). They concluded that T-tube drainage is associated with significantly longer operative time and hospital stay as compared with primary closure after LCBDE. They also emphasized that currently available evidence cannot justify the routine use of T-tube drainage after LCBDE^[33].

Podda *et al*^[34] did a meta-analysis of all studies comparing primary duct closure and T-tube drainage after LCBDE (total 16 studies, 1770 patients). Primary duct closure showed a significant advantage over T-tube in terms of postoperative bile peritonitis ($P = 0.02$), operative time, duration of hospitalization, and median hospital cost (all $P < 0.00001$).

DISCUSSION

Pre-operative ERCP followed by LC is the most commonly used treatment modality for management of choledocholithiasis. ERCP carries a high rate of morbidity and mortality mostly due to post-procedure pancreatitis, duodenal perforation and bleeding. It also causes injury to sphincter of oddi which should be avoided in younger patients. LCBDE offers a one stage treatment with similar or better stone clearance rate and with a shorter hospital stay. It also preserves function of sphincter of oddi and hence prevents reflux related complications^[2,3]. LCBDE has been found to be safe even in elderly population^[14,35]. A Cochrane systematic review by Martin *et al*^[36] concluded that a single-stage treatment in the form of LCBDE *via* TC approach is the procedure of choice for intraoperatively discovered CBD calculi.

Despite the simplicity and success of LCBDE, many surgeons across the globe are still not comfortable or confident regarding the procedure. Petelin *et al*^[37] did a web based survey among United States surgeons regarding their choice for managing choledocholithiasis. For preoperatively known CBD calculi, 86% preferred preoperative ERCP. Those in metropolitan areas were more likely to choose preoperative ERCP than those in nonmetropolitan areas (88% vs 79%, $P < 0.001$). For CBD stones discovered intraoperatively, 30% chose LCBDE as their preferred method of management with no difference between metropolitan and nonmetropolitan areas ($P = 0.335$). The top reasons for not performing LCBDE were: Availability of a reliable ERCP, lack of equipment, and lack of skill performing LCBDE. They concluded that many surgeons are uncomfortable performing LCBDE, and advanced training may be needed. There is a risk of surgeons losing the art, which may still be required in cases of unavailability or failure of ERCP^[38].

Both TC and TD approaches are safe and effective. TD stone extraction is associated with a increased risk of bile leaks and requires more expertise in intracorporeal suturing and choledochoscopy^[21]. TC stone extraction seems a more accessible technique with lower complication rates. Choice depends on number of stones, size of stone, diameter of cystic duct and CBD (Table 1)^[39].

Stone clearance during LCBDE can be confirmed by IOC or choledochoscopy. Intra-operative choledochoscopy is better than IOC for determining ductal clearance after TD LCBDE and is less cumbersome and less time-consuming.

Choledochotomy after LCBDE (TD approach) is conventionally managed by T-tube closure. Primary closure of choledochotomy is a safe and effective option with less operative time and hospital stay. Biliary stent also reduces cost and hospital stay as compared to T-tube. There is lack of randomized trial comparing primary closure with biliary stent.

In patients having cholangitis, it is advisable to go for drainage of biliary obstruction by ERCP followed by LC. LCBDE can be offered to all other patients with CBD stones if expertise is available^[21]. If laparoscopic exploration fails, it is prudent to convert it to open bile duct exploration and removal of ductal stones.

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