Management of Common Bile Duct Stones in the Laparoscopic Era

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Abstract There is no consensus regarding the ideal management of concurrent gallbladder and common bile duct (CBD) stones. Currently the treatment protocol involves most commonly a sequential approach consisting of endoscopic sphincterotomy followed by laparoscopic cholecystectomy or a single stage laparoscopic procedure, including cholecystectomy and exploration of the CBD. For this article literature search was performed using online search engines, Google, Pubmed, the online Springer link library and the Cochrane Database Systematic Review. Review articles, prospective and retrospective studies which detailed or compared the various treatment strategies for CBD stones were selected and analyzed. This review article aims to provide an insight into the optimal management of CBD stones in different clinical scenarios. Endoscopic sphincterotomy has inherent morbidity and complications like CBD stone recurrence whereas laparoscopic CBD exploration demands considerable expertise which is available only at specialized centres. The clinical presentation of the patient, number of stones, size of CBD, available resources and technical expertise at hand are an important consideration for the ideal management in different scenarios.

Keywords Laparoscopic cholecystectomy · Endoscopic sphincterotomy · CBD stones · Laparoscopic CBD exploration

Introduction

The incidence of gallstones is very common and varies from 6 % to 10 % in adult population. Their treatment involves surgeons, endoscopists and anaesthesiologists depending on clinical presentation. The “gold standard” treatment for cholelithiasis is laparoscopic cholecystectomy (LC), whereas the “gold standard” treatment for isolated common bile duct (CBD) stones, especially in cholecystectomized patients, is endoscopic clearance [1]. On the contrary, when gallstones and CBD stones are present concurrently, the treatment is a challenge. A consensus on optimal management does not exist. Several approaches are used, all having their proponents, such as open surgery, laparoscopy, and laparoendoscopic treatments, either sequential or simultaneous.

From 10 % to 18 % of patients undergoing Laparoscopic Cholecystectomy (LC) for gallbladder stones have synchronous CBD stones [2, 3]. These should be treated even if asymptomatic [4]. Prior to the development of minimally invasive surgery, when the surgical approach to CBD stones consisted of choledocholithotomy by open surgery, there was considerable morbidity (11–14 %) and even mortality (0.6–1 %) [5]. With the advent of endoscopic and laparoscopic techniques, CBD stones were removed preoperatively by endoscopy, which was followed by LC [6]. With refinements in laparoscopic techniques and experience many centers have started performing laparoscopic CBD exploration with acceptable results and complications [7]. Simultaneous or single-stage laparoscopic cholecystectomy and CBD exploration has not yet become standard management. There are only a few randomized trials available comparing the single stage with sequential management (ERCP followed by LC) of patients with concomitant gallstones and CBD stones [8, 9]. Combined single stage

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laparoendoscopic approach to the management of choledocholithiasis has also been advocated by established centres [1, 10] with results comparable to sequential management and single stage total laparoscopic exploration.

Diagnosis

The preoperative evaluation for CBD stones should include a careful history, biochemical tests and abdominal ultrasonography. It seems reasonable to avoid further diagnostic preoperative investigations and routine intraoperative cholangiography in patients with absence of jaundice, normal liver function tests, and ultrasonographic evidence of a normal biliary tree (CBD diameter <9 mm) even in the presence of a recent acute Cholecystitis [11].

Investigation of the group at risk is necessary. If there is any suspicion that preoperative choledocholithiasis is present magnetic resonance cholangiopancreatography (MRCP) or endoscopic retrograde cholangiopancreatography (ERCP) is performed. ERCP should be performed only in patients who are expected to require an intervention; it is not recommended for use solely as a diagnostic test [11].

It is desirable that *all those and only those* patients with choledocholithiasis should undergo CBD exploration at cholecystectomy. CBD should be imaged if there is intraoperative doubt about choledocholithiasis. This can be achieved by radiographic intraoperative cholangiography (IOC) via the transcystic approach or intracorporeal laparoscopic ultrasonography (LUS). In experienced hands, LUS seems to be as accurate as cholangiography for diagnosis of choledocholithiasis, but can be performed more rapidly. Li et al. in 2009 have shown that LUS is more sensitive than IOC for detecting stones but IOC is better for delineating the anatomy. Both these techniques should be viewed as complementary method to maximise the intraoperative detection of occult CBD stones [12].

Management Options

No consensus exists regarding the ideal management of gallbladder and CBD stones. CBD stones can be detected preoperatively, intraoperatively or postoperatively. Consequently the management options are quite varied especially in the present era of advanced laparoendoscopic techniques. The following management strategies are available:

- Endoscopic Sphincterotomy (EST) with stone extraction followed by laparoscopic cholecystectomy.
- Simultaneous endoscopic stone extraction with laparoscopic cholecystectomy
- Combined laparoscopic cholecystectomy and CBD exploration (LCBDE)
- Open CBD exploration

- EST post cholecystectomy

Every procedure has its advantages and disadvantages and there is a broad overlap between the indications for an ideal management option in a particular clinical scenario.

Review of Literature

Literature search was performed using online search engines, Google, Pubmed, the online Springer link library and the Cochrane Database Systematic Review. Textbooks of gastrointestinal surgery and laparoscopy were also reviewed. Review articles, prospective and retrospective studies which detailed or compared the various treatment strategies for CBD stones were selected and analyzed. Case reports were not reviewed for the article.

Several studies have compared a “laparoscopic- first” approach to the management of CBD stones with the more commonly used “sequential treatment” i.e. endoscopic extraction followed by laparoscopic cholecystectomy. Laparoscopic CBD exploration involves either transcystic approach (fluoroscopy guided or choledochoscopy) or laparoscopic choledochotomy and stone extraction.

The treatment of known CBD stones—preoperative EST followed by LC vs. LCBDE was compared in two randomized control trials [8, 9]. The results of the two approaches are similar, although the length of hospital stay is shorter with LCBDE in the Cuscheiri, et al. study. The weakness inherent in these studies is that they fail to include the morbidity of negative preoperative ERCP.

Costi et al. [2] performed a case–control study comparing a single stage laparoscopic approach with sequential treatment. No difference emerged concerning early and late complications, mortality, or laparotomies needed to accomplish cholecystectomy and CBD clearance. The postoperative hospital stay was shorter in the single stage group. In this group, only 22 patients underwent choledochotomy (45 %), and 15 patients underwent perioperative ERCP (30 %). Conversions decreased with practice. After choledochotomy, an increasing number of patients underwent primary closure of the CBD (with no biliary drain), without complications. They came to the conclusion that a single stage laparoscopic approach to gallbladder/CBD tones is safe and feasible. It may allow the majority of surgeons to avoid excessively difficult/dangerous surgical procedures as well as unnecessary ERCPs in most cases. A tendency toward a lower incidence of conversions and a rarer use of biliary drains may lead to an improved immediate outcome for patients undergoing a single stage approach.

Bansal et al. [6] conducted a prospective randomized trial which compared single stage laparoscopic treatment with sequential treatment of CBD stones. 15 patients were

randomized to each group and the two groups had comparable demographic and clinical profile. In group I there was a success rate of 93.5 % in comparison with 86.7 % in group II ($p=0.32$, Fisher's exact test). The complications were similar in the two groups. The results showed equivalent success rate in terms of morbidity and hospital stay. They concluded that laparoscopic approach seems to be favorable because of the smaller number of procedures and hospital visits.

Chander et al. [13] operated on 150 patients with documented CBD stones. Of these, 4 patients underwent transcystic exploration of CBD and 146 patients had their CBD stones removed through the transcholedochal route. There were 34 men and 116 women patients with age ranging from 15 to 72 years. The mean size of the CBD on ultrasound was 11.7 ± 3.7 mm and on MRCP 13.8 ± 4.7 mm. The number of stones extracted varied from 1 to 70 and the size of the extracted stones from 5 to 30 mm. The average duration of surgery was 139.9 ± 26.3 min and the mean intraoperative blood loss was 103.4 ± 85.9 ml. There were 6 conversions to open procedures, 1 postoperative death (0.7 %), and 23 patients (15 %) had non-fatal postoperative complications. Three patients had retained stones (2 %) and one developed recurrent stone (0.7 %). In their opinion LCBDE when performed by an experienced surgeon results in no additional morbidity or mortality as compared to open surgery, with excellent success rates (98 % in this series), and thus specially benefits the subgroup of patients with multiple, large, impacted stones in a dilated CBD who were traditionally subjected to open exploration.

Karaliotas C. et al. [14] performed transcholedochal laparoscopic CBD exploration on 32 patients who had unsuccessful attempts at endoscopic CBD stone extraction. Previous operations, cholangitis, anatomic abnormalities, and stone impaction were the principal reasons for failure of ERCP. Stone extraction under direct laparoscopic choledochotomy was achieved in 20 of 31 patients (64.51 %). Biliary stents were inserted in 7 patients (21.8 %) and T tubes were placed in 21 patients (65.6 %). Five laparoscopic choledochoduodenostomies were performed. There were 11 conversions to open surgery. Morbidity was 12.5 %. The authors believed that patients with previous operations in the upper abdomen, because of adhesions, excessive fibrosis in the hepatoduodenal ligament, and altered anatomy (from Billroth II or Roux-en-Y reconstruction) and pathologic entities (Mirizzi syndrome and intrahepatic lithiasis of the left biliary tree) had the greatest relative risk of conversion to an open procedure. Stone impaction was not a predictor of method failure (odds ratio=0.44), while it has been regarded as the number one factor of failed CBD clearance in ERCP. Laparoscopic CBD exploration after failed endoscopic stone removal was shown to be very effective

(successful duct clearance was 64.51 %) despite the predicted high degree of difficulty for this patient population.

Ahmed et al. [10] compared preoperative versus intraoperative endoscopic sphincterotomy for management of CBD stones. 198 patients diagnosed preoperatively with gallbladder and CBD stones were eligible. They were randomly divided into two groups: Preoperative endoscopic Sphincterotomy (PEST)/LC group ($n=100$) and LC/Intraoperative endoscopic Sphincterotomy (IOEST) group ($n=98$). The operative duration, surgical success rate, number of stone extracted, postoperative complications, retained common bile duct stones, and postoperative lengths of stay were compared prospectively. There were no statistically significant differences in surgical time, surgical success rate, CBD diameter, stone size, or stone number between the two groups. The success rate was 95.3 % and 97.8 % for PEST/LC and LC/IOEST, respectively. There were no significant difference in postoperative retained stones, surgical time, and complications, but the total hospital stay was significantly shorter in the LC/IOEST group. They concluded that PEST/LC and LC/IOEST are both good options for dealing with preoperatively diagnosed CBDS, but when there is enough experience and facilities, LC/IOEST, as a single-stage treatment, should be preferable.

When CBD stones are discovered intraoperatively, a surgeon has to decide whether to go ahead with single stage laparoscopic management or complete the cholecystectomy followed by sequential endoscopic clearance of CBD. Two prospective randomized studies have evaluated the merits of immediate versus delayed treatment for bile duct stones. Rhodes et al. [15] randomized 80 patients at the time of diagnosis by cholangiography to either laparoscopic exploration or delayed postoperative EST. Patients were excluded if they had preoperative EST, cholangitis, or acute pancreatitis. The laparoscopic approach entailed transcystic exploration ($n=28$) of the duct followed, if necessary, by laparoscopic choledochotomy ($n=12$) in those patients with CBD exceeding 6 mm in diameter. This study showed that both techniques were associated with a 75 % successful bile duct clearance rate at the time of first intervention. Final duct clearance was not significantly different, although there was a trend towards better clearance with the laparoscopic approach. The length of hospital stay was significantly shorter with the singlestage approach (1 day, 3.5 day; $p<0.001$). There was no significant difference in morbidity (18 %, 15 %; $p=NS$) or mortality (0 %, 0 %). However, the authors concluded that the transcystic approach was preferred.

Nathanson et al. [16] conducted a study wherein they compared single stage laparoscopic management with delayed endoscopic management of intraoperatively discovered CBD stones. Patients were included only if the transcystic approach failed to clear the intraoperatively

discovered CBD stones. Eighty-six patients were randomized to laparoscopic choledochotomy or delayed postoperative EST. There were no differences between the two approaches in terms of bile duct clearance rates, morbidity, or length of hospital stay. However, the patients undergoing choledochotomy experienced a significantly higher rate of bile leak (14.6 %) from the choledochotomy. The authors conclude that both techniques are efficacious, while recognizing that the laparoscopic approach may be limited in less experienced centers.

Hong et al. [17] compared laparoscopic cholecystectomy combined with intraoperative endoscopic sphincterotomy with laparoscopic CBD exploration. For this study, 234 patients with cholelithiasis and choledocholithiasis diagnosed by preoperative B-ultrasonography and intraoperative cholangiogram were divided at random into an LC-LCBDE group (141 cases) and an LC-IOEST group (93 cases). There was no difference between the two groups in terms of surgical time, surgical success rate, number of stone extractions, postoperative complications, retained common bile duct stones, postoperative length of stay, and hospital charge. It was concluded that both LC-IOEST and LC-LCBDE were shown to be safe, effective, minimally invasive treatments for concomitant gallbladder and CBD stones.

Greca et al. [1] reviewed the simultaneous laparoendoscopic rendezvous (RV) for the treatment of CBD stones with single stage totally laparoscopic (TL) treatment and sequential treatments (ST). Data was collected from 27 papers concerning 795 patients. The overall effectiveness of RV was 92.3 %. The morbidity rate was 5.1 %, and the mortality rate was 0.37 %. Almost all the authors were satisfied with the procedure. The authors' comparison to ST and TL showed that the advantages outweigh the disadvantages mostly related to logistical problems. They were of the view that the results are at least comparable with those of the other available approaches. The effectiveness of RV is greater with reciprocal implementation of surgical and endoscopic procedures. The morbidity and the risk of iatrogenic damage seem lower than with ERCP-ES and the risk of residual stones lower than with TL treatment. The RV procedure is safe and can sometimes be the preferable option, but collaboration between surgeon and endoscopist is mandatory.

Discussion

Which Approach to Use and When?

Like gallbladder stones, CBD stones can be silent, painful or cause complications. When choosing the optimal management protocol it is important to consider all factors like

patient's physiological status, number, size and location of stones, diameter of CBD, availability of resources and most importantly the experience and expertise of the surgeon and/or endoscopist.

Stones Diagnosed Preoperatively

The general trend of management of preoperatively diagnosed CBD stones has been by ERCP with stone extraction with stenting if indicated, followed by laparoscopic cholecystectomy. However single stage LCBDE is emerging as a primary and cost effective treatment modality with less morbidity [18].

In elderly and unfit patients, ERCP and stone extraction from the CBD is the initial and probably the definitive treatment. It is also the initial treatment in patients presenting with jaundice, cholangitis or severe pancreatitis. Laparoscopic cholecystectomy is undertaken once the condition of the patient has improved. Biliary stenting is advocated for patients with large dilated CBD, multiple impacted stones or stones not completely removed by CBD [11].

For patients who are fit for surgery, the choice is between single stage operative exploration of CBD or a sequential approach i.e. preoperative or postoperative ERCP with EST along with laparoscopic cholecystectomy. ERCP has a morbidity rate of 5 to 9.8 % and a mortality rate of 0.3 to 2.3 % [19, 20], mostly due to postoperative acute pancreatitis, duodenal perforation and bleeding. Moreover it causes injury to the sphincter of Oddi which should be avoided in patients younger than 60 years [21, 22]. Recent studies indicate that one-stage management of CBD stones with LCBDE has less morbidity and mortality and is cost-effective with a short hospital stay [23]. It treats both gallstones and CBD stones in single stage compared with sequential procedures, and is performed as a daycare procedure [24]. LCBDE also preserves the function of sphincter of Oddi and hence prevents reflux-related complications, such as cholangitis and recurrent stones associated with sphincter damage [21]. Performing ERCP contextually to LC implies organizational problems concerning the availability of an endoscopist in the operating theater whenever needed. Finally, performing ERCP after surgery would raise the dilemma of managing CBD stones whenever ERCP fails to retrieve them because a third procedure would then be needed.

Reference centers for laparoscopic surgery currently propose treating both gallbladder and CBD stones during the same laparoscopic procedure [8, 19, 25]. No consensus has been achieved concerning the best approach (laparoscopic or endoscopic) because the laparoscopic management of CBD stones has not had a wide diffusion, and little is known about its long-term results. In situations where there are difficulties in performing a combined laparoendoscopic

procedure or the laparoscopic experience is limited, it is safer to perform an ERCP followed by cholecystectomy.

Stones Discovered Intraoperatively

Decision making is easier when stones are discovered intraoperatively. The available options are; (a) total laparoscopic clearance, (b) combined laparoendoscopic treatment, (c) conversion to open CBD exploration, and (d) post cholecystectomy ERCP.

If the surgeon is experienced the most appropriate treatment would be a total laparoscopic approach. Several cohort studies have shown that two thirds of the stones detected by intraoperative cholangiography can be removed via the transcystic approach [16]. For patients in whom transcystic extraction of CBD stones fails, laparoscopic choledochotomy and stone extraction may be performed. However, this approach requires experience in laparoscopic suturing and a CBD of adequate diameter. Alternative management options have been described, but have not been subjected to RCT. For example, intraoperative ES has been reported in a number of centers. This approach is wholly dependent on the availability of endoscopic expertise in the operating room. Available results, although limited, show high clearance rates in excess of 90 %, with minimal morbidity and no increase in the length of hospital stay over that of laparoscopic cholecystectomy alone [26, 27].

A Cochrane systematic review by Martin et al. [3] concluded that a single-stage treatment of bile duct stones via the cystic duct approach was recommended for intraoperatively discovered CBD stones. In patients where it is not possible to clear the duct by this approach, a delayed postoperative ES should be the preferred option in most centers. However, it was also noted that the reported experience is limited, and larger randomized trials are warranted to compare these therapeutic options.

The other alternative to immediate treatment of CBS stones discovered at surgery is delayed treatment. Surgeons can insert a biliary stent through the cystic duct into the CBD and through the sphincter of Oddi [28]. This procedure ensures access to the bile duct for postoperative ES.

A potential study when laparoscopic exploration fails might be the use of open CBDE in younger patients versus postoperative ES in older people. Open CBDE has been shown in RCTs to result in morbidity ranging from 11 % to 14 % and mortality from 0.6 % to 1 % [5]. Interestingly, Morgenstern et al. [29] reported on 220 open CBDE before the laparoscopic revolution. Their results revealed no mortality in patients under 60 years of age and 4.3 % mortality in those over 60. This suggests that patient age could affect the treatment algorithm, and that ES should be strongly considered in patients above the age of 60 [5].

Finally, the indications for a surgical drainage procedure or an EST must be considered. A Roux-en-Y hepaticojejunostomy, a choledochojejunostomy, or a surgical sphincteroplasty may be indicated for sphincter of Oddi stenosis/dysfunction, primary CBD stones, patients with duodenal diverticula, multiple CBD stones, or intrahepatic stones. Similarly, EST is indicated for patients with CBD stones with severe preoperative cholangitis or pancreatitis, and for sphincter of Oddi stenosis/dysfunction. When these indications overlap, open CBDE and EST are often complementary. However, open CBDE remains the “gold standard” for selected, rare patients such as those with Mirizzi syndrome, Billroth II anatomy, and those requiring a drainage procedure [5].

Stones Discovered Postoperatively

These patients are best managed by endoscopic clearance, which is considered as the least morbid procedure. Failure rates of up to 10 % have been reported [18]. In these situations the treatment options are either laparoscopic or open exploration depending on the surgical expertise and resources at disposal.

Conclusion

CBD stones are usually treated with sequential treatment by EST followed by laparoscopic cholecystectomy. However, recent studies indicate that single stage laparoscopic management might be the preferred option in established centres especially if the patient has multiple stones with a dilated CBD. It does not cause any damage to the sphincter of Oddi, which has been shown to result in cholangitis and recurrent CBD stones. In patients presenting with cholangitis and jaundice, it may be advisable to relieve the biliary obstruction by EST and then perform laparoscopic cholecystectomy. If laparoscopic experience is limited, it is advisable that CBD stones should be removed by either pre or postoperative EST and laparoscopic cholecystectomy. Finally if laparoscopic exploration fails it is prudent to convert to open exploration of CBD, remove the ductal stones and perform a biliary drainage procedure if indicated.

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