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Research Article

# Laparoscopic vs. Open Choledocholithiasis Interventions: Unraveling the Dominant Trends in Surgical Practice: A Single-Center, 6-Year, Retrospective Study

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## Abstract

**Background:** Surgical approaches are vital for managing common bile duct (CBD) stones, with laparoscopic CBD exploration (LCBDE) and open CBD exploration (OCBDE) being crucial. OCBDE dominated choledocholithiasis management in Taiwan from 2000 to 2013, but recent advancements favor laparoscopic techniques. However, their utilization rates remain unassessed.

**Methods:** A retrospective study of 456 choledocholithiasis patients was conducted, covering patient characteristics, preoperative tests, surgical techniques, and outcomes. Statistical tests included the chi-square test, Student's t-test, or the nonparametric Mann–Whitney U test.

**Results:** LCBDE shows advantages over OCBDE, with lower mean blood loss, fewer postoperative complications, reduced stone recurrence, and shorter hospital stays (4.7 days vs. 8 days). The trend reveals LCBDE rising from 45% in 2017 to 75% in 2022. Moreover, there is a significant decrease in T-tube utilization and a notable increase in intraoperative choledochoscopy with LCBDE.

**Conclusion:** The study highlights the evolution of choledocholithiasis management, demonstrating the superiority of LCBDE over OCBDE. Routine choledochoscopy during LCBDE could enhance primary closure rates and improve outcomes in managing choledocholithiasis.

**Keywords:** Choledocholithiasis; Laparoscopic CBD exploration (LCBDE); Open CBD exploration (OCBDE); Surgical trends

## Introduction

Choledocholithiasis refers to stones in the Common Bile Duct (CBD), which may cause CBD obstruction and result in pain, jaundice, as well as cholangitis and sepsis [1]. The prevalence of choledocholithiasis among patients undergoing cholecystectomy ranges from 4.6% to 18.8% [2,3]. There are several management options for choledocholithiasis, including non-surgical approaches, such as Endoscopic Retrograde Cholangiopancreatography (ERCP), as well as surgical procedures like Laparoscopic CBD Exploration (LCBDE) and open CBD exploration (OCBDE). Despite the popularity of two-stage management involving ERCP accompanied by Laparoscopic Cholecystectomy (LC), one-stage methods play an important role in CBD stone management because they reduce the need for additional procedures, the rate of related complications, and overall hospitalization duration, as well as medical costs [4].

Generally, the choice of method relies on the patient's clinical status and the clinician's preference. According to Taiwan's Longitudinal Health Insurance Database, between 2000 and 2013, various approaches were used, yielding diverse outcomes. Notably, among surgical methods, laparoscopic methods did not take on a predominant role over open methods in the management of choledocholithiasis during that time. Several factors contributed to this, such as the technical complexity associated with laparoscopic procedures, the limited establishment and familiarity of these techniques among surgeons, and skepticism regarding their outcomes [5]. Since the establishment of refined techniques and studies comparing the outcomes associated with open vs. laparoscopic methods, laparoscopic approaches have become more popular in recent years, and current evidence indicates that clinical outcomes associated with laparoscopic methods are comparable to those of open methods [6]. However, to our knowledge, the current utilization rates for LCBDE and OCBDE in Taiwan have not been assessed, and their trends over time have not been documented. This study aimed to investigate the evolving trends among surgeons in their choice of surgical techniques for choledocholithiasis management in recent years and explore whether LCBDE is superior to OCBDE for managing choledocholithiasis in real-world scenarios at a single medical center.

## Materials and Methods

### Study Design

This was a retrospective, single-center, observational study. It included 456 patients (242 men and 214 women; mean age, 67.2 ± 15.5 years old) who underwent CBDE for the treatment of choledocholithiasis between 2017 and 2022 at Kaohsiung Medical University Chung-Ho Memorial Hospital. Prior consent from the director of the facility and the Division of Gastroenterological Surgery for the use of the data was obtained. The indication for CBDE was symptomatic choledocholithiasis. This study was approved by the Institutional Review Board (IRB) of Kaohsiung Medical University Chung-Ho Memorial Hospital (IRB Number: KMUHIRB-E(II)-20230254). The patient characteristics collected for analyses were sex, age, symptoms (high fever and jaundice), stone number, and stone size. Biochemical tests for preoperative examination were performed, and the serum levels of white blood cells (WBCs), Glutamic Oxaloacetic Transaminase (GOT), Glutamic-Pyruvic Transaminase (GPT), creatinine, C-reactive protein (CRP), total-bilirubin, alkaline phosphatase (ALP), and γ-glutamyl transferase (γGT) were collected. Surgical and presurgical techniques, such as preoperative drainage (including percutaneous transhepatic gallbladder drainage or percutaneous transhepatic cholangial drainage, T-tube insertion, and ERCP), were also recorded. Operative outcomes, including operation time, postoperative hospitalization duration, blood loss, and surgical complications, were collected from operative notes and discharge summaries. Subsequent readmissions were scrutinized for secondary complications or stone recurrence, ensuring a comprehensive assessment of postoperative outcomes. CBD stone recurrence was defined as documented imaging of bile duct stones 6 months after the index admission and clearance, with follow-up up to October 1, 2023.

### Surgical Procedure

Both OCBDE and LCBDE procedures were performed by surgeons from the Division of General and Digestive Surgery in the Department of Surgery at Kaohsiung Medical University Chung-Ho Memorial Hospital (KMUH).

### Open Procedure

Under general anesthesia, the patient was placed in a supine position, and a right subcostal incision was made. Once the dilatated CBD was dissected free, we created a tiny choledochtomy. Intraoperative choledochoscopy was selectively performed by the surgeons to visualize and remove CBD stones. After stone removal, the small choledochotomy was closed by primary closure or T-tube insertion. The wound was then meticulously closed using Vicryl 2-0 and Vicryl 4-0 sutures.

### Laparoscopic Procedure

Under general anesthesia, the patient was placed in a supine position with the legs spread apart, and trocars were inserted after pneumoperitoneum was established. The number of the trocars was decided by the surgeon. The operations were performed using either a single-incision or triple-incision technique.

### Single Incision

Three 5-mm ports were inserted in a vertical line along a 2-cm paraumbilical incision on the left side. If required, a 2-mm right subcostal incision was made to perform an intraoperative cholangiography.

### Triple Incision

A 10-mm, 30° rigid laparoscope was inserted through an 11-mm periumbilical port for visualization. Beside the 11-mm epigastric working port, another 5-mm port was inserted at the right subcostal area. Under laparoscopic visualization, the surgeon located the distended CBD, opened it via a transcystic or transductive approach, and extracted the stones. Intraoperative choledochoscopy was selectively performed, followed by primary closure or T-tube insertion. The wound was meticulously repaired, layer by layer, with Vicryl 2-0 and Vicryl 4-0.

### Statistical Analysis

The data were entered into an Excel (Microsoft Corp., Redmond, WA, USA) workbook and analyzed using JMP® 14 (Copyright © 2018, SAS Institute Inc., Cary, NC, USA). Statistical significance was declared at a p-values <0.05. The categorical variables of patients who underwent OCBDE and LCBDE were compared using the chi-square test. Continuous variables were analyzed using either Student's t-test or the nonparametric Mann–Whitney U test, as appropriate. The results are presented as means ± standard deviations.

## Results

### Study Sample

The descriptive characteristics of the study sample are shown in Table 1.

| | Open | Laparoscopic | p vlaue |
|---|---|---|---|
| **Total** | Number (%)<br>157(%) | Number (%)<br>299(%) | |
| **Age (Mean±SD) y/o** | 70.68±14.82 | 65.39±15.62 | 0.0004* |
| **Sex** | | | |
| Male | 91(58.0) | 151(50.5) | 0.1293 |
| Female | 66(42.0) | 148(49.5) | |
| **Common bile duct dilation >1cm** | | | |
| No | 10(7.2) | 22(10.1) | 0.3434 |
| Yes | 129(92.8) | 195(89.7) | |
| **Stone number** | | | |
| Single | 18(12.2) | 32(11.2) | 0.7543 |
| Multiple | 129(87.8) | 254(88.8) | |
| **The size of stone in CBD (Mean±SD)** | 0.99±0.60 | 0.80±0.67 | 0.0013* |
| **Fever (>38.5°C)** | | | |
| No | 123(78.3) | 252(84.3) | 0.1150 |
| Yes | 34(21.6) | 47(15.7) | |

**Table 1:** Basic data of patients undergoing common bile duct exploration patient in KMUH during 2017-2022.

The OCBDE group was significantly older than the LCBDE group (mean age, 71 years vs. 65 years), but there was no difference in the gender distribution between the two groups. In terms of clinical status, there was no significant intergroup difference in CBD dilation or stone count. However, the mean size of the largest stone in the CBD was significantly larger in the OCBDE group (99±0.60 cm; range, 0.1-4 cm) than in the LCBDE group (0.80±0.67 cm; range, 0.1-3.5 cm). Preoperative blood test results (WBC count, GOT, GPT, creatinine, CRP, total bilirubin, ALP, and γGT) are summarized in Table 2.

| | Open | Laparoscopic | p vlaue |
|---|---|---|---|
| | Number (%) | Number (%) | |
| **Total** | 157(%) | 299(%) | |
| **WBC** | | | |
| <11,000 | 93(64.6) | 184(67.2) | 0.5974 |
| >11,000 | 51(35.4) | 90(32.8) | |
| **GOT** | | | |
| <40 | 54(35.1) | 61(24.4) | 0.0183* |
| >40 | 100(64.9) | 220(75.6) | |
| **GPT** | | | |
| <40 | 53(34.0) | 103(22.9) | 0.0122* |
| >40 | 103(66.0) | 226(77.1) | |
| **Creatinine** | | | |
| <1.4 | 120(77.9) | 248(87.9) | 0.0068* |
| >1.4 | 34(22.1) | 34(12.1) | |
| **CRP** | | | |
| <11 | 25(23.4) | 92(44.2) | 0.0003* |
| >11 | 82(76.6) | 116(55.7) | |
| **Total Bilirubin** | | | |
| <1.6 | 65(43.1) | 103(36.0) | 0.1519 |
| >1.6 | 86(56.9)) | 286(64.0) | |
| **ALP** | | | |
| <128 | 35(50) | 75(43.9) | 0.3854 |
| >128 | 35(50) | 96(56.1) | |
| **GGT** | | | |
| <60 | 6(11.1) | 16(12.5) | 0.7929 |
| >60 | 48(88.9) | 112(87.5) | |

**Table 2:** Laboratory data before operative intervention of OCBDE and LCBDE.

There were significant differences between the OCBDE and LCBDE groups in the preoperative mean levels of GOT (p=0.0183), GPT (p-0.0122), creatinine (p=0.0068), and CRP (p=0.0003). Patients who underwent open surgery had higher mean levels of creatinine and CRP. Moreover, there were no significant intergroup differences in mean WBC counts or in the mean levels of total bilirubin, ALP, or γGT between the two groups.

### Comparison of Operative and Preoperative Variables Between OCBDE and LCBDE

A comparison of preoperative and operative measures employed for the management of choledocholithiasis is outlined in Table 3. No significant differences were observed between the groups regarding the use of ERCP (p=0.1164) or the preoperative drainage methods used, such as percutaneous transhepatic gallbladder drainage and percutaneous transhepatic biliary drainage (p=0.5577). T-tube insertion were significantly more common in association with OCBDE (p<0.0001), whereas intraoperative choledoscopy was significantly more common in the LCBDE group (p<0.0001) (Table 3).

| | Open | Laparoscopic | p vlaue |
|---|---|---|---|
| **Total** | **Number (%)** 157(%) | **Number (%)** 299(%) | |
| **ERCP** | | | |
| No | 92(58.6) | 200(66.9) | 0.1164 |
| Pre-op | 62(39.5) | 90(30.1) | |
| Post-op | 3(1.9) | 9(3.0) | |
| **Pre-operation drainage(PTGBD/PTCD)** | | | |
| No | 124(79.0) | 243(81.3) | 0.5577 |
| Yes | 33(21.0) | 56(18.7) | |
| **T-tube** | | | |
| No | 17(10.9) | 171(57.2) | <0.0001* |
| Yes | 139(89.1) | 128(42.8) | |
| **Choledoscope** | | | |
| No | 88(56.1) | 78(26.1) | <0.0001* |
| Yes | 69(43.9) | 221(73.9) | |

**Table 3:** Comparison of Surgical and pre-surgical Parameters Between OCBDE and LCBDE for Choledocholithiasis Management.

Notably, the trend of T-tube utilization in association with LCBDE markedly decreased over time, while the usage of intraoperative choledochoscopy significantly increased (Figures 1,2) (Table 4). In 2017, most surgeons (82.9%) inserted T-tubes as part of LCBDE procedures, while by 2022, the trend had shifted significantly, with T-tube insertion being performed in only 15.5% of cases. Notably, the utilization of intraoperative choledochoscopy in association with LCBDE increased to 100% in 2022. With the significant decrease in T-tube use in the LCBDE group, we further evaluated the association of T-tube use with patient characteristics as well as operative variables in Table 5. There were significant associations between T-tube insertion during LCBDE and the number of CBD stones (p=0.0283), the use of an intraoperative choledochoscope (p<0.0001), as well as the duration of postoperative hospitalization (p=0.0046). Among patients undergoing LCBDE, the presence or absence of T-tube insertion was not significantly associated with age (p=0.1752), gender (p=0.0971), diameter of the stone in the CBD (p=0.2147), operation time (p=0.9912), complications (p=0.0905), or stone recurrence (p=0.0535). T-tube insertion was, however, associated with multiple CBD stones, lower utilization of intraoperative choledochoscopy, and longer hospital stays.

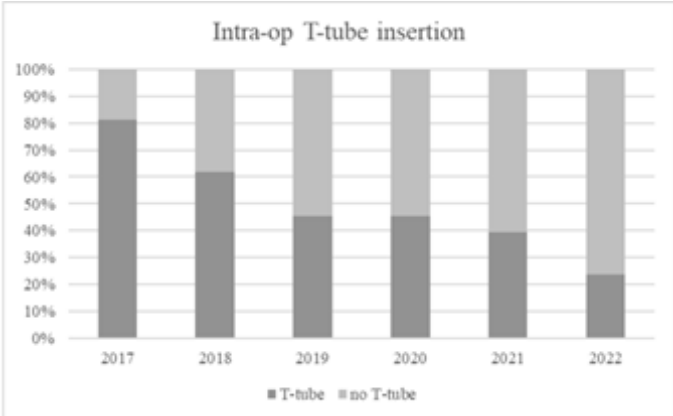


**Figure 1:** The trend of T-tube intra-operative insertion in LCBDE.


**Figure 2:** The trend of intra-operative choledochoscopy in LCBDE.

| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|
| | **Number (%)** | **Number (%)** | **Number (%)** | **Number (%)** | **Number (%)** | **Number (%)** |
| **Total** | 32(%) | 34(%) | 47(%) | 53(%) | 38(%) | 38(%) |
| **T-tube** | | | | | | |
| No | 6(18.8) | 13(38.2) | 17(36.2) | 29(54.7) | 23(60.5) | 29(76.3) |
| Yes | 26(81.2) | 21(61.8) | 30(63.8) | 24(45.3) | 15(39.5) | 9(23.7) |
| **Intra-op choledochoscope** | | | | | | |
| No | 19(59.4) | 15(44.1) | 15(31.9) | 15(28.3) | 8(21.1) | 0(0) |
| Yes | 13(40.6) | 19(55.9) | 32(68.1) | 38(71.7) | 30(79.9) | 38(100) |

**Table 4:** Number of T-tube and intra-operative choledochoscope use in LCBDE through years.

| | No T-tube | T-tube | p vlaue |
|---|---|---|---|
| | **Number (%)** | **Number (%)** | |
| **Total** | 116(%) | 115(%) | |
| **Age (Mean±SD) y/o** | 68.10±15.21 | 65.40±14.67 | 0.1752 |
| | | | **Sex** |
| Male | 54(46.9) | 66(57.9) | 0.0971 |
| Female | 61(53.1) | 48(42.1) | |
| **Number of stone** | | | |
| Multiple | 18(16.1) | 7(6.6) | 0.0283* |
| single | 94(83.9) | 99(93.4) | |
| **Size of stone** | | | |
| <0.7 cm | 60(57.7) | 48(49.0) | 0.2147 |
| >0.7 cm | 44(42.3) | 50(51.0) | |
| **Intra-op choledochoscopy** | | | |
| No | 18(15.5) | 49(42.6) | <0.0001* |
| Yes | 98(84.5) | 66(57.4) | |
| **Operation time(hr) (Mean±SD)** | 2.87±0.98 | 2.87±1.33 | 0.9912 |
| **Surgical complication** | | | |
| No | 103(89.6) | 94(81.7) | 0.0905 |
| Yes | 12(10.4) | 21(18.3) | |
| **Post-op Hospital stay (days) (Mean±SD)** | 4.31±2.01 | 5.34±3.23 | 0.0046* |
| **Recurrence** | | | |
| No | 105(90.5) | 94(81.7) | 0.0535 |
| Yes | 11(9.5) | 21(18.3) | |

**Table 5:** Impact of T-tube Insertion on Clinical Characteristics and Outcomes of Patients Undergoing LCBDE.

### Operative Outcomes

Operative outcomes of OCBDE and LCBDE are shown in Table 6.

| | Open | Laparoscopic | Relative risk (95% CI) | p vlaue |
|---|---|---|---|---|
| | **Number (%)** | **Number (%)** | | |
| **Total** | 157(%) | 299(%) | | |
| **Blood loss (Mean±SD)** | 146.73±269.45 | 42.17±94.99 | | <0.0001* |

| | | | | |
|---|---|---|---|---|
| **Operation time (Mean±SD)** | 2.11±1.04 | 3.04±1.27 | | <0.0001* |
| **Post-op hospital stay (days) (Mean±SD)** | 8.02±5.49 | 4.70±2.70 | | <0.0001* |
| **Overall hospital stay (days) (Mean±SD)** | 17.77±11.22 | 11.05±7.36 | | <0.0001* |
| **Complication** | | | | |
| No | 121(77.6) | 259(87.2) | 1.757 (1.167-2.648) | 0.0066* |
| Yes | 36(22.4) | 38(12.8) | | |
| **Residual stone** | | | | |
| No | 150(95.5) | 288(96.3) | 1.212 (0.479-3.064) | 0.6846 |
| Yes | 7(4.5) | 11(3.7) | | |
| **Recurrence** | | | | |
| No | 132(84.1) | 278(92.7) | 2.171 (1.266-3.724) | 0.0041* |
| Yes | 25(15.9) | 22(7.3) | | |

**Table 6:** Comparative Analysis of Surgical Outcomes Between LCBDE and OCBDE for CBD Stone Management.

One death occurred in the OCBDE group, and no deaths were observed in the LCBDE group. The mean blood loss was significantly higher in the OCBDE group than in the LCBDE group (146.73±269.45 mL vs. 42.17±94.99 mL, p<0.0001). Postoperative complications were observed in 12.8% of patients in the LCBDE group and 22.4% of patients in the OCBDE group (p=0.0066, Relative risk = 1.757, 95%CI= 1.167-2.648). The most common complication reported in both groups is bile leakage, accounting for 11.4% in the OCBDE group and 7.7% in the LCBDE group. The second most common complication is infection, which includes wound or intraabdominal infection. In the OCBDE and LCBDE groups, they account for 9.5% and 4%, respectively (Table 7).

| **Complication** | **OCBDE (n=157)** |
|---|---|
| bile leak | 18(11.4%) |
| infection | 15(9.5%) |
| Hypovolemic shock | 3(1.9) |
| **Complication** | **LCBDE (n=299)** |
| bile leak | 23(7.7%) |
| infection | 12(4%) |
| Ascites | 1(0.3%) |
| Hypovolemic shock | 1(0.3%) |
| paralytic ileus | 1(0.3%) |

**Table 7:** Surgical complication reported in OCBDE and LCBDE.

Furthermore, there was a significant difference in the recurrence rates between the two groups (p=0.0041). However, there was no statistically significant difference (p=0.6846, Relative risk=1.212, 95%CI=0.479-3.064) in the incidence of residual stones requiring secondary management within 6 months between OCBDE and LCBDE. The mean operation duration for OCBDE was 2.11 hours (range, 1-7 hours), while for LCBDE, it was 3.04 hours (range, 2-9 hours). There was a significant difference between the laparoscopic and open procedures in terms of mean operative duration (p< 0.0001), with the OCBDE group having a significantly shorter duration. The mean postoperative hospital stay after OCBDE was 8 days, compared with 4.7 days for LCBDE. This difference was statistically significant, with LCBDE favored due to its shorter recovery period(p<0.0001).

### The Evolution of Choledocholithiasis Management

The trend of surgeons managing CBD stones is shown in Table 8 and Figure 3. The analysis revealed a substantial increase in the adoption of laparoscopic techniques for choledocholithiasis management over the study period. In 2017, open surgery accounted for more than half (55%) of the choledocholithiasis cases, while laparoscopic procedures constituted the remaining 45%. However, by 2022, the trend had shifted significantly, with laparoscopic approaches representing 75% of cases, whereas open surgeries had been reduced to 25%.

| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|
| | Number (%) | Number (%) | Number (%) | Number (%) | Number (%) | Number (%) |
| **Total** | 82(%) | 53(%) | 79(%) | 86(%) | 81(%) | 76(%) |
| **OCBDE** | 47(57.3) | 23(43.4) | 30(38.0) | 18(20.9) | 22(27.2) | 18(23.6) |
| **LCBDE** | 35(42.7) | 30(56.6) | 49(62.0) | 68(79.1) | 59(73.8) | 58(76.4) |

**Table 8:** Surgeon managing choledocholithiasis through years.

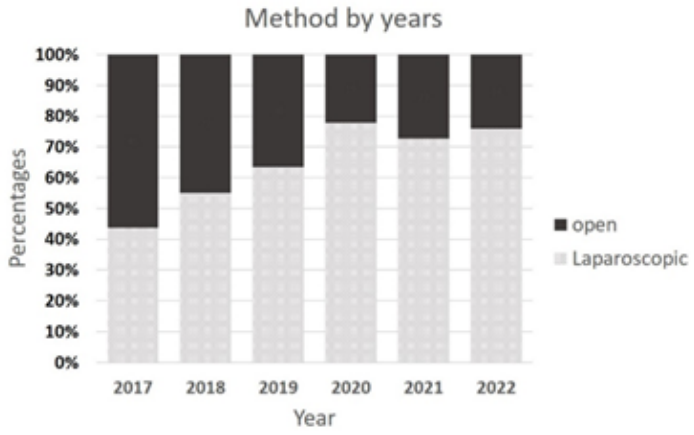


**Figure 3:** Trend of surgeon managing choledocholithiasis.

## Discussion

In the last decade, OCBDE has been the preferred choice for surgeons in Taiwan when it comes to choledocholithiasis, primarily due to the lack of experience in laparoscopic methods. Some surgeons are not convinced that LCBDE and its surgical outcomes are as reliable as other treatments [5]. In recent years, the surgical management of choledocholithiasis has entered a new era. In the hands of skilled practitioners, LCBDE has emerged as the preferred treatment for choledocholithiasis over OCBDE [7]. Consistent with our study, compared to the open approach, laparoscopic management for bile duct stones has been reported to lead to less intraoperative bleeding [8] and to result in shorter hospital stays [9-11] even in patients with a history of previous biliary surgery [12].

This study included a comprehensive analysis of choledocholithiasis management strategies, focusing on OCBDE and LCBDE techniques. The study sample was meticulously described, showcasing significant differences between the two surgical methods with regard to patient age, biochemical levels, and operative outcomes. Notably, patients in the OCBDE group were significantly older than those in the LCBDE group. An important finding was the longer operation times associated with LCBDE, potentially leading to extended durations of anesthesia. This finding underlines the surgeon's consideration for anesthesia duration, especially for older patients, impacting the choice of surgical technique. As for the biochemistry aspect, the study showed that CRP was associated with a preference for laparoscopic procedures. According to Díaz-Flores et al., CRP can be considered a predictor of difficult laparoscopic cholecystectomy in patients with acute cholecystitis, with a CRP cut-off of 11 mg/dL. This finding aligns with our observation that CRP levels higher than 11 mg/dL were significantly more common among patients undergoing OCBDE compared to those in the LCBDE group [13].

In terms of operative techniques, the study demonstrated notable distinctions, with OCBDE procedures being associated with more utilization of T-tube insertion. T-tube insertion is a well-established surgical approach employed to ensure the drainage of bile in the CBD due to temporary swelling and to facilitate postoperative CBD exploration. However, patients with a T-tube experience longer operating times and hospital stays, and there is an apparent lack of evidence regarding the benefits of T-tube insertion on clinically important postoperative outcomes [14,15]. The OCBDE group's significantly higher T-tube insertion rates may be attributable to the experience passed down by senior surgeons, who traditionally opt for T-tube placement in open procedures to decompress the CBD and to facilitate the extraction of residual stones through the T-tube [16]. In association with LCBDE, several studies support primary closure over T-tube drainage [17-20]. We delved into the characteristics of patients who underwent LCBDE to ascertain if a T-tube was inserted. The trends in intraoperative T-tube insertion and choledochoscope usage were contrasting. Increased choledochoscope use may result in a clearer visual field and improved clearance, thereby reducing the necessity for T-tube insertion [16,21,22]. Moreover, surgeons tend to place T-tubes in patients with multiple CBD stones, regardless of stone size. We found the insertion of a T-tube to be associated with a longer postoperative hospital stay but not with stone recurrence or complication rates. Surprisingly, there was no significant difference in operation times associated with T-tube insertion. This could have been due to the additional time

required for choledochoscopy or due to the significant variations in experience among surgeons, leading to substantial differences in surgical duration and preventing statistically significant results.

There were significant intergroup differences in operative outcomes. OCBDE was associated with a higher mean blood loss volume but a shorter mean operation duration. However, LCBDE was associated with shorter hospital stays and a lower complication rate, highlighting its advantages in terms of patient recovery and reduced postoperative issues. Regarding the recurrence rate, in the past, there has been skepticism about the higher recurrence rate of choledocholithiasis [23,24]. Though this study's findings shed light on the decreased recurrence rates associated with LCBDE in choledocholithiasis management, the results need to be interpreted carefully as selection bias may influence the outcome. According to Parra et al., the only independent risk factor for choledocholithiasis recurrence following LCBDE is age, with the elderly being at higher risk for stone recurrence [25]. Apart from age or surgical intervention, there are multiple other risk factors influencing the stone recurrence rate, including CBD anatomy (diameter, angulation), genetics, and previous biliary tract surgery [26]. Therefore, more study is needed to elucidate the relationship between LCBDE and a lower recurrence rate of CBD stones.

A skilled LCBDE surgeon requires a comprehensive grasp of biliary anatomy and adeptness in interpreting intraoperative cholangiography, mastering diverse approaches to the CBD, including transcystic and transductal methods. Expertise in various stone extraction techniques, such as flushing, balloon extraction, basket extraction, and choledochoscopy, is essential. Furthermore, the surgeon must demonstrate exceptional skill in intracorporeal suturing during choledochotomy, showcasing precision and finesse in their surgical interventions. Additionally, substantial experience is required to master these techniques, ensuring a surgeon's proficiency in handling complex cases and delivering optimal patient outcomes. The learning curve for LCBDE has been investigated in several studies. According to Durán et al., a single surgeon's learning curve for LCBDE may consist of approximately 60 cases, provided that proper training is available [27]. Additionally, Zhu et al. determined a figure of approximately 54 cases [28]. Although a systematic review has been conducted, studies reporting the number of cases required to master LCBDE have been heterogeneous, making it challenging to obtain a precise answer [29]. However, there is no doubt that mastering this skill demands significant effort and dedication.

## Limitations

While the study provides valuable insights into the management trends of choledocholithiasis, several limitations should be acknowledged. First, the study was conducted at a single medical center, which might limit the generalizability of the findings. Regional variations in surgical practices and patient demographics could affect the results. Second, this was a retrospective study, which may introduce bias in data collection and limit the availability of comprehensive information. Third, the study's reliance on existing hospital records might result in missing or incomplete data, thereby affecting the overall analysis. Lastly, the study did not extensively evaluate the role of surgical expertise and experience in outcomes. Surgical skill levels and experience significantly impact the success rates of most procedures.

## Conclusion

This retrospective study has offered valuable insights into the evolution of choledocholithiasis management. According to Taiwan's Longitudinal Health Insurance Database during 2000 to 2013, LCBDE has been shown to be superior to OCBDE in managing choledocholithiasis, attributable to the gradually maturing techniques, which lead to shorter hospital stays, lower complication rates, and reduced recurrence rates. The trend depicted reflects a paradigm shift from open procedures to laparoscopic techniques, aligning with global surgical advancements. The increasing predominance of LCBDE underscores the surgical community's growing confidence in these methods, emphasizing their efficacy, safety, and improved patient outcomes. Additionally, routine choledochoscopy usage to extract CBD stones will likely increase the rate of primary closure and facilitate the superior outcomes of LCBDE in the management of choledocholithiasis.

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