Meta-analysis of single-stage versus two-staged management for concomitant gallstones and common bile duct stones

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Abstract

Objective: The purpose of this article was to compare the effectiveness and safety of single-stage (laparoscopic cholecystectomy [LC] plus laparoscopic common bile duct exploration [LCBDE]) with two-stage (LC plus endoscopic retrograde cholangiopancreatography (ERCP)/endoscopic sphincterotomy [EST]) in management for concomitant gallstones and common bile duct (CBD) stones.

Materials and Methods: Systematic review and meta-analysis of randomised controlled trials (RCTs) comparing outcomes following single-stage with two-stage management for concomitant gallstones and CBD stones published from 1990 to 2017 in PubMed, Embase and the Science Citation Index. The primary outcomes were stone clearance from the CBD, post-operative morbidity and mortality. The secondary outcomes were retained stone, conversion to other procedures, length of hospital stay and total operating time. Pooled risk ratio (RR) or weighted mean differences (WMD) with 95% confidence intervals (95% CIs) were calculated using either the fixed effects model or random effects model.

Results: Eleven RCTs studies were included in this analysis. These studies included a total of 1338 patients: 666 underwent LC + LCBDE and 672 underwent LC + ERCP/EST. The meta-analysis showed that no significant difference was noted between the two groups regarding CBD stone clearance (RR: 1.06; 95% CI: 0.99–1.14; P = 0.12), post-operative morbidity (RR: 1.03; 95% CI: 0.79–1.34; P = 0.81), mortality (RR: 0.30; 95% CI: 0.06–1.41; P = 0.13), retained stone (RR: 0.91; 95% CI: 0.57–1.47; P = 0.71), conversion to other procedures (RR: 0.80; 95% CI: 0.55–0.16; P = 0.23), length of hospital stay (WMD: 1.24, 95% CI: 25.42, 95% CI: 3.57–1.09, P = 0.30), total operating time (WMD: 25.42, 95% CI: 22.38–73.22, P = 0.30).

Conclusion: Single-stage is efficient and safe in the treatment of patients with concomitant gallstones and CBD stones while avoiding the second procedure. In selected patients, single-stage management for concomitant gallstones and CBD stones might be considered as the preferred approach. However, the findings have to be carefully interpreted due to the existence of heterogeneity, in addition, patient’s condition, operator’s experience also should be taken into account in making treatment decisions.

Keywords: Common bile duct stones, endoscopic retrograde cholangiopancreatography, endoscopic sphincterotomy, gallstones, laparoscopic cholecystectomy, laparoscopic common bile duct exploration, meta-analysis

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INTRODUCTION

Choledocholithiasis is identified in approximately 3%–10% of patients with cholelithiasis,[1] standard treatment for concomitant gallstones and common bile duct (CBD) stones in the preendoscopy and era was open cholecystectomy and CBD exploration. With the advent and development of endoscopic and laparoscopic techniques, a range of minimally invasive therapeutic strategies has been used in the management of concomitant gallstones and CBD stones patients, such as endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic sphincterotomy (EST), laparoscopic CBD exploration (LCBDE). Currently, as evolved and refinements in laparoscopic techniques and equipment, with increasing experience of surgeons, more and more centres prefer conducting LCBDE to remove CBD stones. LCBDE has the advantage of being a minimal access procedure, and it avoids the disruption of the intact sphincter of Oddi, the morbidity and mortality associated with ERCP as well as the need for multiple procedures.[2] However, it is still unclear whether laparoscopic cholecystectomy (LC) plus LCBDE (the single-stage) is superior to LC with ERCP/EST (the two-stage). Therefore, we conducted this meta-analysis of all of the randomised controlled trials (RCTs) to compare the clinical effectiveness and safety between the two minimally invasive techniques in the treatment of patients with gallstones and CBD stones and provide the most appropriate approach for patients with choledocholithiasis.

MATERIALS AND METHODS

Study selection
To identify all relevant studies that compared outcomes following single-stage with two-stage management for concomitant gallstones and CBD stones, electronic searches were performed of the PubMed, Embase and the Science Citation Index from January 1990 to December 2017. The following terms were used: ‘concomitant’, ‘gallstones’, ‘CBD stones’, ‘LC’, ‘LCBDE’, ‘EST’, ‘ERCP’ and ‘gallstones’. Reference lists of all retrieved articles were manually searched for additional studies. The language was restricted to English only.

Criteria for inclusion and exclusion
The inclusion criteria for study in the meta-analysis were as follow: (1) the type of study was RCTs; (2) type of participants, patients with confirmed or suspected CBD stones with gallstones or those with gallstones that were found to have CBD stones at LC by intraoperative cholangiography; (3) intervention, pre-operative ERCP/EST plus LC versus LC plus LCBDE or post-operative ERCP/EST plus LC versus LC plus LCBDE, (4) report on at least one of these outcomes: stone clearance from the CBD, post-operative morbidity and mortality, retained stone, conversion to other procedures, length of hospital stay, total operating time; (5) if publications reported on the same study population, then the most informative article was included.

The following studies were excluded: (1) non-randomised trials; (2) retrospective analyses and reviews; (3) abstracts, letters, editorials and expert opinions; (4) studies lack control group or the control group was unreasonable; (5) studies comparing intraoperative ERCP/EST plus LC with LC plus LCBDE and (6) studies were impossible to extract or calculate data of interest.

Data extraction and outcomes of interest
Two reviewers (Li ZQ and Sun JX, respectively) independently extracted the following parameters from each study: (1) first author, year of publication and country; (2) number of patients in each group, median age of patients, gender composition, study design and quality of study; (3) treatment outcomes include stone clearance from the CBD, post-operative morbidity and mortality, retained stone, conversion to other procedures, length of hospital stay, total operating time. All relevant text, tables and figures were reviewed for data extraction. Discrepancies between the two reviewers were resolved by consensus discussion or asking the third evaluator to evaluate the article.

Statistical methods
The meta-analysis was performed using the Review Manager (RevMan) software, version 5.1. Pooled risk ratio (RR) or weighted mean differences (WMD) with 95% confidence intervals (95% CIs) were calculated for dichotomous outcomes and continuous outcomes, respectively. Statistical heterogeneity among the studies was evaluated by the Cochran Chi-square test (the test level was set to $\alpha = 0.1$), and the size of the heterogeneity was assessed using the $I^2$ statistic, in which $I^2 >50\%$ indicated significant heterogeneity. A fixed-effects model was used when no heterogeneity was detected, which means that there was no variances among studies. If significant heterogeneity existed, random-effects model was used for meta-analysis. The estimates of the means and standard deviations (SDs) were required to calculate the CIs for continuous data. However, a few published clinical trials reported a median and a range instead of a mean and SD To adjust for this difference, we assumed that the median was equal to the mean, and we estimated the SD according to the reported range odd ratio 95% CI.[3] Results were considered
statistically significant when \( P < 0.05 \). Publication bias was qualitatively evaluated using funnel plots.

**Assessment of the study quality**

The quality and bias risk of the included studies was evaluated using the tool recommended by the Cochrane Review Handbook 5.1, there are six aspects: (1) random allocation method; (2) allocation scheme hidden; (3) whether the survey object, treatment plan implementer or result measure was blinded; (4) the completeness of the resulting data; (5) selective reporting of findings and (6) other bias sources. The two reviewers independently read the full text and conducted a quality evaluation and then cross-checked the results of the quality evaluation of the trials that were difficult to determine by discussion or by the third evaluator.

**RESULTS**

**Selections of trials and patients characteristics**

According to the search strategy described previously, the abstracts and titles of 877 primary relevant studies were indentified for initial review. Based on the selection and exclusion criteria, reviewers identified 43 potential studies for full-text review. On further review, 23 were excluded because they were non-randomised trials, 3 were excluded because they were duplicated trials, 1 was abstracts and another 5 articles were eliminated due to they compared LC plus intraoperative ERCP/EST with LC plus LCBDE. Finally, a total of 11 studies published between 1990 and 2017 matched the selection criteria and were therefore included in this meta-analysis. There were eight trials comparing LC plus pre-operative ERCP/EST with LC plus LCBED and three trials comparing LC plus post-operative ERCP/EST with LC plus LCBED. Figure 1 shows the search process.

All these studies include a total of 1338 patients: 672 treated with LC plus ERCP/EST (two-stage group) and 666 treated with LC plus LCBDE (single-stage group). The key characteristics, outcomes of the studies and the summary of meta-analysis are listed in Tables 1-3. The risk of bias for the include studies is summarised in Figures 2 and 3.

**Common bile duct stone clear rate**

All the studies reported the data of CBD stone clear rate. The success rates of CBD stone clearance was 91.59% (523 of 571) in the single-stage group and 85.74% (493 of 575) in the two-stage group. There was no significant difference in CBD stone clear rate between the two group (RR: 1.06; 95% CI: 0.99–1.14; \( P = 0.12 \)) [Figure 4].

**Post-operative morbidity**

All the studies reported the data of post-operative morbidity. Overall post-operative morbidity occurred

in 14.20% (91 of 641) of patients in the single-stage group and 13.93% (90 of 646) of patients in the two-stage group. The meta-analysis demonstrated that there was no statistically significant difference between the two groups (RR: 1.03; 95% CI: 0.79–1.34; \( P = 0.81 \)) [Figure 5].

**Mortality**

All the studies reported the data of mortality. The rates of mortality were 0.16% (1 of 612) in the single-stage group and 0.96% (6 of 624) in the two-stage group. No statistically significant difference was found between the two groups (RR: 0.30; 95% CI: 0.06–1.41; \( P = 0.13 \)) [Figure 6].

**Retained stone rate**

Six studies reported the data of retain stone rate. The rates of retain stone were 7.11% (28 of 394) in the single-stage group and 7.88% (32 of 406) in the two-stage group. The summarised estimate suggested that the rate of retained stone between the two groups was not significantly different (RR: 0.91; 95% CI: 0.57–1.47; \( P = 0.71 \)) [Figure 7].

**Conversion to other procedure**

All the studies reported the data on conversion to other procedure. The conversion rate in the single-stage group and two-stage group were 6.71% (43 of 641) and 8.67% (56 of 646), respectively. There was no significant difference between the two groups (RR: 0.80; 95% CI: 0.55–1.16; \( P = 0.23 \)) [Figure 8].
### Table 1: Characteristics of studies included in the meta-analysis

| Years | First author | Country | Type of study | Total number of patients | LC + LCBDE | LC + ERCP/EST |
|-------|--------------|---------|---------------|--------------------------|------------|--------------|
|       |              |         |               | Number of patients | Sex (male/female) | Age (years) | Number of patients | Sex (male/female) | Age (years) |
| 1999  | Cuschieri et al. | Scotland | RCT | 300 | 150/90 | 19-88 | 150/108 | 18-89 |
| 2002  | Sgourakis [11] | Greece | RCT | 78 | 36/21 | 43-88 | 42/25 | 46-89 |
| 2005  | Nathanson et al. | Australia | RCT | 86 | 41/25 | 56.1 (17-91) | 45/28 | 53.6 (18-92) |
| 2009  | Noble et al. [7] | The UK | RCT | 91 | 44/28 | 75.9 (70-80.8) | 47/22 | 74.3 (70-78.9) |
| 2010  | Bansal et al. | India | RCT | 100 | 15/11 | 47.1 (34-72) | 15/10 | 39.0 (23-64) |
| 2010  | Rogers et al. | America | RCT | 112 | 57/40 | 39.9±1.9 | 55/39 | 44.6±1.9 |
| 2013  | Koc et al. [10] | Turkey | RCT | 111 | 57/37 | 51.5±16.6 | 54/36 | 54.9±17.9 |
| 2014  | Bansal et al. | India | RCT | 168 | 84/61 | 45.1±15.1 | 84/50 | 43±13.7 |
| 2014  | Ding et al. | China | RCT | 221 | 110/57 | 58.42±7.21 | 111/58 | 57.5±13.6 |
| 2016  | Barreras González et al. | Cuba | RCT | 88 | 43/3 | - | - | - |
| 2016  | Lv et al. [14] | China | RCT | 53 | 29/9 | 61±14.5 | 24/9 | 63.5±12.4 |

RCT: Randomized controlled trial, CBD: Common bile duct, LC: Laparoscopic cholecystectomy, ERCP: Endoscopic retrograde cholangiopancreatography, LCBDE: Laparoscopic CBD exploration, EST: Endoscopic sphincterotomy

### Table 2: Outcomes of the 13 included randomised controlled trials (laparoscopic cholecystectomy + laparoscopic common bile duct exploration) versus (laparoscopic cholecystectomy-endoscopic retrograde cholangiopancreatography/endoscopic sphincterotomy)

| Included studies | Stone clearance from the CBD (%) | Retained stone (%) | Post-operative morbidity (%) | Mortality (%) | Conversion to other procedures (%) | Total operating time (min) | Length of hospital stay (day) |
|------------------|--------------------------------|-------------------|-----------------------------|---------------|----------------------------------|---------------------------|-----------------------------|
|                  | LC + LCBDE | LC + ERCP | LC + LCBDE | LC + ERCP | LC + LCBDE | LC + ERCP | LC + LCBDE | LC + ERCP | LC + LCBDE | LC + ERCP | LC + LCBDE | LC + ERCP | LC + LCBDE | LC + ERCP | LC + LCBDE | LC + ERCP |
| 1999 Cuschieri    | 82.6 | 83.7 | Not mentioned | 15.8 | 12.5 | 0.8 | 1.5 | 15 | 14.7 | Not mentioned | 6 (4.2-12) | 9 (5.5-14) |
| 2002 Sgourakis   | 85.7 | 84.3 | Not mentioned | 17.9 | 18.8 | 0 | 3.1 | 14.3 | 15.6 | 90 (70-310) | 105 (60-255) | 3 (2-7) | 7.4 |
| 2005 Nathanson   | 97.6 | 71.1 | 2.4 | 4.4 | 17.1 | 13.3 | 0 | 2.4 | 6.7 | 158.8 | 147.9 | 6.4 | 7.7 |
| 2009 Noble       | 100 | 55.6 | Not mentioned | 43.2 | 29.8 | 0 | 9.1 | 42.6 | Not mentioned | 5 (2-7) | 3 (2-7) |
| 2010 Bansal      | 86.7 | 93.3 | Not mentioned | 15.3 | 13.3 | 0 | 6.7 | 15.4 | 153 (120-240) | Not mentioned | 4 (3-9) | 4.2 (2-11) |
| 2010 Rogers      | 88.2 | 96.8 | Not mentioned | 10.5 | 9.1 | 0 | 3.5 | 1.8 | 174 (67) | 183 (39) | 5.3 (3.2) | 6.6 (4.0) |
| 2013 Koc         | 96.5 | 94.4 | 3.5 | 5.5 | 7.0 | 11.1 | 0 | 0 | 1.9 | 93.47 (32.06) | 113.33 (36.07) | 3 | 6 |
| 2014 Bansal      | 88.1 | 79.8 | 3.6 | 0 | 23.8 | 22.6 | 0 | 3.6 | 8.3 | 3.6 | 135.7 (36.6) | 72.4 (27.6) | 4.6 (2.4) | 5.3 (6.2) |
| 2014 Ding        | 93.6 | 94.6 | Not mentioned | 3.6 | 5.4 | 0 | 2.7 | 0.9 | Not mentioned | Not mentioned | Not mentioned | |
| 2016 Gonzalez    | 97.7 | 93.3 | 2.3 | 11.1 | 4.7 | 13.3 | 0 | 0 | 0 | 17 (40-270) | 9.8 (30-240) | 2.1 | 3.1 |
| 2016 Lv          | 96.6 | 100 | Not mentioned | 3.4 | 12.5 | Not mentioned | 0 | 0 | 0 | Not mentioned | 6.72 (1.3) | 10.91 (1.6) |

SD: Standard deviation, CBD: Common bile duct, LC: Laparoscopic cholecystectomy, ERCP: Endoscopic retrograde cholangiopancreatography, LCBDE: Laparoscopic CBD exploration

### Figure 2: Risk of bias graph: Review authors' judgements about each risk of bias item presented as percentages across all included studies

The total operative time

There were five trials include information about the total operative time, among them, two trials offered the median and the range instead of the total operative time. Consequently, according to our predefined plan, we presumed that the median was equal to the mean, and we equated the SD according to the reported range. Significant heterogeneity was found among the trials ($\chi^2 = 170.60, P < 0.00001$, $F = 98\%$), and the meta-analysis indicated no statistically
significant difference between the two groups (WMD: 25.42, 95% CI: 22.38–73.22, P = 0.30) [Figure 9].

Length of hospital stay
There were six trials include information about the length of hospital stay,[4,7,9,11,14] three studies[9,11,14] reported this data in the form of the mean and the SD One study[10] provided the mean and the 95% CI, and the rest of studies[7,8] provided the median and the range. According to our predefined plan, we presumed that the median was equal to the mean, and we equated the SD according to the reported range or 95% CI. Significant heterogeneity was found among the trials (χ² = 264.07, P < 0.00001, I² = 98%), and the meta-analysis indicated no statistically significant difference between the two groups (WMD: 1.24, 95% CI: 3.57–1.09, P = 0.30) [Figure 10].

Test for publication bias
Funnel plots of the study results are shown in Figure 11. The funnel plots on stone clearance from the CBD in included studies demonstrated asymmetrical, indicating the presence of publication bias [Figure 11].

DISCUSSION
There are various therapeutic options such as ERCP, LCBDE or open CBD exploration for the management of common gallbladder stones and CBD stones. ERCP and LCBDE are the two most ideal of mini-invasive strategies, which are widely used in patients with cholelithiasis.[15,16] Although both endoscopic and laparoscopic techniques have evolved considerably with refinement in equipment and technique, the optimal treatment for concomitant gallbladder stones and CBD stones is still uncertain.[9,17]

The purpose of this study was to compare the efficacy, safety and the surgical outcomes of LC + LCBDE with LC + ERCP/EST and determine the most

### Table 3: Summary of meta-analysis

| Comparison or outcome          | Number of studies | Number of participants | Statistical method | Effect size | P       | Test for heterogeneity |
|-------------------------------|-------------------|------------------------|--------------------|-------------|---------|------------------------|
| Common bile duct stones clearance | 11                | 1146                   | RR (random), 95% CI | 1.06 (0.99-1.14) | 0.12    | 33.84                  | 0.0002 | 70 |
| Post-operative morbidity      | 11                | 1287                   | RR (fixed), 95% CI  | 1.03 (0.79-1.34) | 0.81    | 6.53                   | 0.77   | 0 |
| Mortality                     | 10                | 1236                   | RR (fixed), 95% CI  | 0.30 (0.06-1.41) | 0.13    | 0.46                   | 0.80   | 0 |
| Retained stone                | 6                 | 800                    | RR (fixed), 95% CI  | 0.91 (0.57-1.7)  | 0.71    | 4.19                   | 0.52   | 0 |
| Conversion to other procedures| 11                | 1287                   | RR (fixed), 95% CI  | 0.80 (0.55-1.16) | 0.23    | 0.26                   | 0.13   | 36 |
| Total operating time          | 5                 | 539                    | WMD (random), 95% CI| 25.42 (−22.38–73.22)| 0.50    | 170.60                 | <0.00001 | 98 |
| Length of hospital stay       | 6                 | 754                    | WMD (random), 95% CI| −1.24 (−3.57–1.09)| 0.30    | 264.07                 | <0.00001 | 98 |

RR: Risk ratio, CI: Confidence interval, WMD: Weighted mean differences
appropriate approach for patients with cholelithiasis. The meta-analysis showed that no significant difference was noted between the two groups in terms of CBD stone clearance (RR: 1.06; 95% CI: 0.99–1.14; P = 0.12), post-operative morbidity (RR: 1.03; 95% CI: 0.79–1.34; P = 0.81), mortality (RR: 0.30; 95% CI: 0.06–1.41; P = 0.13), retained stone (RR: 0.91; 95% CI: 0.57–1.47; P = 0.71), conversion to other procedures (RR: 0.80; 95% CI: 0.55–1.16; P = 0.23), length of hospital stay (WMD: 1.24, 95% CI: 3.57–1.09, P = 0.30), total operating time (WMD: 25.42, 95% CI: 22.38–73.22, P = 0.30).

ERCP with the EST has become the most common intervention for CBD stones after its introduction in the 1970s.[12] The overall success rate of ERCP is well
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Figure 8: Results of the meta-analysis on conversion to other procedures single-stage stage (LC: Laparoscopic cholecystectomy plus, LCBDE: Laparoscopic common bile duct exploration) versus two-stage (LC plus ERCP: Endoscopic retrograde cholangiopancreatography, EST: Endoscopic sphincterotomy)

Figure 9: Results of the meta-analysis on total operating time single-stage stage (LC: Laparoscopic cholecystectomy plus, LCBDE: Laparoscopic common bile duct exploration) versus two-stage (LC plus ERCP: Endoscopic retrograde cholangiopancreatography, EST: Endoscopic sphincterotomy)

Figure 10: Results of the meta-analysis on length of hospital stay single-stage (LC: Laparoscopic cholecystectomy plus LCBDE: Laparoscopic common bile duct exploration) versus two-stage (LC plus ERCP: Endoscopic retrograde cholangiopancreatograph, EST: Endoscopic sphincterotomy)

Figure 11: Funnel plot on stone clearance from the common bile duct

established at about 95% in experienced hands. ERCP avoided the complexities of laparoscopic choledochoectomy and potential problems from T-tube drainage (TTD), but underwent two procedures. ERCP has some but not at all rare failure-related factors, such as post-surgical gastrointestinal anatomic variations (Billroth II), duodenal diverticulum, embedded stones in the ampulla, intrahepatic bile duct stones and CBD strictures.[12,18]

There was a gap period between ERCP and LC, which may cause CBDs recurrences. The time interval between endoscopic papillotomy and LC is controversial. de Vries et al.[19] have shown higher conversion rate when
the cholecystectomy was done more than 2 weeks after EST. Allen et al.\[26,27\] and Donkervoort et al.\[21\] also reported greater difficulty and higher complication rate with LC after ERCP, due to the inflammation and fibrosis in and around Calot’s triangle after ERCP. However, for indications of severe cholangitis, severe biliary pancreatitis and possibly persistent obstructive jaundice ERCP are irreplaceable because it can release biliary obstruction in a timely fashion.

LCBDE has the advantage of being a minimal access procedure, and it is a one-step procedure compared with ERCP. The single-stage treatment provided a single intervention which dealt with all the problems in one step in most patients. With advances in technology and laparoscopic techniques primary LCBDE currently is challenging the present standard of ERCP followed by LC for patients with gallbladder and CBD stones. Since the first experiences reported in 1991, this procedure has been performed together with new technologies and has become the star for laparoscopic management of the CBD stones over the past few decades. LCBDE by an experienced laparoscopic surgeon is currently considered as effective as ERCP.\[10,22\] Sgourakis and Karaliotas\[9\] showed equivalent clearance rate between single-stage and two-stage procedures. Rogers et al.\[10\] in their study also found similar clearance rates. Noble et al.\[7\] reported better success rates for laparoscopic than endoscopic, even for high-risk patients, with no increase in the complication rate or hospital stay. In this meta-analysis, we found that there was no statistically significant difference between one-single group and two-stage group about the CBD stone clearance. However, the success rate in single-stage group is higher than two-stage group.

The post-operative morbidity was similar between the single stage (14.20%, 91 of 641) and two stage (13.93%, 90 of 646), with no statistically significant. LC-ERCP requires two periods of anaesthesia and occasionally two hospital admissions. In addition, ERCP can also be followed by short-term complications,\[23,24\] including pancreatitis, bleeding, perforation and cholangitis. Third, the sphincter of Oddi is destroyed by sphincterotomy, resulting in permanent loss of the biliary sphincter function and damage to the sphincter barrier which prevents duodenobiliary reflux.\[12\] Reflux from the duodenum into the bile duct is associated with a high rate of recurrent cholangitis following sphincterotomy\[25\] and this can lead to CBD stone formation, and also increased the risk of cholangiocarcinoma related to post-sphincterotomy cholangitis could be found in the long term.\[26,27\] The most common complication for LCBDE is bile leak, which is associate with T-tube usage. TTD has been routinely adopted after choledochotomy, not only for post-operative bile duct decompression to decrease biliary complications, such as biliary stricture but also for post-operative cholangiography to detect any residual stones and provide access for trans-T-tube tract stone removal.\[28,29\] In addition, the bile drainage tube must remain in situ for approximately 2 weeks before removal, and this can cause some discomfort. Nevertheless, according to a recent meta-analysis,\[30\] primary closure might be as effective as TTD in the prevention of post-operative complications after choledochotomy. Consequently, it seems that LCBDE is a commendable alternative to the use of ERCP/EST.

Regarding to retain stone rate, conversion to other procedure, mortality, the total operative time and length of hospital stay there were similar between the two therapies with no significant differences.

The limitations of this meta-analysis must be taken into consideration when interpreting its results. First, there was heterogeneity among the included studies. However, one should not be surprising given the variation in the characteristics of populations (age, female/male, stone number, stone size), time intervention between endoscopic papillotomy and LC, laparoscope device and operator experience between the 2 approaches. All these factors contributed to the heterogeneity and had potential impacts on our results. Although we used the random-effects model instead of the fixed-effects model, it was impossible to overcome any potential bias. Second, not all studies provided data on the total operative time and length of hospital time. Third, the restriction of only including studies published in English was another possible limitation. Finally, it is important to bear in mind publication bias, particularly in meta-analysis based on published studies.

CONCLUSION

The current meta-analysis suggested that both LC-LCBDE and LC-ERCP/EST were highly effective in removing CBD stones and were equivalent in complications. LC + LCBDE is an effective and safe treatment option for concomitant gallstones and CBDS regarding long-term and short-term outcomes because it avoids the morbidity and mortality associated with ERCP and maintains the integrity of the sphincter of Oddi. With more refinement in equipment and technique, it is possible that LCBDE may become the gold standard for stones treatment. Certainly, ERCP is irreplaceable because it can release biliary obstructions in acute suppurative obstructive cholangitis patients in a timely fashion, which causes the patients to tolerate the
surgery more easily. Therefore, the optimal management of patients with CBDs should depend on the condition of patients, the expertise of operators and local resources.

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**Conflicts of interest**

There are no conflicts of interest.

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