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Original Article

ERCP Timing in Gallstone Disease: A Meta-Analysis of One-Stage versus Two-Stage Strategies

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ABSTRACT

Background: Cholecystocholedocholithiasis involves gallbladder and bile duct stones. Standard two-stage care involves ERCP followed by cholecystectomy, whereas single-stage intraoperative ERCP may streamline treatment. We performed a meta-analysis comparing stone clearance, complications, and hospital stay between single-stage and two-stage strategies.
Method: We systematically searched PubMed, Scopus, Web of Science, and the Cochrane Library up to April 2025 for clinical studies comparing one-stage laparo-endoscopic rendezvous with two-stage ERCP + LC. RCTs and observational studies reporting stone clearance, complications, conversion, bile leaks, hospital stay, repeat ERCP, or cannulation failure were included. Data extraction and ROB2/NOS assessments were done independently.
Results: Twenty-four studies met the inclusion criteria. The one-stage approach demonstrated significantly higher CBD clearance (96.5% vs. 91.8%; RR = 1.03) and a notably lower overall complication rate (11.55% vs. 19.56%; RR = 0.51). Postoperative pancreatitis (RR = 0.50), cholangitis (RR = 0.33), and bleeding (RR = 0.47) were also significantly reduced. Although conversion to open surgery and bile leak rates were lower in the one-stage group, these differences were not statistically significant. Importantly, single-stage management resulted in shorter hospital stays (mean difference = 3.23 days), fewer postoperative repeat ERCPs (RR = 0.21), and markedly reduced cannulation failure (RR = 0.26).
Conclusion: The one-stage approach for managing bile duct stones offers higher clearance rates, fewer complications, and shorter hospital stays compared to the two-stage approach. These results support adopting one-stage treatment as a more effective and efficient clinical strategy.

1. Introduction

The simultaneous presence of gallbladder and common bile duct (CBD) stones, termed cholecystocholedocholithiasis, represents a clinically significant condition. Common bile duct stones (CBDS) are reported in approximately 8%–20% of patients with gallstones; however, the actual incidence is likely higher, as asymptomatic or undiagnosed cases are common. [1, 2]. The association of these two conditions can lead to many severe complications, such as acute biliary pancreatitis, jaundice, and cholangitis, transforming the choice of the best strategy for treating a benign issue into a potentially life-threatening problem. While the gold standard of treatment for gallstones has been laparoscopic cholecystectomy (LC) since the early 1990s, ERCP is considered optimal for isolated CBDS [3]. The optimal management of cholecystocholedocholithiasis remains debated [4, 5].

Historically, open surgery (choledochotomy with papillotomy) for common bile duct (CBD) stone removal was common but had high risks and is now rarely used, reserved for special cases where minimally invasive methods fail or are unavailable [6]. Preoperative ERCP followed by laparoscopic cholecystectomy is the most common current approach [7]. However, it's invasive, requires two procedures with separate anesthesia sessions, and can create scheduling issues in busy hospitals. Postoperative ERCP is used selectively when CBD stones are unexpectedly found during or after LC, especially when trained personnel or equipment are not immediately available [8]. While less invasive initially, it also requires a second anesthesia session and carries the risk of incomplete stone removal.

Intraoperative ERCP with concomitant laparoscopic cholecystectomy is a single-stage laparoendoscopic treatment. These single-stage laparoendoscopic approaches include primarily intraoperative ERCP, the laparoendoscopic rendezvous (LERV) technique (which was first described almost 20 years ago) [9], and transcystic

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clearance. Compared to the classical two-stage approach of pre-ERCP for CBD stone removal followed by LC, performing LC concurrently with intraoperative ERCP alleviates pain, saving medical resources and costs by addressing two issues in a single procedure. Some studies also showed that the Single-stage Technique can reduce certain complications, such as post-operative pancreatitis and cholangitis [10, 11].

Our meta-analysis aims to evaluate whether the single-stage technique offers benefits over traditional two-stage approaches in terms of CBD stone clearance rates, procedure-related complications, and hospital stay duration in patients with concurrent gallbladder and CBD stones.

2. Methods

2.1. Search Strategy

PubMed, Scopus, Web of Science, and Cochrane Library were searched up to April 2025 for relevant published clinical studies using the following keywords (Gallstone Disease/ Common Bile Duct /Laparoscopic Cholecystectomy/ Celioscopic Cholecystectomy / Endoscopic Retrograde Cholangiopancreatography / LERV). Detailed search strategies for each database were provided in our **(supplementary files)**, **(Table 1)**.

2.2. Selection Criteria

All clinical studies, randomized controlled trials (RCTs), retrospective, prospective, and case-control studies published up to April 2025 that met the following criteria were included in our in our review: (1) comparing one-stage versus two-stage management for concomitant gallbladder with CBD stones studies; (2) reporting at least one of the following outcomes, such as CBD clearance rate, Overall Complication Rate, Post-operative Pancreatitis (PEP), Post-operative Cholangitis, Post-operative Bleeding, Operation Conversion Rate, Bile Leak rate, Length of Hospital Stay, Postoperative second ERCP rate, and cannulation failure rate; and (3) no language restriction for the included studies. Studies comparing laparoscopic CBD exploration (LCBDE) with one or two-stage management were excluded

2.3. Outcomes

1. The primary outcome of this analysis was the success rate of common bile duct (CBD) clearance.
2. Secondary outcomes will be categorized as follows: (1) Safety outcomes, including postoperative pancreatitis, cholangitis, bleeding, bile leak, and overall complication rate; (2) Technical outcomes, such as cannulation failure, conversion rate, and need for second ERCP; and (3) Recovery outcomes, measured by length of hospital stay.

2.4. Data Extraction

An Excel sheet for data extraction was designed. After that, it was accessible to all authors. All authors participated in data extraction. Extracted data for each study included: study ID (last name of first author and the publication year), country, study design, study groups, sample size, age, common bile duct diameter, outcome measures, and key findings.

2.5. Quality Assessment

Two reviewers independently performed quality assessment. A third reviewer was involved in the discussion to reach a consensus. We used the Cochrane risk of bias-2 (ROB 2) tool to assess the risk of bias in the included RCTs [12]. Additionally, we used the Newcastle–Ottawa Scale (NOS) to assess the risk of bias in the included observational studies [13]. **(Table 2)**

2.6. Statistical Analysis

Statistical analysis and all plots were conducted using R (v.4.4.3 for Windows) and the Meta package. Weighted mean differences were used for continuous data, and risk ratios were used for dichotomous data, with 95% confidence intervals (CIs). A p-value < 0.05 was considered statistically significant, determined by the Z test. Heterogeneity was evaluated using Cochran's Q test ($p < 0.1$); inconsistency across studies was quantified using the I2 statistic. Significant heterogeneity was defined as $I2 > 50\%$, in which case a random-effects model was used for pooling; otherwise, we performed continuity correction, i.e., added 0.5 and a proportional amount to groups when zero events were reported in each group, so they could be estimated and included in our meta-analysis.

Some studies reported continuous data as median and range. To solve this problem, we assumed the median was equal to the mean and estimated the SD as one-quarter of the range between the upper and lower limits, using Hozo's method [14]. A sensitivity analysis was conducted to assess the robustness of the pooled results. Publication bias was explored using funnel plots and quantified using the Egger test [15].

3. Results

3.1. Study Characteristics

Twenty-four studies compared one-stage (intraoperative ERCP + cholecystectomy) and two-stage (preoperative ERCP + cholecystectomy) approaches for common bile duct (CBD) clearance, reporting outcomes such as CBD diameter, postoperative complications (e.g., pancreatitis, bleeding), and hospital stay duration, with baseline patient ages typically ranging from 45 to 70 years, between 1999 and 2025, conducted across multiple centers.

3.2. Primary outcome

3.2.1. Success Rate of CBD Clearance

The CBD clearance rate was reported in 21 studies, with an incidence of 1379 of 1429 (96.50%) in the one-stage group and 1451 of 1580 (91.84%) in the two-stage group. The meta-analysis demonstrated that one-stage management achieved a significantly higher CBD clearance rate compared to the two-stage approach (RR: 1.03, 95% CI [1.01, 1.04], $p = 0.0021$), with moderate heterogeneity among studies ($I^2 = 43.1\%$, $\tau^2 = 0.0002$, $p = 0.0193$) **(Supplementary Figure 3)**. After omitting Garbarini–2017, the results remained consistent (RR: 1.02, 95% CI [1.00, 1.03], $I^2 = 29.7\%$) **(Supplementary Figure 13)**.

Subgroup analysis by study design (RCTs vs. retrospective studies) was performed to explore sources of heterogeneity and assess consistency of effects. The pooled analysis of randomized controlled trials (RCTs) showed no statistically significant difference between the one-stage and two-stage approaches (RR: 1.03, 95% CI [0.99, 1.07], $p = 0.0596$; $I^2 = 46.6\%$), whereas retrospective studies demonstrated a statistically significant advantage for the one-stage approach (RR: 1.03, 95% CI [1.01, 1.05], $p = 0.0435$; $I^2 = 45.4\%$). Although the RCT subgroup showed a statistically insignificant effect while the retrospective subgroup did show significance, the test for subgroup differences was not significant ($p = 0.98$). This indicates that the effect sizes of the two subgroups were statistically similar, and the apparent difference in significance is likely attributable to variations in sample size or statistical power rather than a true difference in effect. Therefore, both study designs consistently support a modest benefit of the one-stage approach in achieving higher CBD clearance rates **(Supplementary Figure 18)**.

3.3. Secondary outcome

3.3.1. Overall Complication Rate

The overall complication rate was reported in 16 studies, with incidences of 140 of 1212 (11.55%) in the one-stage group and 255 of 1304 (19.56%) in the two-stage group. The pooled analysis demonstrated that the one-stage approach was associated with a significantly lower overall complication rate compared with the two-stage strategy (RR: 0.51, 95% CI [0.36–0.72], p = 0.0002), with moderate heterogeneity among studies (I^2 = 61.4%, τ^2 = 0.2313, p = 0.0007) **(Supplementary Figure 4)**. Sensitivity analysis by omitting Gerosa et al. (2024) reduced heterogeneity and yielded consistent results (RR: 0.47, 95% CI [0.36–0.62], I^2 = 32.6%) **(Supplementary Figure 14)**.

Subgroup analysis by study design revealed that randomized controlled trials (RCTs) significantly favored the one-stage approach, showing a marked reduction in complications (RR: 0.62, 95% CI [0.46–0.83], I^2 = 4.9%). Similarly, retrospective studies also demonstrated a significant benefit (RR: 0.45, 95% CI [0.25–0.78]), although with higher heterogeneity (I^2 = 75.4%). Although the RCT subgroup showed lower heterogeneity, the retrospective subgroup exhibited greater variability, yet the test for subgroup differences was not statistically significant (p = 0.98). This indicates that the observed difference in statistical significance between subgroups is likely due to variations in sample size or study power rather than a true difference in effect size. Therefore, both study designs consistently support the conclusion that the one-stage approach substantially reduces the overall complication rate compared with the two-stage strategy **(Supplementary Figure 21)**.

3.3.2. Postoperative Pancreatitis

Postoperative pancreatitis was reported in 21 studies, with an incidence of 54 of 1453 (3.7%) in the one-stage group and 135 of 1702 (7.9%) in the two-stage group. The pooled meta-analysis demonstrated that the one-stage approach was associated with a statistically significant reduction in postoperative pancreatitis compared with the two-stage strategy (RR: 0.51, 95% CI [0.34–0.77], p = 0.0014), with low heterogeneity among the included studies (I^2 = 15.6%, τ^2 = 0.1841, p = 0.2556) **(Supplementary Figure 5)**. After omitting Passi et al. (2017), the results remained consistent, and heterogeneity decreased further (RR: 0.45, 95% CI [0.32–0.64], I^2 = 7.7%) (Supplementary Figure 15).

Subgroup analysis by study design showed that randomized controlled trials (RCTs) favored the one-stage approach. However, the effect did not reach statistical significance (RR: 0.44, 95% CI [0.16–1.22], p = 0.12), with no observed heterogeneity (I^2 = 0%, p = 0.4671). Retrospective studies demonstrated a statistically significant reduction in postoperative pancreatitis with the one-stage strategy (RR: 0.53, 95% CI [0.33–0.83], p = 0.01), accompanied by low-to-moderate heterogeneity (I^2 = 31%, p = 0.1437). The test for subgroup differences was not significant (p = 0.76), indicating that both RCT and retrospective analyses yielded statistically similar effects.

3.3.3. Postoperative cholangitis

Outcomes of Postoperative cholangitis were reported in 10 studies, with an incidence of 4 of 623 (0.64%) in the one-stage group and 25 of 793 (3.15%) in the two-stage group. The meta-analysis demonstrated that the one-stage approach was associated with a statistically significant reduction in Postoperative cholangitis compared to the two-stage approach (RR: 0.35, 95% CI [0.14, 0.88], p = 0.0263), and there was no heterogeneity among the studies (I^2 = 0.0%, τ^2 = 0.1306, p = 0.6216) **(Supplementary Figure 6)**.

3.3.4. Postoperative bleeding

Postoperative bleeding outcomes were reported in 15 studies, with an incidence of 16 of 1045 (1.53%) in the one-stage group and 34 of 1151 (2.95%) in the two-stage group. The meta-analysis demonstrated that the one-stage approach was associated with a statistically significant reduction in Postoperative bleeding compared to the two-stage approach (RR: 0.47, 95% CI [0.27, 0.82], p = 0.0082), and there was no heterogeneity among the studies (I^2 = 0%, τ^2 = 0, p = 0.8829) **(Supplementary Figure 7)**.

3.3.5. Bile leak

Outcomes of Bile leak were reported in 9 studies, with an incidence of 14 of 801 (1.74%) in the one-stage group and 17 of 819 (2.07%) in the two-stage group. The meta-analysis demonstrated that the one-stage approach was associated with a statistically insignificant reduction in Bile leak compared to the two-stage approach (RR: 1.44, 95% CI [0.68, 3.02], p = 0.3630), and there was no heterogeneity among the studies (I^2 = 0.0%, τ^2 = 0.0868, p = 0.7754) **(Supplementary Figure 9)**.

3.4. Technical outcomes

3.4.1. Operation conversion rate

The conversion rate for the operation was reported in 12 studies, with an incidence of 26 of 821 (3.17%) in the one-stage group and 89 of 915 (9.73%) in the two-stage group. The meta-analysis demonstrated that the one-stage approach was associated with a statistically insignificant reduction in Operation conversion rate compared to the two-stage approach (RR: 0.56, 95% CI [0.30, 1.04], p = 0.0649), and there was no significant heterogeneity among the studies (I^2 = 22.2%, τ^2 = 0.2223, p = 0.2257) **(Supplementary Figure 8)**. By omitting Raab 2024 (RR: 0.47, 95% CI [0.30, 1.04], I^2 =8.1%), **(Supplementary Figure 16)** .Subgroup analysis revealed that randomized controlled trials (RCTs) favored the one-stage strategy with a significant reduction in conversion (RR: 0.49, 95% CI [0.25, 0.96], p = 0.0445; I^2 = 26.6%), whereas retrospective studies demonstrated a non-significant effect (RR: 0.63, 95% CI [0.22–1.83], p = 0.2312; I^2 = 25.9%).confirming that the overall findings were robust and mainly driven by the RCT subgroup **(Supplementary Figure 20)**.

3.4.2. Postoperative second ERCP rate

Outcomes of Postoperative second ERCP were reported in 6 studies, with an incidence of 6 of 435 (1.38%) in the one-stage group and 30 of 365 (8.22%) in the two-stage group. The meta-analysis demonstrated that the one-stage approach was associated with a statistically significant reduction in Postoperative second ERCP compared to the two-stage approach (RR: 0.21, 95% CI [0.08, 0.58], p = 0.0026), and there was no heterogeneity among the studies (I^2 = 0.0%, τ^2 = 0.2894, p = 0.4846) **(Supplementary Figure 11)**.

3.4.3. Cannulation failure rate

Cannulation failure rate was reported in 12 studies, with an incidence of 8 of 828 (0.97%) in the one-stage group and 44 of 761 (5.78%) in the two-stage group. The meta-analysis demonstrated that the one-stage approach was associated with a statistically significant reduction in cannulation failure rate compared to the two-stage approach (RR: 0.26, 95% CI [0.14, 0.51], p < 0.0001), and there was no heterogeneity among the studies (I^2 = 0.0%, τ^2 = 0, p = 0.8979) **(Supplementary Figure 12)**.

Table 1: The baseline characteristics of our included studies

Study ID	Country + Year	Study Type	Group	Sample Size	Age (years)	CBD diameter (mm)	NOS
ElGeidie et al. [16]	Egypt 2011	RCT	One-stage	98	31.2 (20–67)*	9.6 (8–18)*	-
			Two-stage	100	27.5 (19–64)*	9.2 (7–20)*	
González et al. [17]	Cuba 2016	RCT	One-stage	99	58.4 (23–87)*	8.2 (4–20)*	-
			Two-stage	100	57.7 (20–84)	8.4 (5–12)*	
Lella et al. [18]	Italy 2006	RCT	One-stage	60	54.2 (22–60)*	NR	-
			Two-stage	60	54.2 (22–60)*	NR	
Morino et al. [19]	Italy 2006	RCT	One-stage	46	56.6 (22–82)*	CBD 10 mm = 60.8%	-
			Two-stage	45	63.1 (25–83)*	CBD 10 mm = 64.4%	
Muhammedoğlu et al. [20]	Turkey 2020	RCT	One-stage	39	60.5 (median)	12 (median)	-
			Two-stage	80	60.5 (median)	11 (median)	
Rabago et al. [21]	Spain 2006	RCT	One-stage	59	NR	NR	-
			Two-stage	64	NR	NR	
Sahoo et al. [22]	India 2014	RCT	One-stage	42	NR	NR	-
			Two-stage	41	NR	NR	
Tzovaras et al. [23]	Greece 2012	RCT	One-stage	50	66 (22–87)**	9 (4–20)**	-
			Two-stage	49	69 (25–85)**	9 (4–21)**	
Liu et al. [24]	China 2017	RCT	One-stage	32	42 (5.2)***	NR	-
			Two-stage	31	40 (6.1)***	NR	
Farid et al. [25]	Egypt 2024	RCT	One-stage	218	37.50 (25–60)**	NR	-
			Two-stage	218	42.50 (18–65)**	NR	
Garbarini et al. [26]	Italy 2016	Retrospective	One-stage	143	59 (16–88)*	NR	9
			Two-stage	106	68 (23–88)*	NR	
Greca et al. [11]	Italy 2007	Retrospective	One-stage	19	54 (9–88)*	NR	9
			Two-stage	19	52 (25–84)*	NR	
Jiang et al. [27]	China 2019	Retrospective	One-stage	22	56.5 (9.8)***	8.5 (6.2)***	7
			Two-stage	29	62.2 (10.4)***	7.8 (2.9)***	
Meyer et al. [28]	France 1999	Retrospective	One-stage	30	57 (28–84)*	NR	6
			Two-stage	203	56 (18–91)*	NR	
Muhammedoğlu et al. [29]	Turkey 2019	Retrospective	One-stage	31	61.29 (19.9)***	NR	8
			Two-stage	25	53.6 (18.1)***	NR	
Passi et al. [30]	America 2017	Retrospective	One-stage	37	41.1 (26.5)***	6.1 (4.7)***	9
			Two-stage	177	53.5 (21.2)***	8.6 (5.1)***	
Qian et al. [31]	China 2019	Retrospective	One-stage	123	56.3 (15.5)**	6.8 (2–14)**	9
			Two-stage	137	58.2 (16.0)**	7.2 (0.8–15)**	
Gerosa et al. [32]	Italy 2024	Retrospective	One-stage	105	72 (36–86)**	NR	9
			Two-stage	85	70 (41–78)**	NR	
Di Lascia et al. [33]	Italy 2021	Retrospective	One-stage	20	58 (30–80)**	NR	9
			Two-stage	20	64 (45–85)**	NR	
Mohamed et al. [34]	Egypt 2023	Retrospective	One-stage	100	41.56 (16.5)***	NR	8
			Two-stage	120	45.34 (13.6)***	NR	
Percario et al. [35]	Italy 2025	Retrospective	One-stage	120	NA	>10 mm	8
			Two-stage	70	NA	>10 mm	
Raab et al. [36]	Austria 2024	Retrospective	One-stage	103	62.6 (mean)	N/A	9
			Two-stage	66	63.8 (mean)	N/A	
Hu et al. [37]	China 2017	Retrospective	One-stage	28	51.0 (14.6)***	NR	7
			Two-stage	24	52.3 (12.9)***	NR	
Lv et al. [38]	China 2023	Case-control (Retrospective)	One-stage	40	60.5 (8.5)***	12.08 (2.25)***	8
			Two-stage	42	63.9 (11.6)***	12.86 (2.61)***	

*, Mean (range); **, median (range); ***, mean (standard deviation); NOS, Newcastle Ottawa scale for our retrospective studies

3.5. Recovery outcomes

3.5.1. Length of hospital stay

Outcomes of Length of hospital stay were reported in 20 studies, but many reported these outcomes as medians and ranges. We applied the Hozo et al. statistical method. The data was converted into a uniform format of means and standard deviations for analysis. The meta-analysis demonstrated that the one-stage approach was associated with a statistically significant shorter length of hospital stay compared to the two-stage approach (MD: -3.23, 95% CI [-4.23, -2.23], $p < 0.0001$), and there was a significant heterogeneity among the studies ($I^2 = 93.3\%$, $p < 0.0001$) **(Supplementary Figure 10)**. RCT subgroup: The pooled analysis of RCTs demonstrated that one-stage management significantly reduced the length of hospital stay compared to the two-stage approach (MD: –3.07 days, 95% CI [–4.43, –1.72], $p < 0.0001$), with very high heterogeneity ($I^2 = 91.8\%$, $\tau^2 = 3.5022$, $p < 0.0001$). Retrospective subgroup: Similarly, retrospective studies confirmed a significant reduction in hospital stay with one-stage treatment (MD: –3.45 days, 95% CI [–4.89, –2.02], $p < 0.0001$), again with considerable heterogeneity

Table 2: Quality assessment of included studies using the Newcastle-Ottawa Scale (NOS)

Study ID	S1	S2	S3	S4	C1	C2	O1	O2	O3	Total
Garbarini et al. [26]	*	*	*	*	*	*	*	*	*	9/9
Gerosa et al. [32]	*	*	*	*	*		*	*	*	8/9
Hu et al. [37]	*	*	*	*	*		*	*		7/9
Di Lascia et al. [33]	*	*	*	*	*	*	*	*	*	9/9
Lv et al. [38]	*		*	*	*		*	*	*	8/9
Meyer et al. [28]	*	*	*	*	*		*			6/9
Muhammedoğlu et al. [29]	*	*	*	*	*		*	*	*	8/9
Passi et al. [30]	*	*	*	*	*	*	*	*	*	9/9
Qian et al. [31]	*	*	*	*	*	*	*	*	*	9/9
Percario et al. [35]	*	*	*	*	*		*	*		8/9
Raab et al. [36]	*	*	*	*	*	*	*	*	*	9/9
Jiang et al. [27]	*	*	*	*	*		*	*		7/9
Greca et al. [11]	*	*	*	*	*	*	*	*	*	9/9
Mohamed et al. [34]	*	*	*	*	*		*	*	*	8/9

*, Mean (range); NOS, Newcastle Ottawa scale

($I^2 = 94.5\%$, $\tau^2 = 6.0386$, $p < 0.0001$). Both favored the one-stage approach to reducing hospital stay **(Supplementary Figure 19)**. We conducted leave-one-out analyses to address heterogeneity across studies and assess the strength of the results. The leave-one-out meta-analysis showed no significant difference in heterogeneity in the Length of hospital stay. Omitting the study by Hu (2017) shifts the mean difference to MD: -3.45 [-4.38; -2.51] and reduces heterogeneity to 86.2%, suggesting it may contribute disproportionately to the variability **(Supplementary Figure 17)**.

3.6. Publication bias

A funnel plot was constructed to assess the potential for publication bias among the included studies. In the plot, the effect estimates were symmetrically distributed around the pooled effect size, suggesting a low likelihood of publication bias. A slight asymmetry was observed, which may be attributable to heterogeneity or small-study effects rather than true bias. Visual inspection of the funnel plot did not reveal significant gaps or clustering that would indicate missing studies on one side of the plot. This interpretation was supported by Egger's regression test, which yielded a p-value of 0.24, indicating no significant effects. The result of Egger's test ($t = -1.22$, $p = 0.2401$) suggests that there is no statistically significant funnel plot asymmetry, implying no strong evidence of publication bias in the included studies.

3.7. Certainty of Evidence

The evidence suggests that one-stage procedures for common bile duct clearance have a slightly higher success rate than two-stage approaches. Randomized trials show a small advantage, though the confidence in this finding is only moderate because the results are somewhat uncertain. Non-randomized studies also point to a similar benefit but offer low certainty due to their study design. Across all studies, there were no major concerns about bias or inconsistency, and the overall direction of the findings was consistent. In summary, one-stage procedures appear to be somewhat more effective, but the confidence in this conclusion remains cautious because of methodological limitations and imprecision in the available evidence

4. Discussion

Endoscopic Retrograde Cholangiopancreatography (ERCP) remains a cornerstone in the management of choledocholithiasis and other biliary tract disorders. Still, it has several limitation due to high risk of pancreatitis, bleeding, and perforation even not success in all patient our study show 24 studies with a total 5,728 patients, with 2,881 patients (50.3%) in the one-stage group (intraoperative ERCP and laparoscopic cholecystectomy) and 2,847 patients (49.7%) in the two-stage group (preoperative ERCP followed by cholecystectomy).patients, demonstrates that one-stage management for choledocholithiasis is associated with superior clinical outcomes compared to the traditional two-stage approach. One-stage procedures yielded a significantly higher common bile duct (CBD) clearance rate (96.5% vs. 91.8%) and notably lower overall complication rates (11.6% vs. 19.6%), including reduced incidences of postoperative pancreatitis, Cholangitis, and bleeding. However, reductions in bile leak and conversion rates did not reach statistical significance. Nonetheless, the one-stage approach demonstrated favorable trends overall and appears to be a safer and more effective strategy for managing choledocholithiasis in appropriately selected patients.

Although the one-stage approach requires close coordination between surgical and endoscopic teams, patients benefit from shorter hospital stays and fewer repeat ERCPs, largely because treatment is consolidated into a single procedure. This streamlined pathway reduces delays between interventions, minimizes repeated anesthesia exposure, and lowers the risk of interval complications—ultimately enhancing both clinical efficiency and patient outcomes. However, these advantages must be weighed against higher initial setup costs and the need for specialized equipment and training.

Comparison with current guidelines. Our meta-analysis demonstrating higher CBD clearance, fewer overall complications (notably lower rates of post-ERCP pancreatitis), fewer repeat ERCPs, reduced cannulation failure, and shorter hospital stay with one-stage (laparo-endoscopic rendezvous) management — aligns with

guideline authors who recognize potential advantages of single-session strategies in suitable patients and high-expertise centres. ESGE and ASGE guidance acknowledge that intraoperative rendezvous techniques may reduce the risk of procedural pancreatitis and improve technical success, but they continue to recommend that the choice of timing and technique (preoperative ERCP, intraoperative ERCP/rendezvous, or laparoscopic bile-duct exploration) be individualized based on patient presentation and local surgical/endoscopic expertise. In cases of suspected or confirmed acute cholangitis, the Tokyo Guidelines prioritize prompt biliary drainage based on severity. While our pooled data on the one-stage approach for cholangitis reduction are reassuring, severe cholangitis still mandates urgent decompression, and the timing/mode of drainage should follow established severity-based algorithms. Our findings support guideline positions that intraoperative rendezvous is an effective option and suggest that, where logistical and expertise barriers can be overcome, guidelines could more strongly endorse single-session management as a preferred strategy to reduce pancreatitis, repeat procedures, and hospital stay [39, 40].

Operator experience is a critical determinant of success in LERV procedures. High-volume centers with skilled surgical and endoscopic teams consistently report lower complication rates, reduced cannulation failures, shorter operative times, and higher rates of duct clearance.

Di Lascia et al. (2019) reported that a one-stage procedure was associated with longer operative times and required greater technical expertise [33].

Cuschieri et al. (1999) reported technical challenges with intraoperative ERCP and concluded that the two-stage approach remained a safer and more feasible option. These studies highlight that, despite the potential advantages of the one-stage approach, its success is highly dependent on institutional resources and operator experience [41].

Many studies strongly support our findings, demonstrating that the one-stage approach using the laparoscopic-endoscopic rendezvous (LERV) technique significantly reduced the incidence of post-ERCP pancreatitis and shortened hospital stays compared to the traditional two-stage method, with higher CBD clearance rates and lower overall complication rates [41, 42, 43].

Morino et al. (2006) reported that the LERV technique not only improved the success rate of bile duct stone removal but also reduced the need for additional procedures and facilitated faster patient recovery [19]. Similarly, Bozkurt et al. (2013) demonstrated that intraoperative ERCP combined with laparoscopic cholecystectomy achieved higher bile duct clearance rates and significantly fewer postoperative complications compared to the two-stage approach. This strategy was also associated with shorter hospital stays and a reduced need for repeat ERCPs, thereby enhancing both patient outcomes and healthcare efficiency [44].

However, past techniques or protocols present several challenges. It often necessitates two separate hospital admissions and anesthesia sessions, increasing overall costs and patient burden. Additionally, some stones may pass spontaneously before ERCP, rendering the procedure redundant in certain cases. A false-negative rate of 6.1% was observed, indicating that stones were occasionally missed. Moreover, the Inflammation sometimes mandates conversion to open surgery. Failure of the ERCP procedure itself sometimes necessitated an additional, third intervention to manage the bile duct stones or related complications, which increases patient risk.

4.1. Limitations

The present analysis included studies with mixed designs (randomized controlled trials and retrospective cohort studies). This inherent variation in study methodology may have introduced bias and heterogeneity, potentially affecting the reliability of the pooled estimates. In addition, several other limitations should be acknowledged. First, some of the included studies reported continuous variables as median and range, which required transformation into mean and standard deviation using Hozo's method. While this statistical approach is widely applied in meta-analyses, it introduces a degree of approximation and potential error, and thus, our pooled results should be interpreted with caution. Second, the studies spanned more than two decades (1999–2025) and were conducted across diverse healthcare systems. Advances in laparoscopic and endoscopic techniques, improvements in perioperative care, and variations in healthcare infrastructure and practice patterns over time and across regions may have contributed to heterogeneity and limited the generalizability of our findings. Third, although stone size and bile duct diameter are important determinants of clearance, only a limited number of studies reported these variables, and the data were expressed in heterogeneous formats (mean, median, or percentages). This inconsistency precluded subgroup or stratified analyses based on these clinically relevant factors. Fourth, although overall complication rates were consistently reported, most studies did not stratify complications by severity (e.g., using the Clavien–Dindo classification or distinguishing between major and minor complications). The lack of standardized complication reporting prevented a meaningful pooled analysis of morbidity profiles. Finally, while cost-effectiveness is an important consideration in the choice between one-stage and two-stage management, very few studies reported hospital resource utilization data, and no consistent cost-effectiveness data were available to allow pooled analysis of economic outcomes.

Future research directions

Future studies should aim to overcome these limitations by adopting standardized definitions and classification systems for complications (such as the Clavien–Dindo grading), consistently reporting bile duct diameter and stone characteristics, and including comprehensive cost-effectiveness analyses. Moreover, well-designed, contemporary randomized controlled trials conducted across diverse healthcare systems would provide more robust, generalized evidence to guide clinical practice. Mixed between randomized controlled trials and retrospective analyses, which may introduce heterogeneity and affect the strength of pooled conclusions. Also, differences in patient selection criteria, operator experience, and institutional protocols across studies could influence outcomes. And how studies address confounding variables encountered by physicians in assessing bile duct clearance or complication severity.

5. Conclusions

These findings have important implications for clinical practice and could influence future guideline recommendations for the management of choledocholithiasis. The demonstrated superiority of the one-stage approach in terms of CBD clearance, reduced complications, shorter hospital stays, and fewer repeat procedures supports its adoption as the preferred strategy. Current guidelines, which often present both one-stage and two-stage options, may benefit from more explicit recommendations favoring the one-stage approach

Conflicts of Interest

The authors declare no competing interests that could have influenced the objectivity or outcome of this research

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Authors' Contribution

MG contributed to conceptualization, project administration, and preparation of tables. AA, AWM, AA, and ZA performed screening, data extraction, and risk of bias assessment. MW conducted statistical analysis using R software, drafted the manuscript, and wrote the discussion section.

Data Availability

All data supporting the findings of this study are available within the article and its supplementary materials. No new datasets were generated.

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