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Operating Time and Length of Stay Evaluation and Correlation Analysis of Three Treatment Modalities for Choledocholithiasis: A Retrospective Study in a Tertiary Hospital and Review

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ABSTRACT

Background: Operating time (OT) and length of stay (LOS) are widely recognized as objective indicators of healthcare quality and procedural efficiency. Choledocholithiasis is treated with three treatment modalities: endoscopic retrograde cholangiopancreatography (ERCP), laparoscopic (LCBDE) and open common bile duct exploration (OCBDE). Therefore, evaluation of OT and LOS among these three procedures, particularly in Indonesia, are necessary.
Objective: This study evaluates operating time and length of stay and its correlation across three treatment modalities for choledocholithiasis and compares the findings with those reported in previous studies abroad.
Method: A retrospective comparative study was conducted using secondary data from medical records of patients treated for choledocholithiasis with ERCP, LCBDE, or OCBDE at Sardjito Hospital between 2023 and 2026. Data about operating time and length of hospital stay were collected and compared among treatment modalities using appropriate statistical methods.
Result: The average OT and LOS for ERCP were 89.54 minutes and 3 days, respectively. For LCBDE, the average OT and LOS were 129.67 minutes and 5 days, respectively. For OCBDE, the average OT and LOS were 115.02 minutes and 8 days, respectively. Operating time showed a weak correlation with postoperative LOS but no significant correlation with total LOS.
Conclusion: ERCP is the shortest OT and LOS modality. LCBDE had the longest OT, while OCBDE had the longest LOS. No significant difference of OT between LCBDE and OCBDE. Review of previous studies show differences in LOS influenced by drainage management, time to residual stone evaluation, and postoperative complications.

INTRODUCTION

Cholelithiasis is one of the most common gastrointestinal diseases requiring hospitalization. Choledocholithiasis is found in approximately 10–15% of patients undergoing cholecystectomy[1]. Recent studies[2] have reported an increasing incidence of cholelithiasis in Asia over recent decades, which is expected to be accompanied by a corresponding rise in choledocholithiasis. The increasing prevalence of obesity and metabolic syndrome associated with modern lifestyles has contributed to the rising incidence of gallstone disease[3].

Choledocholithiasis can be managed using three main treatment modalities, including endoscopic retrograde cholangiopancreatography (ERCP), laparoscopic common bile duct exploration (LCBDE), and open common bile duct exploration (OCBDE). ERCP is a minimally invasive endoscopic technique combined with fluoroscopy used for both the diagnosis and treatment of biliary and pancreatic disorders. It is recommended as a first-line treatment according to local consensus because it is the least invasive option and is particularly beneficial in cases of cholangitis and pancreatitis. Current studies on ERCP report a relatively good stone clearance rate, ranging widely from 70% to 97%, which is influenced by

multiple factors[4]. This approach still relatively less frequently used to treat because its high cost procedures especially in the developing country.

Bile duct exploration is defined as a surgical procedure, either open or laparoscopic, involving direct inspection of the biliary tract lumen, removal of common bile duct (CBD) stones, management of strictures or other injuries, and restoration of normal bile flow. Open common bile duct exploration (OCBDE) is the conventional invasive approach, but it provides superior visualization of the bile duct and allows tactile feedback during stone extraction. Several systematic reviews have reported higher stone clearance rates with the open approach compared with other modalities.

LCBDE is a minimally invasive method that has been adopted by some centers as a first-line treatment for choledocholithiasis due to its feasibility and favorable postoperative outcomes. In terms of mortality, morbidity, and complications, LCBDE shows comparable results to ERCP and OCBDE. Additionally, LCBDE offers flexibility for both patients and surgeons, as it can be performed as either a single-stage or a two-stage procedure.

Operating time is an indicator that reflects the complexity of intraoperative factors. These factors include the surgeon, patient, and case characteristics, but may also be influenced at multiple levels by operating room workflow, team coordination, hospital policies, and resource availability[5]. Operating time has been consistently associated with surgical site infection and postoperative morbidity, but not with mortality[6,7,8,9]. However, in some specific surgical procedures, no significant association between operating time and postoperative morbidity has been observed[10]. Therefore, an operating time should be studied in a procedure-specific context.

Furthermore, length of stay reflects the overall performance of a healthcare institution and is an indicator of resource utilization as well as the burden of preoperative and postoperative complications[11]. Theoretically, prolonged operating time may increase the risk of postoperative complications and consequently extend length of stay (LOS), but the association between operating time and length of stay still unclear. Although previous studies have compared clinical outcomes among ERCP, LCBDE, and OCBDE, variations in operating time and length of stay remain reported across different institutions. Therefore, evaluation of the differences in operating time and length of stay together may provide a practical overview of disease burden, procedural performance, and healthcare efficiency. However, comparative data evaluating these efficiency indicators among the three modalities remain limited, particularly in developing healthcare settings.

The ongoing shift toward minimally invasive approaches, particularly ERCP and laparoscopic techniques, continues to transform the management of choledocholithiasis worldwide. At the same time, healthcare systems are increasingly operating under financial constraints, making procedural efficiency an important consideration. As a result, optimizing resource utilization through reductions in operating time and length of hospital stay has become one of the key objective in modern surgical practice.

RESEARCH METHODS

This study was a retrospective comparative study conducted at Dr. Sardjito Hospital, Indonesia. The study was performed in the Department of Digestive Surgery from January 2023 to January 2026. In this study, the inclusion criteria were patients diagnosed with choledocholithiasis who underwent ERCP, LCBDE, or OCBDE as definitive treatment. The exclusion criteria were patients younger than 18 years or older than 65 years, had conversion to another surgical procedure, or had malignancy, hepatolithiasis, isolated common bile duct stricture, or a history of chemotherapy or radiotherapy. In addition, to ensure diagnostic accuracy and the realibity of operating time measurements, patients with negative intraoperative findings for stones were excluded. Patients with incomplete medical records or who died during hospitalization were also excluded.

The targeted sample size was calculated using the Dahlan formula[12] for an independent comparative analysis of categorical variables, with a significance level (α) of 5% (95% confidence interval) and a type II error rate (β) of 10% (90% statistical power). This study predefined a clinically significant difference of 1 day for the purpose of sample size calculation. The minimum required sample size was 53 participants. Medical record data were collected using convenience sampling after approval from the institutional review board. All collected data were anonymized and analyzed anonymously to ensure patient confidentiality. The data collected included operating time (OT), length of stay (LOS),

and postoperative length of stay (PLOS). Additional variables recorded were patient age, sex, type of procedure, comorbidities, preoperative magnetic resonance cholangiopancreatography (MRCP) findings, need for biliodigestive bypass, conversion to open surgery, intraoperative findings of negative stone exploration, T-tube placement, and the surgical approach (transcystic or choledochotomy).

Operating time was defined as the duration from skin incision to skin closure. For ERCP, operating time was defined as the interval from endoscope insertion through the oral cavity to its withdrawal. Length of stay was divided into total length of stay (LOS) and postoperative length of stay (PLOS). Total LOS was defined as the duration from hospital admission to discharge, whereas PLOS was defined as the duration from the day of surgery to hospital discharge. Data were analyzed using IBM SPSS Statistics version 27. Continuous variables were compared among groups using one-way ANOVA for normally distributed data or the Kruskal–Wallis test for non-normally distributed data. Correlation between operating time and LOS/PLOS was assessed using Kendall's tau correlation test. A p-value of <0.05 was considered statistically significant.

RESULTS AND DISCUSSION

This retrospective study initially collected data from 265 patients between 2023 and 2026. After applying the exclusion criteria, 102 patients were included in the final analysis (Image 1).

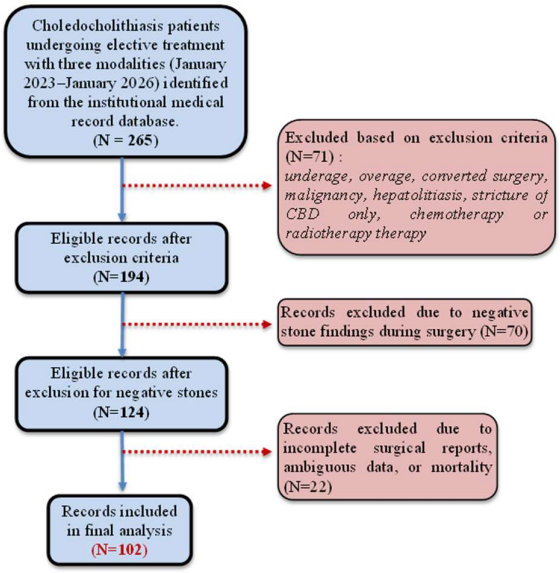

Image 1. Patients Selection Flow Chart

As shown in Table 1, baseline characteristics showed no significant differences among groups, except for preoperative MRCP utilization, which was higher in the OCBDE group. Preoperative MRCP is typically performed after initial radiological evaluations, such as ultrasonography or computed tomography, when further biliary assessment is required. The higher utilization of MRCP in the open approach group may reflect the selection of more complex cases of choledocholithiasis, including multiple stones, larger stones, or suspected biliary strictures.

Table 1. Baseline Characteristic Data

	ERCP (n=13)	LCBDE (n=48)	OCBDE (n=41)	p-value
Mean Age (year)	40.69±14,19	42.98±11.84	44±12.32	P=0.62
Male	69.2%	56.3%	48.8%	P=0.42
Female	30.8%	43.7%	51.2%	

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Preoperative MRCP	30.8%	33%	61%	**P=0.02**
Biliodigestive bypass	-	12.5%	19.5%	P=0.33

Operating time data were normally distributed and showed homogeneity across the three groups, whereas length of stay data were not normally distributed. The mean operating times were 89.54 ± 44.58 minutes for ERCP, 129.67 ± 44.49 minutes for LCBDE, and 115.02 ± 32.03 minutes for OCBDE. The median length of stay was 3 days for ERCP, 5 days for LCBDE, and 8 days for OCBDE. Postoperative length of stay showed a similar pattern, with median values of 2 days for ERCP, 3 days for LCBDE, and 5 days for OCBDE. Correlation analysis demonstrated that operating time was significantly correlated with postoperative length of stay but not with total length of stay. (Table 1)

Table 2. The Operating Time, LOS and PLOS Across the Three Treatment Modalities

No.	Procedure	Mean operating time (minutes)	Prolonged operating time	Median LOS (days)	Median PLOS (days)
1	ERCP	89.54 ± 44.58	15.3%	3	2
2	LCBDE	129.67 ± 44.49	22.9 %	5	3
3	OCBDE	115.02 ± 32.03	14 %	8	5
Operating time	One way ANOVA test ERCP vs LCBDE vs OCBDE			**Asymp. Sig. p = .006 (p<0,05)**	
LOS	Kruskall Wallis test ERCP vs LCBDE vs OCBDE			**Asymp. Sig. p = .0001 (p<0,05)**	
PLOS	Kruskall Wallis test ERCP vs LCBDE vs OCBDE			**Asymp. Sig. p = .0001 (p<0,05)**	
	Correlation of operating time to LOS (p-value)			p>0.05 (0.63)	
	Correlation of operating time to PLOS (p-value)			**p<0.05 (0.037)**	

This study demonstrated that ERCP had the shortest operating time among the three treatment modalities for choledocholithiasis. It also showed the lowest length of stay (LOS) and postoperative length of stay (PLOS). These findings reflect the minimally invasive nature of ERCP, which is associated with shorter hospitalization and reduced procedural duration. The combination of the shortest operating time and the lowest LOS and PLOS suggests that ERCP is the most efficient treatment modality in this cohort.

However, comparison with previous studies (Supplementary Table S1) revealed that the mean operating time for ERCP in this study was longer than that reported in many international series. This discrepancy may be explained by the lower procedural volume of ERCP at our institution compared with high-volume centers. In addition, as this study was conducted in a teaching hospital, the involvement of surgical trainees and residents in procedural performance may have contributed to prolonged operating times[9].

LCBDE demonstrated the longest operating time among the three treatment modalities in this study. This finding may be explained by the fact that most LCBDE procedures were performed as a single-stage approach combining laparoscopic cholecystectomy (LC) and laparoscopic common bile duct exploration. Comparison with previous studies showed that the operating time observed in this study was generally comparable to those reported in the literature (Supplementary Table S1). Several factors may contribute to variations in LCBDE operating time across studies, including the surgical approach (transcystic versus choledochotomy)[13,14,15], routine use of T-tube drainage[13,15], performance of biliary bypass procedures such as laparoscopic choledochoduodenostomy (LCDD), and differences in

patient age and case complexity[17,18,19].

Regarding length of stay, ERCP demonstrated the shortest LOS among the three treatment modalities. This may be attributed to the minimally invasive nature of these modalities, which facilitates faster postoperative recovery and earlier discharge. Compared with several published studies, the LOS observed in this study was relatively shorter, which may be attributed to the non-routine use of endoscopic nasobiliary drainage (ENBD). In many centers, ENBD is routinely placed and typically removed 2–5 days after the procedure, thereby prolonging hospitalization[20].

In contrast, OCBDE was associated with the longest LOS and postoperative length of stay (PLOS). As the most invasive modality, OCBDE involves greater surgical trauma and wound burden, which may delay postoperative recovery compared with ERCP and LCBDE. Nevertheless, the LOS and PLOS observed in this study were generally comparable to those reported in the international literature and remained within the ideal LOS range recommended by the local Ministry of Health[21].

Several factors may contribute to the longer LOS reported in LCBDE and OCBDE studies compared with the findings of this study, including prolonged preoperative optimization of patient condition and the requirement for preoperative MRI from the ward[22], particularly in emergency cases; routine placement of drainage devices such as T-tubes and intra-abdominal drain; routine postoperative radiographic evaluation for residual stones (postoperative days 3–5)[23,24,25]; prolonged removal of intra-abdominal drains[26]; and the occurrence of postoperative complications. In this study, all procedures were performed electively. T-tubes were rarely placed, intra-abdominal drains were not routinely used, and routine postoperative evaluation for residual stones was not performed. These perioperative management strategies are aligned with the principles of Enhanced Recovery After Surgery (ERAS), which aim to facilitate recovery and reduce hospital length of stay.

Finally, this study evaluated operating time internally by identifying prolonged operating time, defined as a duration exceeding one standard deviation above the mean operating time for each procedure. The proportion of prolonged operating times was 14.0% for OCBDE, 22.9% for LCBDE, and 15.3% for ERCP, suggesting an acceptable rate of prolonged procedures across all modalities (Table 2). Previous studies have reported an association between prolonged operating time and increased length of stay, often attributed to a higher risk of surgical site infection and postoperative morbidity. However, this association was not observed for total length of stay in the present study. Instead, operating time was significantly correlated only with postoperative length of stay. This finding suggests that prolonged operating time may primarily influence postoperative recovery rather than the overall duration of hospitalization, which is also affected by preoperative factors and institutional practices.

This study has several limitations. First, its retrospective, single-center design is subject to inherent selection bias and may limit the generalizability of the findings to other institutions and patient populations. Second, convenience sampling was used, and treatment modality was determined according to surgeon judgment and patient clinical characteristics rather than random allocation, which may also have introduced selection bias and confounding. Thirdly, operating time and length of stay are not direct indicators of surgical technical proficiency or case complexity. Instead, they should be interpreted as quality improvement metrics that may serve as indicators for performance monitoring and highlight the need for further evaluation when deviations from normal range occur. Finally, the study relied on retrospectively collected medical record data without direct verification by the investigators. Therefore, the accuracy of certain variables depended on the quality of documentation by the operating room team and healthcare staff. Although institutional records are routinely maintained, documentation errors, including inaccurate recording of operative times and dates, cannot be completely excluded.

Future prospective multicenter studies with standardized treatment protocols for each modality are warranted to validate our findings. Longer study periods and larger sample sizes may provide more robust estimates of operating time and length of stay, facilitating the establishment of regional benchmark values for each treatment modality. Such benchmarks could be used to identify prolonged operating times, which may be defined as values exceeding one standard deviation above the mean operating time for a given modality[6].

CONCLUSION

This study demonstrated that ERCP was associated with shorter operating time, length of stay (LOS), and postoperative length of stay (PLOS) compared with LCBDE and OCBDE. Therefore, ERCP may be considered the preferred treatment modality for choledocholithiasis when available and clinically appropriate. Furthermore, LCBDE was associated with a shorter LOS and PLOS than OCBDE, indicating superior postoperative recovery and greater resource efficiency. Therefore when ERCP is not feasible, LCBDE may be preferred over OCBDE. Finally, prolonged operating time was associated with prolonged length of stay, highlighting the importance of operative efficiency in optimizing resource utilization.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at https://docs.google.com/spreadsheets/d/1ju3CBrTeR8rE5MScn4iH4ESspzAbdbtb/edit?usp=drive_link&ouid=114529153233345205133&rtpof=true&sd=true