

LCBDE, three ports, and primary continuous suture of common bile duct for the treatment of cholelithiasis and choledocholithiasis: a retrospective study in Eastern China

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Research Article

Keywords: cholelithiasis and choledocholithiasis, laparoscopic cholecystectomy, laparoscopic common bile duct exploration, primary suture, T-tube drainage

Posted Date: April 27th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1549277/v1>

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Abstract

Background

Laparoscopic cholecystectomy (LC) plus laparoscopic common bile duct exploration (LCBDE) in combination with choledocholithiasis is convenient in the treatment of cholelithiasis. It has the advantage of accelerated recovery. This retrospective study aimed to summarize the experience of cholelithiasis and choledocholithiasis treatment via LC plus LCBDE approach in Eastern China.

Methods

Patients diagnosed with cholelithiasis and choledocholithiasis between July 2019 and October 2021 at the Xishan People's Hospital of Wuxi City were included in the study. During treatment, patients who received LC + LCBDE + primary suturing of the CBD were assigned to the LCBDE-P group, and those who received LC + LCBDE + T-tube drainage of CBD were assigned to the LCBDE-T group. The measurement data were compared between the two groups. P -values < 0.05 indicated statistical significance.

Results

A total number of 88 patients (48 females and 40 males) were divided into two groups: LCBDE-P ($n = 50$) and LCBDE-T ($n = 38$). Multiple linear regression analysis showed that LCBDE-P affected the risk-adjusted hospitalization stay (unstandardized coefficient, -5.352 days; 95% CI: -0.387 to -4.761 ; $P < 0.001$) and medical cost (unstandardized coefficient, -0.494 RMB; 95% CI: -0.712 to -0.277 ; $P < 0.001$) with significant differences. On the other hand, no significant differences were detected in the operation time, intraoperative hemorrhage, clearance rate of CBD stones, postoperative liver function, and postoperative complications ($P > 0.05$) between the two groups.

Conclusions

LCBDE is a safe and feasible strategy for the management of cholelithiasis and choledocholithiasis. Compared to LCBDE-T, LCBDE-P is an independent factor associated with the days and medical costs during hospitalization.

Introduction

Gallstones combined with common bile duct (CBD) stones, also termed cholelithiasis and choledocholithiasis, are a common gastrointestinal digestive disease that may occur in 4.6–12% of all patients with cholecystectomy^[1]. Gallstones may enter the CBD through the cystic duct, forming a state of gallstones combined with CBD stones, causing obstructive biliary tract and obstructive jaundice and

leading to acute cholecystitis, cholangitis, or pancreatitis^[2]. Although laparoscopic cholecystectomy (LC) is the gold standard for symptomatic gallstones; however, the optimal choice for gallstones combined with CBD stones is yet controversial. Currently, four methods are available for the treatment of cholelithiasis and choledocholithiasis: preoperative endoscopic retrograde cholangiopancreatography (pre-ERCP) plus LC, LC plus laparoscopic common bile duct exploration (LCBDE), LC plus intraoperative ERCP, and LC plus postoperative ERCP^[3]. However, whether LCBDE or ERCP is the best method to treat cholelithiasis and choledocholithiasis is yet controversial. Although, the recently updated CBD Stones Management Guidelines of the British Gastroenterology Society pointed out that there is no difference in efficacy, mortality, or morbidity between LCBDE and perioperative ERCP^[4]. However, the length of hospitalization (days) and total cost differed significantly, and LCBDE may decrease the length of hospitalization day and cost^[5]. Also, significant differences were noted in postoperative complications: bile leakage after LCBDE vs. duodenal papillary sphincter injury after ERCP^[6].

Recently, an updated meta-analysis confirmed that LCBDE is superior to ERCP + LC in the perioperative safety and short- and long-term postoperative efficacy^[7]. Furthermore, the current meta-analysis showed that LCBDE is safe and feasible in terms of perioperative complications, operative conversion rate, operative time, and postoperative efficacy, such as CBD stone clearance rate, length of hospital stay, and stone recurrence rate. This phenomenon suggested that LCBDE is a preferred method for the treatment of gallstones combined with CBD stones. Thus, LCBDE could be a preferred method for the treatment of gallstones combined with the primary suture of CBD or T-tube drainage procedure^[8].

Although the surgeons decide whether T-tube drainage or primary suture should be used during LCBDE, the decision is controversial^[8, 9], which might be related to the placement of the T-tube, patients' discomfort, electrolyte dysregulation, biliary peritonitis, and T tube displacement^[9]. A previous meta-analysis showed that when the T-tube was not used, the odds ratio of complications was reduced and no additional benefits were observed^[8]. Therefore, some of the postoperative complications may be avoided without T-tube drainage after the treatment of choledocholithiasis via LCBDE, while the patient's quality of life can also be improved significantly^[10]. Reportedly, the ability of traditional T-tube drainage to reduce bilirubin is better than that of primary suture of CBD in the early postoperative period, but the difference in long-term outcomes between the two groups is not statistically significant^[11]. Whether these controversies are related to differences in surgical procedures is yet to be elucidated.

Typically, minimally invasive surgical treatment of gallstones and CBD stones is safe and reliable, as described in the Tokyo Guidelines 2018^[12]. In the LCBDE + primary suture of CBD, after the CBD stones are removed, the choledochotomy is carried out with 4 – 0 or 5 – 0 absorbable sutures in a continuous or interrupted manner^[13]. Moreover, a novel concept of minimally invasive surgical treatment of cholelithiasis has gradually been designed: ultra-minimally invasive, aesthetic, and no-scar^[14]. Thus, we began to implement the LCBDE approach to the three-port method combined with fewer ports (**Supple. Surgery methods**), at the Department of General Surgery in Xishan people's Hospital of Wuxi City, since 2019 to reduce the injury in the abdominal wall compared to the standard 4-port method, as described

previously ^[15], followed by CBD primary continual sutures or T-tube drainage to benefit the patients. Consistently, postoperative aesthetics were ascribed to sophisticated, minimally invasive surgical procedures and required expert surgeons.

Therefore, the present study aimed to summarize the treatment experience and efficacy of LCBDE combined with primary suturing of the CBD to gallstones with extrahepatic biliary duct calculi in our medical center from July 2019 to October 2021.

Methods

Study design

This retrospective study included 88 patients with gallstones combined with CBD stones admitted at Xishan People's Hospital of Wuxi City between July 2019 and October 2021. All the gallstones combined with CBD stones were identified using transabdominal ultrasonography (USG) and magnetic resonance cholangiopancreatography (MRCP). The study was approved by the Ethics Committee of Xishan People's Hospital of Wuxi City. The requirement for informed consent was waived due to the retrospective design. The study complied with the Declaration of Helsinki.

Inclusion criteria^[16]: (1) The CBD was examined before the operation to show varying degrees of dilation (diameter \geq 8 mm); (2) No obvious bile duct stenosis, biliary variability, or intrahepatic bile duct stones on preoperative USG or MRCP; (3) No tumors detected in the liver, biliary tract, or pancreatic head in previous examinations.

Exclusion criteria^[17]: (1) Stenosis of the distal CBD or dysfunction of the papillary sphincter was detected by intraoperative Choledochoscopy; (2) Conversion to laparotomy; (3) Acute hepatitis or severe liver damage; (4) Heart, lung, and renal insufficiency in those who cannot tolerate laparoscopic surgery; (5) Those accompanied with a malignant tumor.

T-tube drainage indications^[18]: (1) Repeated exploration of the lower end of the CBD with a probe during CBD exploration can cause damage to the bile duct mucosa, inflammation of the nipple, and narrowing or stricture of the CBD after surgery; (2) Purulent cholangitis; (3) Insufficient biliary flushing; (4) Residual gallstones.

Surgical technique

The surgery of LC + LCBDE + primary suture (LCBDE-P) or LC + LCBDE + T-tube drainage (LCBDE-T) was performed using the three-port method by the same surgical team (**Supple. Surgery methods**). The patients were under general anesthesia and tracheal intubation, as described previously^[9].

Data collection

Data, including items of postoperative liver function, postoperative complications, hospitalization day, and medical cost, were collected for both LCBDE-P and LCBDE-T groups during the same period. Both groups were regularly followed up via telephone or outpatient clinic.

The present study aimed to compare the length of hospital stay, cost, duration of anesthesia, laboratory parameters (white blood cell (WBC) count, total serum bilirubin, alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transpeptidase (GGT), C-reactive protein (CRP) levels), and clinical outcomes between patients undergoing LC + LCBDE, primary suture of CBD vs. T-tube drainage.

Statistical analysis

The data were analyzed using SPSS 22.0 (IBM, Armonk, NY, USA). The continuous data were expressed as means \pm standard deviations and analyzed using Student's t-test. Categorical data were presented as frequencies and scores and were analyzed using Fisher's exact test. Simple and multiple linear regression models were used to estimate the coefficient, and the 95% confidence intervals (CIs) for hospitalization (days) and medical cost (RMB) were based on the propensity scores^[19] obtained from patient characteristics: site of postoperative complications, operation time, intraoperative hemorrhage, stone subtype, gender, age, body weight, preoperative WBCs, preoperative direct bilirubin, preoperative total bilirubin, preoperative ALT, and preoperative AST. $P < 0.05$ indicated statistical significance.

Results

Characteristics of the patients

A total 159 patients were diagnosed as gallstones combined with CBD stones. at Xishan People's Hospital of Wuxi City. Of these, 88 were included in this study from July 2019 to October 2021 based on the exclusion and inclusion criteria. Among 159 patients, 3 patients were excluded due to anesthesia intolerance, and 62 patients were treated with laparotomy. A total 94 patients were treated with LC + LCBDE, of which 6 were excluded because of the conversion to laparotomy. Finally, 38 patients were treated with LCBDE-T, and the remaining 50 were treated with LCBDE-P process (Fig. 1).

No significant between-group differences were observed in gender, age, body weight, WBC count, bellyache, combined gastrointestinal ulcer, pancreatitis, cholangitis, obstructive jaundice, fever, nausea and/or vomiting, direct bilirubin (DB), total bilirubin (TB), ALT, and AST (all $P > 0.05$, Table 1).

Table 1
Characteristic and clinical features of patients

Items	LCBDE-P (n = 50)	LCBDE-T (n = 38)	P-value
Gender (M/F)	19/31	21/17	0.107
Age (years)	58.880 ± 13.752	61.763 ± 13.13	0.295
Body weight (kg)	61.980 ± 10.125	63.311 ± 11.832	0.504
WBC (10 ⁹ /L)	5.995 ± 2.870	6.889 ± 2.447	0.111
Bellyache (Yes/No)	35/15	27/11	0.915
Combined gastrointestinal ulcer (Yes/No)	3/47	3/35	0.938
Pancreatitis (Yes/No)	3/47	3/35	0.938
Cholangitis (Yes/No)	17/33	18/20	0.204
Obstructive jaundice (Yes/No)	12/38	16/22	0.071
Fever (Yes/No)	5/45	6/32	0.626
Nausea and/or Vomit (Yes/No)	14/36	11/27	0.922
DB (μmol/L)	18.087 ± 25.441	28.074 ± 29.267	0.071
TB (μmol/L)	31.565 ± 53.371	39.571 ± 31.958	0.370
ALT (U/L)	152.100 ± 199.539	167.711 ± 160.780	0.485
AST (U/L)	92.320 ± 121.217	98.237 ± 106.067	0.579
WBC, white blood cell; DB, direct bilirubin; TB, total bilirubin; ALT, alanine aminotransferase; AST, aspartate aminotransferase.			

Analysis of intraoperative

Compared to the LCBDE-T group, the operation time was shorter in the LCBDE-P group, combined with less intraoperative hemorrhage, but not significantly. The clearance rate of CBD stones in both groups was 100%. Similarly, no statistically significant differences were detected in the stone subtype of CBD between the two groups (Table 2, $P > 0.05$).

Table 2
Analysis of the intraoperative characteristics

Items	LCBDE-P (n = 50)	LCBDE-T (n = 38)	P-value
Operation time (min)	130.940 ± 52.548	146.895 ± 50.549	0.160
Intraoperative hemorrhage (mL)	20.000 ± 12.570	33.947 ± 77.342	0.219
Clearance rate of CBD stones (%)	100	100	-
Stone subtype of CBD stones			0.263
Solitary (< 3)	25	16	
Multiple (≥ 3)	18	21	
Sediment-like	7	1	

Analysis of postoperative liver function

Next, we adjusted the data as D, which represented the preoperative value minus the postoperative value on day 3. The comparison of LCBDE-P with the LCBDE-T group showed no significant between-group differences such as Δ DB, Δ TB, Δ ALT, and Δ AST (Table 3, $P > 0.05$).

Table 3
Analysis for the characteristics of postoperative liver function in all patients

Items	LCBDE-P (n = 50)	LCBDE-T (n = 38)	P-value
Δ DB	8.385 ± 19.767	2.902 ± 21.674	0.234
Δ TB	14.960 ± 51.501	3.501 ± 27.621	0.234
Δ ALT	72.449 ± 139.997	84.889 ± 108.220	0.662
Δ AST	51.551 ± 101.866	44.250 ± 84.366	0.730

DB, direct bilirubin; TB, total bilirubin; Δ , preoperative value minus the postoperative value on day 3.

Economic benefits

Compared to the LCBDE-T group, the length of hospitalization was significantly decreased in the LCBDE-P group. This finding was in line with that of medical costs in the LCBDE-T group vs. LCBDE-P group during the hospitalization (Table 4, $P < 0.001$).

Table 4
Economic benefits of LCBDE-P vs. LCBDE-T

Items	LCBDE-P (n = 50)	LCBDE-T (n = 38)	P-value
Hospitalization (days)	14.120 ± 4.376	21.105 ± 7.451	< 0.001
Medical Cost (RMB 10K)	2.060 ± 0.434	2.733 ± 0.673	< 0.001
RMB, Ren Min Bi. 10K, 10 thousand Yuan.			

Postoperative complications

Two cases of postoperative bile leakage, 1 case of abdominal infection, and 2 cases of abdominal infection were found in the LCBDE-T group; however, no significant differences were detected compared to the LCBDE-P group (Table 5, $P > 0.05$).

Table 5
Postoperative complications of LCBDE-P vs. LCBDE-T

Items	LCBDE-P (n = 50)	LCBDE-T (n = 38)	P-value
Hemorrhage	0	0	-
Bile leakage	0	2	0.184
Abdominal infection	0	1	0.432
Cholangitis	0	2	0.184
Pancreatitis	0	0	-
Recurrent choledocholithiasis	0	0	-

Analyses of the length of stay and medical cost during hospitalization

Linear regression analyses for the length of stay and medical cost during hospitalization are shown in Table 6. Simple and multiple linear regression analysis showed that LCBDE-P affected the risk-adjusted hospitalization stay (unstandardized coefficient, -5.352 days; 95% CI: -0.387 to -4.761; $P < 0.001$) and medical cost (unstandardized coefficient, -0.494 RMB; 95% CI: -0.712 to -0.277; $P < 0.001$).

Table 6
 Linear regression analysis of the effects of LCBDE on the length of stay and medical cost during hospitalization

		Coefficient	95% CI	P-value
Hospitalization (Days)				
Simple linear regression	LCBDE-T	Reference	-9.540 to -4.430	< 0.001
	LCBDE-P	-6.985		
Multiple linear regression*	LCBDE-T	Reference	-0.387 to -4.761	< 0.001
	LCBDE-P	-5.352		
Medical cost (RMB 10K)				
Simple linear regression	LCBDE-T	Reference	-0.911 to -0.435	< 0.001
	LCBDE-P	-0.673		
Multiple linear regression*	LCBDE-T	Reference	-0.712 to -0.277	< 0.001
	LCBDE-P	-0.494		
*Coefficient adjusted for the propensity score (postoperative complications, operation time, intraoperative hemorrhage, stone subtype, gender, age, body weight, preoperative white blood cells, preoperative direct bilirubin, preoperative total bilirubin, preoperative ALT, and preoperative AST)				

Discussion

Gallstone with extrahepatic-biliary duct calculi is a common digestive tract disease with an incidence of 7–20%^[20]. Nonetheless, the treatment of this disease is controversial, although multiple methods are recommended^[3]. With the development and maturity of laparoscopic technology, LCBDE has been used more frequently today in the diagnosis and treatment of gallstones combined with CBD stones than in the last decade, enriching the experience of surgeons^[21]. However, whether to use primary suture of the CBD or T-tube drainage is still controversial^[3]. In addition, advanced expertise level in specialized hepatic surgery in medical hospitals is uneven^[5, 22, 23]. Patients treated with minimally invasive surgery expect less surgical trauma and postoperative aesthetics and recovery rapidly, posing a continual challenge for surgeons. Surgeons need to continuously improve their surgical technology. The present study aimed to summarize the experience in the treatment of gallstones combined with CBD stones in a medical center in Eastern China.

The rapid development of minimally invasive technology and the continuous improvement of surgical instruments are beneficial to the patients, including decreased surgical trauma, alleviated pain, and accelerated recovery^[24]. Therefore, to accomplish LCBDE, three ports were selected in the management approach in our surgical team since July 2019 (**Figure S1–3**) compared to a fifth port that may be added

in addition to the standard four ports, as described previously^[15, 17]. Herein, 88 patients successfully accomplished LCBDE via a three-port method in our hospital, except 6 patients who converted to laparotomy because of unclear anatomy of the Calot triangle (Fig. 1).

Since LCBDE was first described in 1991^[25], the removal of CBD stones can be performed via two methods: an approach to cystic duct incision or CBD incision according to the characteristics of the patients^[26, 27]. In this study, the patients accepted the approach to CBD incision for the removal of stones; the clearance rate of the CBD stones was 100% in both groups without a statistically significant difference (Table 2). In clinics, flexible and proficient control of choledochoscopy and tacit cooperation with the assistant surgeon play a key role in improving the efficiency of CBD stone removal. Subsequently, repeated choledochoscopy is an effective way to avoid residual CBD stones. In addition, the CBD incision was sutured with a 4 - 0 absorbable thread in one stage (continuous round-trip) in the LCBDE-P group (**Figure S3**), performed after the clearance of CBD stones and without postoperative bile leakage, cholangitis, and suture (Table 5, $P > 0.05$). Interestingly, the operation time of LCBDE-P was shorter, combined with less intraoperative hemorrhage than that of LCBDE-T, but without a statistical difference (Table 2, $P > 0.05$). This phenomenon could be attributed to the placement of the T-tube via interrupted suture, thereby requiring more time compared to the primary suture of CBD; also, the T-tube may interfere with the surgeon's suturing operation, prolonging the operation time. However, patients accomplished primary continual sutures of the CBD depending on the individual characteristics of the patients who fulfilled the indications^[16, 28]. Therefore, this study suggested whether the patients received primary suture of the common bile duct or T-tube drainage depends on whether they meet the corresponding indications, which should also be evaluated by the surgeons.

In the present study, all patients who underwent LCBDE procedure, irrespective of primary suture or T-tube drainage, were recovered and discharged from the hospital (Table 3, 4). Similarly, the three-port method of LCBDE decreases the scar in the abdomen, as the method is minimally invasive, thereby improving the aesthetics. Simultaneously, the patient's liver function recovered rapidly after surgery. Thus, the preoperative value minus the postoperative value on day 3 was expressed as " Δ ," which represented the changes of the liver function pre- and postoperation. However, there was no statistically between-group difference in postoperative liver function (Table 3, $P > 0.05$). At this point, we choose the value of postoperative day 3 as the key variable because most patients recovered soon and very well after the operation, with almost normal liver function on postoperative day 5. Exhilaratingly, the hospitalization Day and medical Cost were decreased in **LCBDE-P** group, and with obviously statistically differences (Table 4, $P < 0.0001$). Furthermore, both univariate and multivariate regression analyses confirmed that LCBDE-P was an independent factor associated with the days and medical costs during hospitalization (Table 6, $P < 0.0001$). After 3 months follow-up, short-term complications were mainly 2 cases of postoperative bile leakage, 1 case of Abdominal Infection, and 2 cases of cholangitis in LCBDE-T group, but there were no significant differences compared to the LCBDE-P group (Table 5, $P > 0.05$). For complications, patients with postoperative bile leakage gradually recovered by extending the placement of abdominal drainage tubes and preventing abdominal infection at the same time. Postoperative

abdominal infection and cholangitis patients returned to normal after receiving anti-infective treatment. According to these results, our experience confirmed that the three-port method of LCBDE is safe and feasible. Moreover, primary continual sutures of the CBD are efficient and economical in the treatment of cholelithiasis and choledocholithiasis under well-controlled indications. Importantly, LCBDE should be carried out by highly selected expert surgeons who have advanced experience and technology in minimally invasive biliary tract surgery. Simultaneously, the usage of abdominal puncture Trocars to explore and improve the novel strategy of choledocholithotomy under endoscopy are more conducive to embodying the advantages of minimally invasive biliary tract surgery, which may benefit more patients with choledocholithiasis.

Nevertheless, the present study has some limitations. It is a retrospective analysis in a single medical center with only a small number of cases from high-level hospitals, no long-term follow-up, and without a comparison group. The heterogeneity is limited, and patients were from the Jiangsu province, lacking a multicenter and/or regional comparative analysis. Additional feedback from patients undergoing this procedure is needed for the promotion of the strategy.

Conclusions

This study summarized the experience in treating cholelithiasis and choledocholithiasis in the medical center in Eastern China. Despite improved technology, the three-port method and primary running suture of CBD is a safe and feasible strategy for the treatment of cholelithiasis and choledocholithiasis. LCBDE-P is an independent factor associated with the length of hospital stay and medical costs during hospitalization in the treatment of the patients diagnosed with cholelithiasis and choledocholithiasis.

Declarations

Authorship Statement

This study was designed by CB Chen and CB Chen also drafted the manuscript. ZP Xu, SB He, and CL Zhao: performed research, reviewed this manuscript, and manuscript editing. WD Hu, N Tang and C Ge: designed the mathematical methods. ZW Zhang, JY Gu, and WW Zhao: organized the cases. ZX Dai, WG Wang, and S Zhang: collected and analyzed the data. All authors read and approved the final manuscript.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author (Chaobo Chen) upon reasonable request. For any queries, kindly contact bobo19820106@gmail.com.

Acknowledgments

We are grateful to thank all the members of the Department of General Surgery, Department of Interventional and Vascular Surgery at Xishan People's Hospital of Wuxi City, and members of the

Department of Hepatic-Biliary-Pancreatic Surgery, the Affiliated Drum Tower Hospital of Nanjing University Medical school, for their continuing support for this study. We are very glad to thank Professor Songbing He from the Department of General Surgery at the First Affiliated Hospital of Soochow University for his generous help. The datasets used and/or analyzed during the current study are available from the corresponding authors (Chaobo Chen) upon reasonable request. For any queries, kindly contact bobo19820106@gmail.com.

Conflict of Interest Statement

The authors declare no competing interests.

Funding

This study was supported by a research project of Wuxi Municipal Health Commission (Project, No. M202160), Project of National Science Foundation of Jiangsu Province of China (BK20191172), Project of Gusu Medical Key Talent of Suzhou City of China (GSWS2020005), and Project of New Pharmaceuticals and Medical Apparatuses of Suzhou City of China (SLJ2021007).

Ethical Approval

The study was approved by the Ethics Committee of Wuxi Xishan People's Hospital, No xs2022ky004. The study complied with the Declaration of Helsinki. The need for individual consent was waived by the committee.

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Figures

Detailed Surgery Flow Diagram

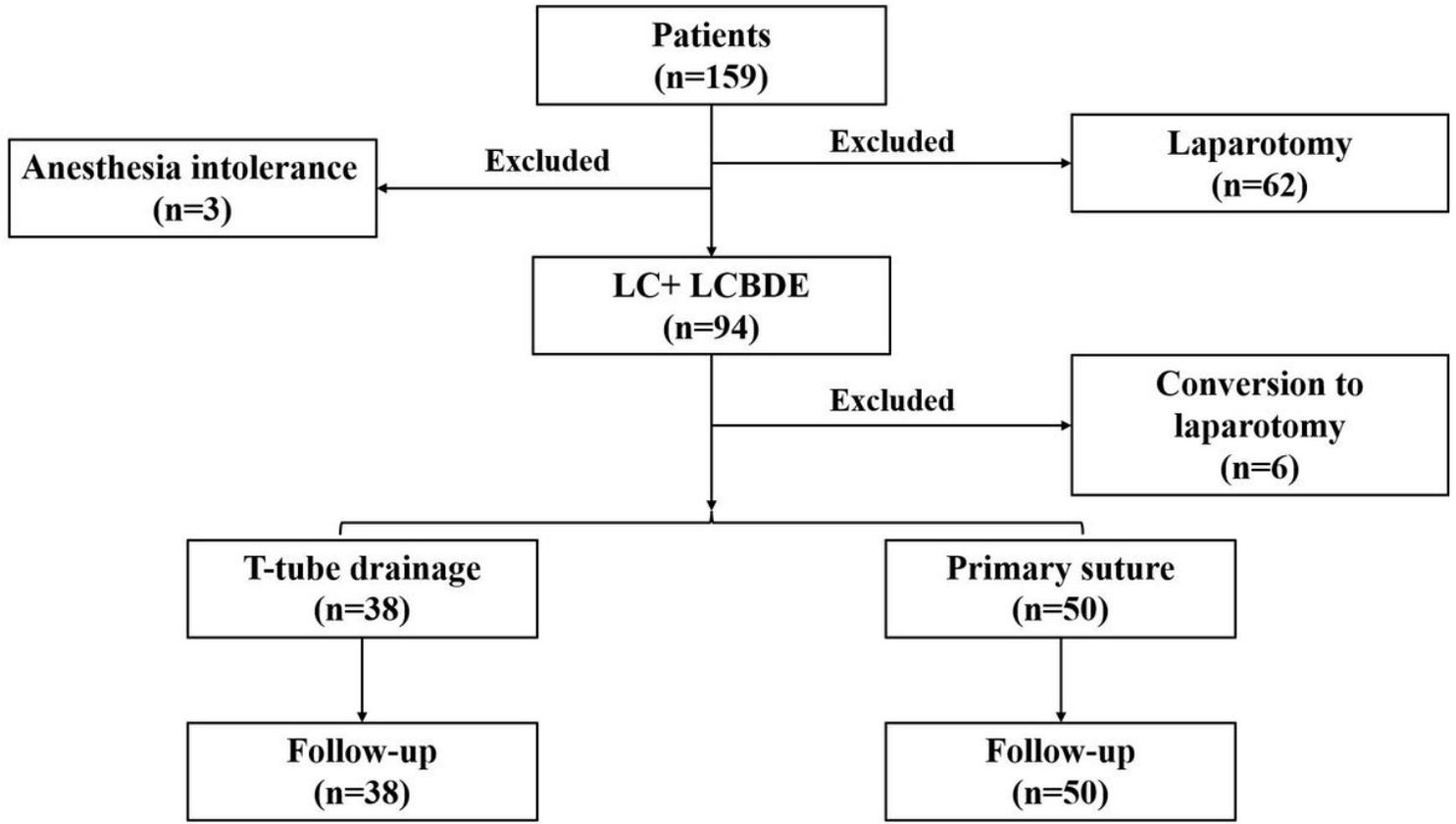


Figure 1

Figure 1

Flow Diagram.

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