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ORIGINAL ARTICLE

# A predictive nomogram to identify factors influencing the success of a concomitant laparoscopic cholecystectomy with common bile duct exploration for choledocholithiasis

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## Abstract

**Background:** Single-staged laparoscopic common bile duct exploration (LCBDE) offers clear benefits in terms of cost and shorter hospitalization stays. However, a failed LCBDE requiring conversion to open surgery is associated with increased morbidity. This study reviewed the factors determining success of LCBDE, and created a predictive nomogram to stratify patients for the procedure.

**Methods:** A retrospective analysis of 109 patients who underwent LCBDE was performed. A nomogram was developed from factors significantly associated with conversion to open surgery and validated.

**Results:** Sixty-two patients underwent a successful LCBDE, while 47 patients required a conversion to open CBDE. The presence of underlying cholangitis (crude OR 2.70, 95% CI: 1.12–6.56, p = 0.017), together with its subsequent interventions, seemed to adversely increase the rate of conversion to open surgery. The predictive factors included in the nomogram for a failed laparoscopic CBDE included prior antibiotic use (adjusted OR (AOR) 2.98, 95% CI: 1.17–7.57, p = 0.022), previous ERCP (AOR 4.99, 95% CI: 2.02–12.36, p = 0.001) and abnormal biliary anatomy (AOR 9.37, 95% CI: 2.18–40.20, p = 0.003).

**Conclusion:** LCBDE is useful for the treatment of choledocholithiasis. However, patients who were predicted to have an elevated risk for open conversion might not be ideal candidates for the procedure.

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## Introduction

Up to 3–10% of patients with cholelithiasis have concomitant choledocholithiasis.[1] Though the definitive treatment for symptomatic cholelithiasis is usually straightforward with a laparoscopic cholecystectomy, there are various modalities available for the treatment of choledocholithiasis. Modern management of common bile duct (CBD) stones includes either a single or two-staged approach. The single-staged approach combines laparoscopic cholecystectomy and a laparoscopic CBD exploration (LCBDE) in the same setting. The two-staged approach involves a laparoscopic cholecystectomy with either a preoperative, intraoperative or postoperative endoscopic retrograde cholangiopancreatography (ERCP). A meta-analysis of all the randomized controlled trials comparing these two different approaches have reported equivalent rates of stone clearance, morbidity and mortality, but with fewer procedures required for patients who underwent a single-staged approach.[1] However, LCBDE is technically more demanding and has a steep learning curve prior to achieving outcomes similar to a conventional two-staged approach.[2,3] Furthermore, in a patient planned for LCBDE, a need to convert to an open CBD exploration (CBDE) intraoperatively is associated with more blood loss, postoperative complications and overall morbidity.[4] Such patients if well selected preoperatively might be more suitable for a 2-staged approach. On the other hand, for other patients with a failed ERCP, LCBDE appeared to be effective in the treatment of CBD





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stones.[5,6] This study thus aims to identify the various factors predicting for the success of LCBDE, and attempt to create a predictive nomogram to aid in stratifying patients for a successful LCBDE.

## Methodology

A retrospective review of all patients who underwent a cholecystectomy with concomitant CBDE, from 1st January 2010 to 31st December 2015, was obtained from the database of the National University Hospital (NUH), Singapore. Demographic, clinicoradiologic and intraoperative information were obtained. For biochemical investigations, the latest blood investigations done just prior to the surgery were recorded. This study obtained Institutional Ethics Board approval (NHG DSRB Ref: 2015/01184).

All patients underwent either a laparoscopic cholecystectomy with a concomitant LCBDE (Group A), or laparoscopic converted to open cholecystectomy and concomitant CBDE (Group B). The diagnosis of choledocholithiasis was made preoperatively based on imaging and liver function tests. All the patients had the laparoscopic cholecystectomy performed via a conventional 4-port approach. Pneumoperitoneum was always performed using open Hasson's technique for port insertion,[7] done either transumbilical or infraumbilical. Calot's triangle was dissected, the critical view of safety[8] achieved and the cystic artery was clipped. Following which, the cystic duct was clipped at its distal end and partially cut proximally. An intraoperative cholangiogram was performed to confirm the presence of choledocholithiasis. If a filling defect was noted on the cholangiogram, a LCBDE was subsequently performed. The right midclavicular 5 mm laparoscopic port was upsized to 10 mm disposable port, and a choledochoscope was inserted. All LCBDEs were attempted first via a transcystic approach. Failing which, in patients with suitable ductal size (at least 1 cm), a choledochostomy was created laparoscopically, and a transcholedochal CBDE was performed. Exploration of the bile duct was performed using choledochoscope and Dormia basket. The biliary opening (transcystic or transcholedochal) was sutured using polydioxanone sutures with intracorporeal laparoscopic suturing. The use of any biliary drainage devices such as T-tube, antegrade or retrograde stents was also documented.

Prior antibiotic use was defined as antibiotics which were prescribed for the patient prior to surgery during the same admission. Previous ERCP were defined as patients who had previous ERCP procedures done, prior to surgery.

Presence of any significant biliary anatomical abnormalities, such as Mirizzi's syndrome, cholecysto-fistula, or if the cystic to common hepatic duct junction was not well visualized, were all considered as abnormal biliary anatomy and were documented.

Patients' characteristics were summarized by mean ± standard deviation (SD) for continuous variables with approximately normal distribution and median (interquartile range) for those with skewed distributions. Categorical variables were presented by n (%). To compare patients' characteristics between Groups A and B, the Fisher's exact test was employed for categorical variables, and the independent two-sample *t*-test and the Wilcoxon rank-sum test were adopted for continuous variables with normal and skewed distributions respectively. The corresponding effect measures, crude odds ratio (OR) and its 95% confidence interval (CI) were calculated from their exact definitions for categorical variables, and the univariate logistic regression for continuous variables. The ln-transformation was performed for skewed continuous variables. Variables identified as possibly statistically significant ($p < 0.10$) were selected to further develop a multivariable logistic regression via a backward selection procedure. The final model contained variables with $p < 0.05$ to construct a Kattan-styled nomogram.[9–12] The nomogram was subsequently validated for its discriminative ability by a receiver-operating characteristics (ROC) curve, with the area under the curve (AUC) and its 95% CI estimated. For the purpose of internal validation, a bootstrap method of 1000 times resampling was employed to obtain a bias-corrected AUC. A calibration plot was also done to validate the nomogram, which depicted the distance between observed and predicted probabilities of a laparoscopic converted to open CBDE. The similar bootstrap resampling method was adopted to obtain the bias-corrected predicted probabilities. Lastly, the Hosmer–Lemeshow test summarized the goodness-of-fit of the nomogram. Statistical analyses were conducted using STATA/SE 14 (StataCorp LP, College Station, Texas, USA). The calibration plots were generated by R version 3.3.1 (R Foundation for Statistical Computing, Vienna, Austria) using *rms* package. All statistical analyses were performed assuming a two-sided test with 5% significance level.

## Results

Between 1st January 2010 to 31st December 2015, a total of 168 patients underwent a planned cholecystectomy with possible concomitant CBDE (Fig. 1).

In the 47 patients who underwent conversion to open CBDE the reasons documented were due to peritoneal adhesions either in the region of the hepatoduodenal ligament or the Calot's triangle that prevented the critical view of safety from being established (19/47), inability to successfully cannulate or remove the stones laparoscopically (17/47) and abnormal anatomy due to Mirizzi's syndrome or fistulation (5/47). Of the 62 patients who had LCBDE successfully completed it was performed via the transcystic approach in 49 (79%) and a transcholedochal approach in 13 (21%). Overall success rate for LCBDE was 57% (62/109).

In total, the median length of stay for Group A and Group B patients were 4 (interquartile range 2–7) and 5 (interquartile range 4–10) respectively ($p = 0.025$). For Group A patients, 77% (48/62) had no complications while five patients suffered Clavien grade 2 and 6 suffered Clavien grade 1 complications




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