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Pre-operative predictors for open conversion in elective laparoscopic cholecystectomy in a tertiary care centre

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Abstract
Background: Laparoscopic cholecystectomy has emerged as the standard of care for benign gallbladder disease esp. cholelithiasis. Conversion to open surgery, though not to be considered a failure, adds to the post-operative morbidity, and prolongs hospital stay. This study attempts to determine the factors that could predict pre-operatively, the risk for open conversion.
Methods: This retrospective single centre study from a tertiary care centre in South India (Government Medical College, Thiruvananthapuram) included 204 consecutive laparoscopic cholecystectomy patients. The goal of the study was to determine the pre-operative predictors of open conversion in patients undergoing elective laparoscopic cholecystectomy.
Results: The prevalence of conversion to open cholecystectomy in this series was 10.29% the predominant reason for which was frozen Calot's triangle (71.4%). Out of the pre-operative predictors of conversion to open surgery that were studied, imaging features of GB wall thickening (>3mm) or Common bile duct dilatation (≥7mm) had a statistically significant odds ratio of 61.44 for conversion.
Conclusion: Pre-operative imaging features of GB wall thickening (>3mm) or Common bile duct dilatation (≥7mm) is a significant predictor of conversion to open surgery during elective laparoscopic cholecystectomy.

Keywords: cholecystectomy, laparoscopic, conversion to open surgery, predictors

Introduction
The first open cholecystectomy was performed in 1882 by the German Surgeon Carl Johann August Langenbuch in Berlin [1]. More than a century later, at a time when the dictum was "big surgeons make big incisions", Erich Mühe, in 1985 performed the first laparoscopic cholecystectomy (LC), [2] revolutionizing the surgical access in gallbladder surgery. Presently, laparoscopy has become the standard surgical approach in benign gallbladder pathologies. Conversion rate to open cholecystectomy is about 4.2% to 6.2% with some of the larger studies showing higher rates up to 15% [3, 4]. Previous analysis of the conversion rate at our centre established it at 10.29%, consistent with the other published data from tertiary care centres [5]. Advent of newer energy devices and secure stapling techniques have further reduced the need for open conversion. The reasons for conversion to open surgery can be patient specific, disease specific, surgeon specific and technical factors. If the difficult cholecystectomy requiring open conversion can be predicted preoperatively, it assists in preoperative patient counselling as well as surgeon preparedness, thus enhancing patient safety. The present study intends to study the predictors of conversion to open surgery in elective cholecystectomy in a tertiary care centre.

Materials and Methods
Patients and Study Design
This was the part of a larger retrospective single centre study from a tertiary care centre in South India (Government Medical College, Thiruvananthapuram) published earlier primarily aimed at the prevalence and reasons for conversion to open surgery [5]. 218 elective cholecystectomies were performed during the study period from January 2017 to December 2019; of which 14 cases were elective open cholecystectomies. 204 consecutive patients who underwent laparoscopic cholecystectomy in the Department of Surgical Gastroenterology, Government Medical College, Thiruvananthapuram were included in the study. Being a training centre, the cases were done by experienced laparoscopic surgeons as well as trainees under the guidance

of senior surgeons. The prospectively held hepatopancreaticobiliary surgery operative database held in the department was scrutinized and data collected. The previous study had established the proportion of conversion and rationale for conversion. The primary objective of this study was to determine the pre-operative predictors of open conversion in patients undergoing elective laparoscopic cholecystectomy. Informed written consent was obtained from all patients before surgery according to the institutional protocol. This study was performed in accordance with the declaration of Helsinki and was approved by the ethics review committee of Government Medical College, Thiruvananthapuram [HEC No: 08/05/2021/MCT]

Surgical Principles and Procedures

The procedure was performed under general anaesthesia with a standard abdominal preparation. Nasogastric tubes were placed in all cases and foley's catheter for selected cases where difficulty was anticipated. Four laparoscopic trocars are necessary for all patients. An initial supra-umbilical trocar 10 or 11mm was inserted using the Hasson's open technique and it served as the primary location for the laparoscopic telescope and attached camera [6]. Insufflation with carbon dioxide was begun at a low rate, approximately 0.5 to 1.5 L/min, continued until reaching the desired intra-abdominal pressure, usually 12 to 14 mm Hg. A 30-degree side-viewing laparoscope was used for all cases. The patient is repositioned in the reverse Trendelenburg position at about 30 degrees to allow the colon and omentum to fall away from the upper abdomen, providing better exposure of the gall bladder. A second 12mm trocar was placed in the subxiphoid area. Two 5 mm trocars are placed laterally in the right subcostal area, one near the midclavicular line and one near the anterior axillary line. A major proportion of patients had Calot's triangle dissection first followed by demonstration of the "critical view of safety" as described by Strasberg *et al* [7]. This was followed by clipping of the cystic duct and artery – 2 clips on the patient side and 1 clip on the gallbladder side with subsequent gallbladder fossa dissection. "Difficult cholecystectomies" were performed "fundus first" with few needing stapled transection of the wide/thickened cystic duct using an endo-stapler. Cases that required conversion were opened using a right subcostal [Kocher's incision] or upper midline laparotomy incision depending on ease of access.

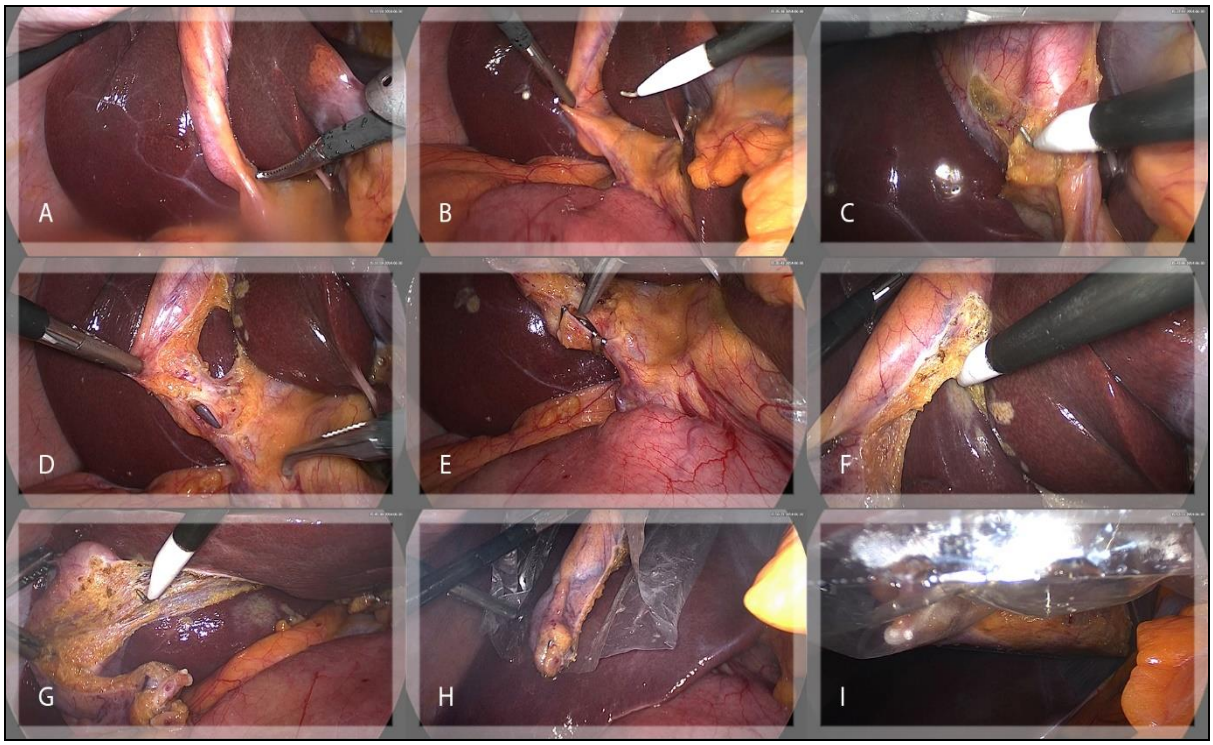

Fig 1: Steps during standard 4 port laparoscopic cholecystectomy

Table 1

A. Initial fundal retraction
B. Lateral traction on the Hartmann's pouch to start dissection
C. Posterior dissection
D. Critical view of safety of Strasberg
E. Clipping the cystic duct and artery
F. GB fossa dissection
G. Final dissection of the fundus off the cystic plate
H. Gall bladder placed into the specimen bag
I. Specimen with endo-bag extraction through the epigastric port

Cut-offs for Various Predictors of Conversion to Open Surgery.
Age >65 was found to be a significant predictor for anticipated difficult cholecystectomy and subsequent conversion from literature [9]. Our laboratory cut-off for normal serum alkaline phosphatase was 115 and total leucocyte count was 11,000. On pre-operative imaging GB wall thickness >3mm [10] was considered thickened and common bile duct ≥7mm was considered dilated [11, 12].

Statistical Analysis
R statistical software version 4.0.5 was used for all statistical analysis. Descriptive statistics are reported in mean and standard deviation or median and interquartile range for continuous variables and in absolute numbers and percentages for categorical variables. Proportion of conversion to open surgery was reported in percentages with 95% confidence interval. Multivariate logistic regression analysis was done to estimate the odds ratio of each predictor for open conversion. P value <0.05 was considered statistically significant.

Results
Rationale for conversion to open surgery during laparoscopic cholecystectomy
Table.1 shows the proportion of conversion to open surgery and the reasons for the same [5]. Of the 204 patients planned for elective laparoscopic cholecystectomy, 183 (89.7%) were accomplished laparoscopically. 21 patients (10.29%) were converted to open surgery for safe completion of cholecystectomy. The primary reason for conversion was frozen calot's triangle (71.4%) owing to intense inflammation with subsequent failure to delineate calot's anatomy safely i.e., cystic artery and duct. Few of the patients (9.5%) had Mirizzi syndrome [8] with the large Hartmann's pouch calculi compressing the common bile duct (CBD) and producing upstream CBD dilatation. A similar proportion (9.5%) also had a cholecysto-enteric fistula. A small percentage (4.76%) had a distended CBD on laparoscopic visualization requiring CBD exploration. One patient (4.76%) was found to be grossly cirrhotic impeding the safe laparoscopic dissection of GB off the cystic plate, consequently necessitating conversion.

Pre-operative predictors of conversion to open surgery during laparoscopic cholecystectomy
Pre-operative predictors of conversion studied included advanced age (> 65years), male sex, jaundice as the presenting symptom, Diabetes Mellitus, previous upper abdominal surgeries, ERCP stenting, prior history of acute cholecystitis or acute pancreatitis, aetiology of stone disease or polyps, raised total leucocyte count, raised serum alkaline phosphatase and pre-operative imaging features of GB wall thickening or CBD dilatation. Table 2 shows the proportion of conversion in each group. The study population comprised of 72 males (35.3%) and 132 females (64.7%) with ages ranging from 14 to 75 years (median age of 48 years). 28 (13.73%) were over age 65 years of which 17.86% required conversion compared to 9.09% of those below age 65. 16.67% males required conversion in comparison to 6.81% females. Majority of cases were stone disease (94.6%) whereas polyp was present in 4.4% and stone along with polyp in 0.98%. Pain was the predominant symptom (94%) [Conversion rate 9.38%] while the remaining 5.8% had pain along with jaundice [25% conversion]. 19.6% of the cases had diabetes mellitus [12.5% conversion vs 9.75% in non-diabetics] while a small proportion (1.47%) had previous upper abdominal surgeries. Previous ERCP and stenting was required in 11.76% [16.67% conversion rate vs 9.44% in non-stented patients]. History of acute pancreatitis and cholecystitis were present in 3.92% [25% conversion vs 9.69% in patients without pancreatitis] and 23.5% [13.5% conversion vs 9.5% conversion in patients without cholecystitis] respectively. Raised total leucocyte count was present in 7.8% [31.25% conversion vs 8.25% conversion in those with normal leucocyte count] and raised serum alkaline phosphatase in 11.27% [34.8% conversion vs 7.18% conversion in those with normal ALP]. Features of GB wall thickening (>3mm) or common bile duct dilatation in the preoperative imaging was present in 25.49% [62.5% conversion vs 0.65% in patients without these features on preoperative imaging].
Multivariate logistic regression analysis [Table 3] showed jaundice as the presenting symptom, male gender, prior history of acute cholecystitis or acute pancreatitis and pre-operative imaging features of GB wall thickening or CBD dilatation had higher odds of conversion to open surgery but only pre-operative imaging features of GB wall thickening or CBD dilatation was found to be statistically significant.

Table 2: Proportion and rationale for conversion to open surgery during laparoscopic cholecystectomy

	Number	Percentage	CI
Total Lap Cholecystectomy attempted	204		
Successfully completed	183	89.7	[84.7-93.5]
Conversions	21	10.3	[6.63-15.5]
Rationale for Conversion			
Frozen Calot's Triangle	15	71.4	[47.7-87.8]
Mirizzi Syndrome	2	9.5	[1.7 -31.8]
Cholecysto-enteric fistula	2	9.5	[1.7 -31.8]
Dilated CBD	1	4.8	[0.24-25.9]
Cirrhosis – Liver	1	4.8	[0.24-25.9]

Table 3: Proportion of Conversion in each group

	Total Number	Percentage	Proportion of Conversion %
Age >65	28	13.73	17.86
Age <65	176	86.27	9.09
Sex			
Male	72	35.3	16.67
Female	132	64.7	6.81
Symptom			
Pain	192	94.1	9.38
Pain + Jaundice	12	5.8	25
Diabetes Mellitus	40	19.61	12.5
Non-Diabetic	164	80.39	9.75
ERCP + Stenting	24	11.76	16.67
No Stenting	180	88.24	9.44
Previous Acute Pancreatitis	8	3.92	25
No Previous Pancreatitis	196	96.08	9.69
Previous Acute Cholecystitis	48	23.5	13.5
No Previous Cholecystitis	156	76.47	9.5
Total Leucocyte Count – Elevated	16	7.8	31.25
Normal Leucocyte Count	188	92.16	8.25
Raised Alkaline Phosphatase	23	11.27	34.8
Normal Alkaline Phosphatase	171	83.82	7.18
Imaging features suggestive of GB wall thickening or CBD dilatation	52	25.49	62.5
No imaging features of GB thickening or CBD dilatation	152	74.51	0.65
ERCP: Endoscopic retrograde cholangiopancreatography; CBD: Common bile duct GB: Gall Bladder			

Table 4: Multivariate logistic regression analysis

	Total Number	Percentage	Odds Ratio	95% CI	P - value
Age [Years; Median, Range]	**48 [14-75]**		**1.049**	**0.9887 - 1.11**	**0.114**
Sex					
Male	72	35.3	2.352	0.6324 – 8.75	0.202
Female	132	64.7			
Symptom					
Pain	192	94.1			
Pain + Jaundice	12	5.8	1.114	0.134 - 9.26	0.920
Diabetes Mellitus	40	19.61	0.212	0.0308 - 1.45	0.114
Previous upper abdominal surgery	3	1.47			
ERCP + Stenting	24	11.76	0.937	0.1051 - 8.36	0.954
Previous Acute Pancreatitis	8	3.92	4.365	0.242 - 78.75	0.318
Previous Acute Cholecystitis	48	23.5	3.296	0.558 - 19.47	0.188
Aetiology					
Stone	193	94.6			
Polyp	9	4.4			
Stone + Polyp	2	0.98			
Total Leucocyte Count – Elevated	16	7.8	1.0	0.9998-1.000	0.541
Raised Alkaline Phosphatase	23	11.27	1.006	0.9936 - 1.02	0.346
Imaging features suggestive of GB wall thickening or CBD dilatation	52	25.49	61.438	5.0779-743.35	0.001
ERCP: Endoscopic retrograde cholangiopancreatography; CBD: Common bile duct GB: Gall Bladder					

Discussion

Our previous study [5] had established that the frequency of conversion to open surgery during elective cholecystectomy was 10.29%. Also, the most common rationale for conversion to open surgery was the frozen Calot's triangle anatomy preventing the safe dissection and delineation of the cystic artery and cystic duct due to inflammation. Others included Mirizzi syndrome [8], cholecysto-enteric fistula, dilated CBD requiring open CBD exploration and cirrhotic liver.

On comparing the proportions of conversion individually, advanced age (> 65years), male sex, jaundice as the presenting symptom, Diabetes Mellitus, ERCP stenting, prior history of acute cholecystitis or acute pancreatitis, raised total leucocyte count, raised serum alkaline phosphatase and pre-operative imaging features of GB wall thickening or CBD dilatation all showed higher risk of conversion to open surgery. However, on multivariate

analysis, even though jaundice as the presenting symptom, male gender, prior history of acute cholecystitis or acute pancreatitis and pre-operative imaging features of GB wall thickening or CBD dilatation had trended towards higher odds of conversion to open surgery, only pre-operative imaging features of GB wall thickening or CBD dilatation was found to be statistically significant. Pre-operative imaging features of GB wall thickening (>3mm) or Common bile duct dilatation (≥7mm) was found to have odds ratio of 61.44 for conversion and was found to be a statistically significant predictor ($p<0.001$).

There are 2 types of surgical morbidity produced during any surgical operation: A. Access trauma – for access to the diseased area and B. Surgical trauma – for tackling the actual pathology. In minimally invasive surgery, the access trauma is being minimized without compromising the safety. This translates to reduced hospital stay, the early return of bowel function, early return to work and cosmesis. Three and half decades after its introduction, these benefits have made laparoscopic cholecystectomy the standard of care in benign gall bladder diseases including stones and polyps. But the conversion rate to open surgery remains high ranging from 4.2% to 15% [2, 3] chiefly owing to the intra-operative inability to correctly identify the Calot's triangle anatomy or due to bleeding, choledocholithiasis or bile duct injury [7].

Inability to delineate Calot's triangle anatomy may be owing to pericholecystic adhesions due to inflammation produced by previous cholecystitis or previous pancreatitis. Endoscopic stenting also produces peri-choledochal inflammation leading to difficulty in dissection. Male gender is predisposed to severe fibrosis and anatomical changes due to the inflammation and consequently more chances of conversion [13-15]. A longer history of gallstones and increased number of attacks of cholecystitis explain advanced age being a risk factor for conversion [16, 17]. Increased thickness of gallbladder wall on pre-operative ultrasonography portrays the present inflammation or fibrosis due to previous attacks of cholecystitis and is an important predictor for conversion [18, 19]. History of jaundice usually indicates bile duct stones or Mirizzi syndrome – both of which increase the inflammatory reaction in the Calot's triangle and GB fossa. Diabetic patients had a higher incidence of bactibilia and more frequently developed gangrenous cholecystitis and gallbladder perforation, leading to greater chances of conversion [20, 21].

Dissection and delineation of Calot's triangle anatomy in the presence of dense adhesions is unsafe and may produce biliary or vascular injuries leading to long term complications. Conversion in laparoscopy to open surgery is not a failure and timely conversion is essential to ensure patient safety and reduce patient morbidity. The alternative salvage strategies in difficult cases include laparoscopic subtotal cholecystectomy [22].

The ability to predict intra-operative difficulty or conversion could aid in pre-operative patient counselling regarding conversion. Pre-operative prediction of conversion will also ensure that the cases be managed by surgeons with greater expertise avoiding unnecessary patient morbidity. It also promotes better pre-operative preparedness and anticipation for intra-operative difficulty and helps in prompt conversion as needed.

The limitations of our study include wide confidence intervals owing to the smaller sample size. The smaller sample size may also be the reason that, despite being strong predictors of conversion as per literature, few factors could not be established as statistically significant predictors in our study. Further studies with a larger sample size may help us establish more predictors of open conversion based on pre-operative parameters. Additionally, being a training centre, the surgeries are performed by expert faculties as well as trainees under supervision and surgeon's expertise could also be a confounding factor.

Conclusion

Pre-operative imaging features of GB wall thickening (>3mm) or Common bile duct dilatation (≥7mm) can significantly predict conversion to open surgery during elective laparoscopic cholecystectomy.

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