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A Three-Step Conceptual Roadmap for Avoiding Bile Duct Injury During Laparoscopic Cholecystectomy

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Abstract

Background: ***Laparoscopic cholecystectomy is among the most frequently conducted surgical procedures nowadays.***

Aim: ***This investigation aimed to prevent bile duct injury during laparoscopic cholecystectomy.***

Patients and methods: ***This was a prospective cohort research study that included 60 patients at the Department of Surgery in Al-Azhar University Hospitals, Cairo, Egypt.***

Results: ***Regarding post-operative complications and outcomes among studied cases, the mean hospitalization length was 2.4±1.16 days with a range of 1-6 days. There were 18 (30%) with wound infection, 13 (21.7%) with subhepatic collection, 5 (8.3%) with retained stone, 14 (23.3%) with bile leak more than 50-100 mm/24 h, and 13 (21.7%) with bleeding from the abdominal cavity >100 mm/24 h, and mortality was reported in 1 (1.7%). There was a statistically significant correlation between preoperative difficulty with hospital length of stay, retained stone, and bile leak more than 50-100 mm/24 h, P < 0.05. Preoperative difficulty can predict intraoperative outcomes with 87.5% sensitivity, 80% specificity, and 81.6% accuracy. It can also predict conversion to open surgery with a sensitivity of 100%, specificity of 70%, and accuracy of 73.3%. It can also predict overall postoperative complications with a sensitivity of 59%, specificity of 80.5%, and accuracy of 70%.***

Conclusion: ***We determined that difficulty before surgery predicts outcomes during surgery with an 87.5% sensitivity, 80% specificity, and 81.6% accuracy. It predicts the transition to open operations and the overall incidence of post-operative problems, with a 59% sensitivity, 80.5% specificity, and 70% accuracy.***

Keywords: Conceptual roadmap; Bile duct injury; Laparoscopic cholecystectomy

1. Introduction

The gallbladder is a rather unimportant organ. Certain mammalian species lack even just one. The gallbladder is close to essential anatomical structures that convey bile from the liver and provide it with blood flow.[1]

Laparoscopic cholecystectomy is among the most frequently conducted surgical procedures nowadays. It is a procedure with varying degrees of difficulty.[2]

Bile duct injuries represent the most prevalent severe complication associated with cholecystectomy. They are frequently very morbid and may result in mortality. They often lead to further operations, extended recuperation periods, loss of work, and a decline in quality of life. [3]

Most significant bile duct injuries result from misidentification. Consequently, precise anatomical detection of the cystic duct and cystic artery constitutes the primary objective of dissection. While other biliary and vascular structures may be revealed throughout dissection, a precise detection of the cystic duct and cystic artery is essential, as these are the structures that must be severed in cholecystectomy.[3]

Both acute and chronic inflammation elevate surgical complexity, correlating with a heightened risk of damage to hepatic arteries, bile ducts, and portal veins. The objective of the procedure must be altered from total laparoscopic cholecystectomy to an alternative result. The phrase “inflection point” usually means “a pivotal moment” or “a period of significant alteration in a situation.[4]

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The bailout treatment implemented upon reaching the inflection point during either open cholecystectomy or laparoscopic cholecystostomy was a surgical tube cholecystostomy. That operation was often succeeded by a subsequent procedure to eliminate the gallbladder. Subtotal cholecystectomy is a single-stage salvage operation for difficult cholecystectomy. [5, 6]

This study aimed to avoid bile duct injury in laparoscopic cholecystectomy.

2. Patients and methods

This was a prospective cohort research study that included 60 patients at the Department of Surgery in Al-Azhar University Hospitals, Cairo, Egypt.

Inclusion criteria: Age between 20 and 60 years, patients with gallbladder disease and general condition and laboratory investigation are good.

Methods

All cases have been exposed to the following:

Preoperative Management: Full history taking: personal history, complaint and its length, present and past medical history, and family history Physical examinations: General examination: Vital signs (temperature, blood pressure, respiratory rate, heart rate) and signs of (cyanosis, pallor, lymph node enlargement, and jaundice); local examination: Abdominal Examination: Inspection, palpation, percussion, and auscultation; gallbladder Specific examination: palpation and psoas sign, hepatobiliary examination, hernia examination, skin examination, and vascular examination.

Investigational Studies: Routine laboratory investigations: Complete blood count (CBC), renal function test, liver test profile, PT, PTT, and INR, HbA1C, fasting blood glucose, lipid profile, and pancreatic enzymes (Pt suspected of pancreatitis). Radiological investigation: Abdominal and pelvic ultrasound, ECG and Echo (cardiac or old age Pt), MRCP (diagnostic only), ERCP (diagnostic–therapeutic): if suspected calculous biliary obstruction, pulmonary function tests—chest X-ray for those cases with a previous history of pulmonary disorders. Abdominal ultrasound: Patients were fasted for 6-8 hours before an ultrasound examination. The transabdominal ultrasound was performed using a convex probe with a disinfected gel solution as the acoustic medium. Different positions were used to visualize abdominal organs, with soft images measuring gall bladder and common bile duct volume. The examination was conducted fasting and after a fatty meal, management prior to surgery of the general condition, antibiotic prophylaxis: All cases were administered a broad-spectrum antibiotic, specifically the third-generation cephalosporin cefotaxime, at a dosage of one gram by IV drip, with one dose given preoperatively and another dose administered two hours postoperatively, anti-thromboembolic measures (if indicated), and optimum skin hygiene.

Operative management

The laparoscopic cholecystectomy started with the administration of an anesthetic and intubation. The abdomen has been insufflated to twelve to fourteen millimeters of mercury with carbon dioxide, and four tiny incisions have been created for trocar insertion. The gallbladder has been pulled over the liver to reveal the hepatocystic triangular area. A meticulous dissection has been performed to attain the critical view of safety, which involved the removal of fibrous and adipose tissue, identifying only two tube processes entering the gallbladder's base, and detaching the lower part of the gallbladder from the liver to expose the cystic plate. The cystic duct and cystic artery have been identified, occluded, and severed. Electrocautery, or harmonic scalpel, has been utilized to completely detach the gallbladder from the liver bed. Hemostasis has been attained when the abdominal pressure was reduced to eight millimeters of mercury for two minutes to prevent missing any venous hemorrhage. The gallbladder has been eliminated from the abdomen and placed in a specimen pouch, with all trocars extracted under direct view. Fascial closure of trocar sites over five millimeters has been performed to prevent incisional hernias in the postpartum phase.

Follow up

Follow up: It was done on the first day after the surgical procedure, an inpatient hospital stay, then an interval visit as an outpatient in our general surgery clinic.

Ethical Consideration

The data acquired from participants is confidential. The research participants have been named in all reports or publications related to this investigation. Prior to the participants' admission to the research, the research's aim, nature, and risk-benefit evaluation had been explained to them. Informed consent has been acquired.

Statistical Analysis

Data has been gathered for the assessment of general condition advancement, complications following surgery, wound infections, hospital duration, satisfaction of cases, and symptomatic relief related to case complaints. Data has been analyzed utilizing the Statistical Package for Social Sciences (SPSS) software. Data has been presented as counts and percentages for qualitative factors and as a mean plus standard deviation (SD) for quantitative data. Level of significance: A P value more than 0.05 signifies non-significant results, while a P value less than 0.05 signifies significant results.

3. Results

Regarding baseline data of studied cases, the mean age of the studied cases was 49±9 years; there were 27 (45%) ≤ 50 years and 33 (55%) were >50 years. There were 42 (70%) females and 18 (30%) were males. There were 15 (25%) current smokers, 3 (5%) ex-smokers, and 42 (70%) were nonsmokers. The mean BMI was 27.2±4.3; there were 2 (3.3%) underweight, 16 (26.7%) normal weight, 24 (40%) overweight, and 18 (30%) were obese. There were 48 (80%) positive family histories. There were 14 (23.3%) with previous surgical abdominal history. There were 47 (78.3%) with a history of acute cholecystitis. There were 18 (30%) with a history of hospitalization for acute cholecystitis. Regarding comorbidities, there were 31 (51.7%) with no comorbidities, there were 12 (20%) with DM, 24 (40%) with hypertension, there were 12 (20%) cardiac, 3 (5%) were hepatic, 7 (11.7%) were renal, and 13 (21.7%) were respiratory. (Table 1)

Table 1. Baseline data of studied cases

BASELINE DATA		DESCRIPTIVE STATISTICS (N=60)
AGE	Mean ±SD	49±9
	Range	25-60
AGE CATEGORY	≤ 50 years	27(45%)
	>50 years	33(55%)
GENDER	Male	18(30%)
	Female	42(70%)
SMOKING	Current smoker	15(25%)
	Ex-smoker	3(5%)
	Non smoker	42(70%)
BMI	Mean ±SD	27.2±4.3
	Range	17.1-34
BMI CATEGORY	Under weight	2(3.3%)
	Normal	16(26.7%)
	Overweight	24(40%)
	Obese	18(30%)
FAMILY HISTORY	No	12(20%)
	Yes	48(80%)
PREVIOUS SURGICAL ABDOMINAL HISTORY	No	46(76.7%)
	Yes	14(23.3%)
HISTORY OF ACUTE CHOLECYSTITIS	No	13(21.7%)
	Yes	47(78.3%)
HISTORY OF HOSPITALIZATION FOR ACUTE CHOLECYSTITIS	No	42(70%)
	Yes	18(30%)
COMORBIDITIES	No	31(51.7%)
	DM	12(20%)
	HTN	24(40%)
	Cardiac	12(20%)
	Hepatic	3(5%)
	Renal	7(11.7%)
	Respiratory	13(21.7%)
	Neurological	0(0%)

Regarding intraoperative data and prediction of intraoperative difficulty from intraoperative data among studied cases, there were 11.7% conversions to open cholecystectomy. Regarding operative time, there were 68.3% < 60 minutes, 20% were 60-120 minutes, and 11.7% > 120 minutes. There were 21.7% with bile or stone spillage, there were 11.7% with vascular injury, there were 26.7% with biliary duct injury, 5% with viscus injury or perforated gut, 11.7% with hepatic bed injury, and 11.7% with bleeding from the trocar site. Regarding intraoperative difficulty, 73.3% easy, 15% difficult, and 11.7% very difficult. (Table 2)

Table 2. Intraoperative data and prediction of intraoperative difficulty from intraoperative data among studied cases

INTRAOPERATIVE DATA AND PREDICTION OF DIFFICULTY		FREQUENCY (N=60)	PERCENTAGE
CONVERSION TO OPEN CHOLECYSTECTOMY	No	53	88.3%
	Yes	7	11.7%
OPERATIVE TIME	< 60 minutes	41	68.3%
	60-120 minutes	12	20%
	>120 minutes	7	11.7%
BILE OR STONE SPILLAGE	No	47	78.3%
	Yes	13	21.7%
VASCULAR INJURY	No	53	88.3%
	Yes	7	11.7%
BILIARY DUCT INJURY	No	44	73.3%
	Yes	16	26.7%
VISCUS INJURY OR PERFORATED GUT	No	57	95%
	Yes	3	5%
HEPATIC BED INJURY	No	53	88.3%
	Yes	7	11.7%
BLEEDING FROM TROCAR SITE	No	53	88.3%
	Yes	7	11.7%
INTRAOPERATIVE DIFFICULTY	Easy	44	73.3%
	Difficult	9	15%
	Very difficult	7	11.7%

Regarding post-operative complications and outcomes among studied cases, the mean hospital length of stay was 2.4±1.16 days with a range of 1-6 days. There were 18 (30%) with wound infection, 13 (21.7%) with subhepatic collection, 5 (8.3%) with retained stone, 14 (23.3%) with bile leak more than 50-100 mm/24 h, and 13 (21.7%) with bleeding from the abdominal cavity >100 mm/24 h, and mortality was reported in 1 (1.7%). (Table 3)

Table 3. Post-operative complication and outcome among studied cases

POST-OPERATIVE COMPLICATION AND OUTCOME		DESCRIPTIVE STATISTICS (N=60)
HOSPITAL LENGTH OF STAY	Mean ±SD	2.4±1.16
	Range	1-6
WOUND INFECTION	No	42(70%)
	Yes	18(30%)
SUBHEPATIC COLLECTION	No	47(78.3%)
	Yes	13(21.7%)
RETAINED STONE	No	55(91.7%)
	Yes	5(8.3%)
BILE LEAK MORE THAN 50-100 MM/24 H	No	46(76.7%)
	Yes	14(23.3%)
BLEEDING FROM ABDOMINAL CAVITY >100MM/24 H	No	47(78.3%)
	Yes	13(21.7%)
MORTALITY	No	59(98.3%)
	Yes	1(1.7%)

There was statistically significant between preoperative difficulty with hospital length of stay, retained stone, and bile leak more than 50-100 mm/24 h P < 0.05. (Table 4)

Table 4. Incidence of post-operative complication and outcome according to Preoperative difficulty

POST-OPERATIVE COMPLICATION AND OUTCOME		PREOPERATIVE DIFFICULTY			P VALUE
		Easy (n-37)	Difficult (n=12)	Very difficult (n=11)	
HOSPITAL LENGTH OF STAY	Mean ±SD Range	1.7 ±0.5 1-3	3.5 ±1 3-6	3.6 ±0.9 3-6	<0.001*
WOUND INFECTION	No	27(73%)	10(83.3%)	5(45.5%)	0.11
	Yes	10(27%)	2(16.7%)	6(54.5%)	
SUBHEPATIC COLLECTION	No	32(86.5%)	8(66.7%)	7(63.6%)	0.17
	Yes	5(13.5%)	4(33.3%)	4(36.4%)	
RETAINED STONE	No	37(100%)	9(75%)	9(81.8%)	0.01*
	Yes	0(0%)	3(25%)	2(18.2%)	
BILE LEAK MORE THAN 50-100 MM/24 H	No	35(94.6%)	7(58.3%)	4(36.4%)	<0.001*
	Yes	2(5.4%)	5(41.7%)	7(63.6%)	
BLEEDING FROM ABDOMINAL CAVITY >100MM/24 H	No	29(78.4%)	10(83.3%)	8(72.7%)	0.91
	Yes	8(21.6%)	2(16.7%)	3(27.3%)	
MORTALITY	No	37(100%)	11(91.7%)	11(100%)	0.38
	Yes	0(0%)	1(8.3%)	0(0%)	

* significant at p value <0.05

Preoperative difficulty can predict intraoperative outcome with a sensitivity of 87.5%, specificity of 80%, and an accuracy of 81.6%. (Table 5)

Table 5. ROC curve for prediction of outcome throughout surgery depend on difficulty before surgery

AUC	0.83
95% CI	0.71-0.95
P VALUE	<0.001*
SENSITIVITY	87.5%
SPECIFICITY	80%
PPV	61%
NPV	94%
ACCURACY	81.6%

Preoperative difficulty can predict conversion to open surgery with 100% sensitivity, 70% specificity, and 73.3% accuracy. (Table 6)

Table 6. ROC curve for prediction of conversion to open surgery based on preoperative difficulty

AUC	0.84
95% CI	0.74-0.95
P VALUE	<0.001*
SENSITIVITY	100%
SPECIFICITY	70%
PPV	30.5%
NPV	100%
ACCURACY	73.3%

Preoperative difficulty can predict overall postoperative complication with a sensitivity of 59%, with a specificity of 80.5%, and with an accuracy of 70%. (Table 7)

Table 7. ROC curve for prediction of overall post-operative complication based on preoperative difficulty

AUC	0.69
95% CI	0.56-0.83
P VALUE	0.009*
SENSITIVITY	59%
SPECIFICITY	80.5%
PPV	74%
NPV	67.5%
ACCURACY	70%

Intraoperative difficulty can predict overall postoperative complication with a sensitivity of 52%, with a specificity of 97%, and with an accuracy of 75%. (Table 8)

Table 8. ROC curve for prediction of overall post-operative complication based on intra-operative difficulty

AUC	0.74
95% CI	0.61-0.87
P VALUE	0.001*
SENSITIVITY	52%
SPECIFICITY	97%
PPV	94%
NPV	68%
ACCURACY	75%

4. Discussion

Regarding baseline data of the studied cases, our results showed that the mean age of the studied cases was 49±9 years; there were 27 (45%) ≤ 50 years and 33 (55%) were >50 years. There were 42 (70%) females and 18 (30%) males. There were 15 (25%) current smokers, 3 (5%) ex-smokers, and 42 (70%) nonsmokers. The mean BMI was 27.2±4.3; there were 2 (3.3%) underweight, 16 (26.7%) normal weight, 24 (40%) overweight, and 18 (30%) were obese. There were 48 (80%) positive family histories. There were 14 (23.3%) with previous surgical abdominal history. There were 47 (78.3%) with a history of acute cholecystitis.

There were 18 (30%) with a history of hospitalization for acute cholecystitis. Regarding comorbidities, there were 31 (51.7%) with no comorbidities, there were 12 (20%) with DM, 24 (40%) with hypertension, there were 12 (20%) cardiac, 3 (5%) were hepatic, 7 (11.7%) were renal, and 13 (21.7%) were respiratory.

Agrawal et al.[7] intended to predict preoperatively the difficulty of laparoscopic cholecystectomy, reporting an investigation that comprised thirty cases, of whom six were male (twenty percent) and twenty-four were female (eighty percent). The average age of the research participants was 39.47 ± 12.008 years. Most cases were aged ≤50 years (twenty-five cases), whereas just 16.7 percent (five cases) were >50 years. Additionally, there were four cases (13.33 percent) with a history of hospitalization for acute cholecystitis.

Concerning intraoperative data and prediction of intraoperative difficulty from intraoperative

data among the studied cases, we found that there were 11.7% conversions to open cholecystectomy. Regarding operative time, there were 68.3% < 60 minutes, 20% were 60-120 minutes, and 11.7% > 120 minutes. There were 21.7% with bile or stone spillage, 11.7% with vascular injury, 26.7% with biliary duct injury, 5% with viscus injury or perforated gut, 11.7% with hepatic bed injury, and 11.7% with bleeding from the trocar site. Regarding intraoperative difficulty, 73.3% easy, 15% difficult, and 11.7% very difficult. An insignificant correlation has been observed between preoperative prediction and intraoperative prediction for difficulties, p = 0.15.

Our findings diverge from those of E Daly et al.,[8] who indicated that five (five percent) cases have been transformed into open cholecystectomy, four (four percent) cases have been expected to be tough/very difficult, while only one (one percent) case has been assessed as easy and subsequently converted to open cholecystectomy.

Ary Wibowo et al.,[9] showed that sixty cases (forty-five percent) had a wall thickness of four millimeters or more.

Khetan & Yeola,[10] observed that ultrasonographic findings indicated normal gallbladder wall thickness in twenty-four (eighty percent) cases, raised thickness in six (twenty percent) cases, impacted stones in six (twenty percent) cases, and pericholecystic collection in just one (3.33 percent) case.

Our results showed that regarding post-operative complications and outcomes among studied cases, the mean hospital length of stay was 2.4±1.16 days with a range of 1-6 days. There were 18 (30%) with wound infection, 13 (21.7%) with subhepatic collection, 5 (8.3%) with retained stone, 14 (23.3%) with bile leak more than 50-100 mm/24 h, and 13 (21.7%) with bleeding from the abdominal cavity >100 mm/24 h, and mortality was reported in 1 (1.7%).

Our results disagree with Rahman et al.,[11] who reported that regarding postoperative complications, there were 5% with surgical site infection, 2% with intra-abdominal collection, there were 1% with bile leakage, and no cases reported death.

Our findings are according to Agrawal et al.,[7] who stated that there was statistical significance between preoperative difficulty groups regarding hospitalization and impacted stone.

We found that there was statistical significance between intraoperative difficulty with hospital length of stay, retained stone, bile leak more than 50-100 mm/24 h, and bleeding from the abdominal cavity >100 mm/24 h.

Our findings contrast those of HAITHAM et al.,[12] who indicated a significant association between surgery difficulties, sex, and BMI. During surgery, problems showed a significant correlation with prior acute attacks, abdominal scarring, and gallbladder wall thickness.

Our current study showed that preoperative difficulty can predict intraoperative outcome with 87.5% sensitivity, 80% specificity, and 81.6% accuracy. Preoperative difficulty can predict conversion to open surgery with a sensitivity of 100%, a specificity of 70%, and an accuracy of 73.3%. Preoperative difficulty can predict overall postoperative complications with a sensitivity of 59%, a specificity of 80.5%, and an accuracy of 70%. Intraoperative difficulty can predict overall postoperative complications with 52% sensitivity, 97% specificity, and 75% accuracy.

Daly et al.[8] stated that the Receiver Operating Characteristic (ROC) curve for predicting surgery outcomes depending on prior surgery scores for difficult/very difficult versus easy cases, at a cutoff point above five, yielded an area under the curve (AUC) of 0.79, with a ninety-five percent confidence interval of 0.69 to 0.89. The findings indicated a 70.3% sensitivity, 88.9% specificity, 78.8% positive predictive value (PPV), 83.6% negative predictive value (NPV), and 82% accuracy.

Moreover, HAITHAM et al.[12] indicated that the before-surgery scoring exhibited 100% positive predictive value, 100% specificity, 89.5% sensitivity, 84.6% negative predictive value, 93.3% diagnostic accuracy, and a Kappa agreement of 0.862 in comparison to the during-surgery scoring method.

4. Conclusion

We concluded that preoperative difficulty could predict intraoperative outcomes with an 87.5% sensitivity, 80% specificity, and 81.6% accuracy. It can also predict conversion to open surgery with a 100% sensitivity, 70% specificity, and an accuracy of 73.3%. It can also predict overall postoperative complications with a 59% sensitivity, 80.5% specificity, and an accuracy of 70%. Intraoperative difficulty was significantly associated with hospital length of stay, retained stone, bile leak over 50-100 mm/24 hours, and bleeding from the abdominal cavity.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

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