

Factors Associated with Bile Duct Injuries and Conversion in Laparoscopic Cholecystectomy Aden, Yemen Jan. 1st - Dec. 31st, 2022

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DOI: [https://doi.org/10.47372/yjmhr.2026\(15\).1.4](https://doi.org/10.47372/yjmhr.2026(15).1.4)

Abstract

Introduction: Laparoscopic cholecystectomy offers less cardiopulmonary complication and wound infection than open surgery and became the treatment of choice for symptomatic gallstones, acute and chronic cholecystitis but it has twice the rate of the catastrophic bile duct injuries than open surgery. The health care providers should have clear understanding of the factors associated with bile duct injury (BDI) & conversion to predict those undesirable events prior to surgery and prepare appropriate measures. The objective of this study was to determine factors associated with BDI and conversion in laparoscopic cholecystectomy.

Methods: This is a prospective, descriptive study included patients above 13 years old who underwent laparoscopic cholecystectomy from different hospitals in Aden, Yemen during the period 1st Jan. 2022 to 31th Dec. 2022. Analysis was performed using the Statistical Package for Social Sciences (SPSS V.22). Variables were analyzed for association with BDI & conversion. Significance level was taken at $p < 0.05$ level.

Results: The study enrolled 336 patients, 283 females (84.2%) and 53 males (15.8%). The conversion to open cholecystectomy was performed in 15 patients with conversion rate 4.5%. Complications were observed in 32 patients with overall morbidity of 9.5% and without mortalities. BDI was observed in eleven patients (3.3%), two patients had major BDI and underwent subsequent Roux-en-Y hepatico-jejunostomy. There was statistically significant association in conversion with male gender ($p=0.001$), acute calculous cholecystitis ($p=0.003$), ultrasonography findings of contracted gallbladder ($p=0.025$), impacted gallbladder stone ($p=0.024$) and preoperative retrograde cholangiopancreatography (ERCP) ($p=0.012$) while acute calculous cholecystitis ($p=0.006$) and ultrasonographic findings of contracted gallbladder ($p=0.014$) or thickened gallbladder wall ≥ 4 mm ($p<0.001$) were significantly associated with duct injuries.

Conclusion: Male gender, acute calculous cholecystitis, preoperative ERCP and preoperative ultrasonography findings of contracted gallbladder or impacted gallbladder stone were factors associated with conversion from laparoscopic to open surgery while acute calculous cholecystitis and ultrasonographic findings of contracted gallbladder or thickened gallbladder wall ≥ 4 mm were significantly associated with bile duct injuries.

Keywords: Laparoscopic Cholecystectomy, Bile duct injury, Conversion, Risk.

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العوامل المرتبطة بإصابات القناة الصفراوية والتحويل إلى الجراحة المفتوحة في استئصال المرارة بالمنظار، عدن، اليمن، 1 يناير - 31 ديسمبر 2022

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ملخص الدراسة

المقدمة: تقدم جراحة استئصال المرارة بالمنظار الفوائد من حيث تقليل مضاعفات القلب والرئة و التهاب الجروح مقارنة بالجراحة المفتوحة و أصبحت الخيار العلاجي المفضل للحصوات المرارية المسببة للأعراض و التهاب المرارة الحاد و المزمن. و مع ذلك، فإنها تحمل معدلاً أعلى بمرتين من إصابات القناة الصفراوية مقارنة بالجراحة المفتوحة. لذا، يجب أن يكون لدى مقدمي الرعاية الصحية فهم جلي للعوامل المرتبطة بإصابة القناة الصفراوية أو المرتبطة بالحاجة للتحويل من الجراحة بالمنظار إلى الجراحة المفتوحة لتوقع هذه الأحداث غير المرغوب فيها قبل الجراحة و اتخاذ الاجراءات المناسبة. الهدف من هذه الدراسة هو تحديد العوامل المرتبطة بإصابة القناة الصفراوية والتحويل إلى الجراحة المفتوحة في استئصال المرارة بالمنظار.

المنهجية: هذه دراسة وصفية شملت مرضى فوق 13 عامًا خضعوا لجراحة استئصال المرارة بالمنظار في مستشفيات مختلفة في عدن. اليمن خلال الفترة من 1 يناير 2022 إلى 31 ديسمبر 2022. تم إجراء التحليل باستخدام الحزمة الإحصائية للعلوم الاجتماعية (SPSS V.22). تم تحليل مدى ارتباط عدد من العوامل بحدوث إصابات القناة الصفراوية أو التحويل إلى الجراحة المفتوحة وقد اعتبرت القيم الأقل من 0.05 ذات دلالة إحصائية.

النتائج: شملت الدراسة 336 مريضاً بلغ عدد الإناث 283 (84.2%) و عدد الذكور 53 (15.8%). تم إجراء التحويل إلى جراحة المرارة المفتوحة في 15 مريضاً بمعدل تحويل 4.5%. لوحظت مضاعفات في 32 مريضاً بمعدل اعتلال إجمالي 9.5% دون حدوث وفيات. لوحظ إصابة القناة الصفراوية في إحدى عشر مريضاً (3.3%). خضع مريضان بإصابات كبيرة في القناة الصفراوية لعملية جراحية لاحقة لتحويل مسار الكبد إلى الأمعاء الدقيقة. وجد ارتباطاً ذو دلالة إحصائية بين التحويل للجراحة المفتوحة وبين الجنس الذكري ($p=0.001$) و التهاب المرارة الحاد ($p=0.003$) و نتائج فحص المرارة بالسونار وتبين عدم تمييز معالمها أو عدم قدرتها على الامتلاء حتى بعد فترة صيام لا تقل عن 8 ساعات ($p=0.025$)، تبين انحشار لحصوة في عنق المرارة ($p=0.024$) وتنظير القناة الصفراوية قبل الجراحة ($p=0.012$) بينما كان الالتهاب الحاد للحويصلة الصفراوية ($p=0.006$) و نتائج الموجات فوق الصوتية التي تظهر انكماش الحويصلة الصفراوية ($p=0.014$) أو زيادة سماكة جدارها ≤ 4 ملمتر ($p<0.001$) عوامل مرتبطة بإصابات القناة الصفراوية.

الخلاصة: الجنس الذكري، التهاب المرارة الحاد، تنظير القناة الصفراوية قبل الجراحة و نتائج السونار التي تظهر انكماش المرارة و عدم قدرتها على الامتلاء أو انحشار حصاة فيها كانت عوامل مهمة صاحبت الحاجة للتحويل من الجراحة بالمنظار إلى الجراحة المفتوحة لاحقاً بينما كان التهاب المرارة الحاد ونتائج فحص السونار التي تظهر انكماش المرارة أو سماكة جدارها ≤ 4 ملمتر عوامل ارتبطت بإصابات القناة الصفراوية.

كلمات مفتاحية: جراحة استئصال المرارة بالمنظار، إصابة القناة الصفراوية، التحويل، المخاطر.

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Introduction

Laparoscopic cholecystectomy (LC) has less post-operative pain, less post-operative physiologic dysfunction, shorter hospital stay, earlier return to daily activities and associated with fewer cardiopulmonary complications and wound infection rates than open cholecystectomy. However; it has twice the rate of bile duct injuries (BDI) than open approach. Conversion from LC to open surgery is sometimes inevitable to avoid injuries or to treat complications when the procedure cannot progress by laparoscopy and bailout procedures failed, it is associated with prolonged operative duration due to the trial of laparoscopic dissection and accompanying by intense post-operative pain, longer hospital stay and higher hospital charges & cost of treatment [1-3]. The incidence of BDI after LC has shown a decreasing trend though it may still be twice that as with open cholecystectomy [2].

LC is accompanying with an overall complication rate of approximately 10%, higher risk of biliary injury (0.1%-1.5%) when compared to the open approach (0.1%-0.2%) [2] with the more severe injuries often occurring after conversion from laparoscopic to open cholecystectomy [1]. Major bile duct injury is a grave complication associated with prolonged morbidity and diminished overall survival [2].

The health care providers should have a clear understanding of the factors associated with difficult procedure, injuries and conversion to predict those undesirable events and prepare

appropriate measures to decrease their rates. The objective of this study was to determine factors associated with BDI and conversion approach in LC at Aden, Yemen.

Methods

Study design

The study was a prospective, descriptive analytical study. It included patients above 13 years old who underwent LC from different public and private hospitals in Aden, Yemen during the period 1st January 2022 to 31th December 2022.

Target population

Patients with concomitant procedure beside cholecystectomy and patients with presumed diagnosis of biliary cancer were excluded. No patient in studied population had previous upper abdominal surgery except one with epigastric hernia repair.

Variables

The factors assessed for their association with BDI and conversion were: age, gender, pre-operative endoscopic retrograde cholangiopancreatography (ERCP), acute calculous cholecystitis, pre-operative ultrasonography (US) findings of thickened gallbladder (GB) wall ≥ 4 mm, impacted stone at GB outlet and contracted GB (contracted GB on US was referred to a GB that persist contracted even after fasting for at least eight hours prior to examination, it is usually a reflection of a shrunken, nonfunctioning GB in advanced stage of chronic cholecystitis).

Procedures

LC was performed using the four-port technique in 224 Patients while three-port technique in 112 Patients. A Veress needle was inserted and the abdominal cavity was insufflated with the maximum insufflation pressure being 12 mm Hg. All patients underwent cholecystectomy. Nasogastric tubes were placed in all patients. Hepatocystic triangle dissection was performed with critical view of safety (CVS) method in all patients. The hepatocystic triangle was cleared of fat and fibrous tissue, the peritoneum over the infundibulum was opened from the medial and lateral aspect, and the lower 1/3 of the GB was separated from the liver bed by coagulation diathermy. Only two tubular structures observed to enter the GB were clipped. Intraoperative cholangiography was not performed in any of the patients.

Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS V.22). Patient related variables were considered in bivariate analysis for association with

each of the outcomes. Significance was taken at $p < 0.05$ level. Chi-square (χ^2) test was used for categorical variables and Fisher's exact test was used when assumptions for χ^2 test were not met.

Ethical considerations

This study was approved by the committee of postgraduate studies of the Faculty of Medicine and Health Sciences, University of Aden.

Results

The study enrolled 336 consecutive patients underwent LC from different hospitals at Aden city, Yemen during 2022. There were 283 females (84.2 %) and 53 males (15.8 %). Tables 1 and 2 illustrate the clinical and pre-operative US characteristics of the studied patients. The conversion to open cholecystectomy was performed in 15 patients with conversion rate of 4.5%.

Table1: Patients with Laparoscopic Cholecystectomy by Sex and Age, Aden, 2022

Age (years)	Male		Female		Total	
	No.	%	No.	%	No.	%
14-19	1	0.3	5	1.5	6	1.8
20-39	18	5.3	105	31.3	123	36.6
40-59	16	4.8	117	34.8	133	39.6
60-70	13	3.9	36	10.7	49	14.6
>70	5	1.5	20	5.9	25	7.4
Total	53	15.8	283	84.2	336	100

Table 2: Patients with Laparoscopic Cholecystectomy by Clinical Presentation and Characteristics. Aden. 2022

Patient's character	Laparoscopic Cholecystectomy			
	Yes		No	
	No.	%	No.	%
Acute Calcular Cholecystitis	25	7.4	311	92.6
Preoperative ERCP	12	3.6	324	96.4
Thickened GB wall ≥ 4 mm on preoperative US	35	10.4	301	89.6
Impacted stone on US	15	4.5	321	95.5
Contracted GB on US	6	1.8	330	98.2

Complications were observed in 32 patients with overall morbidity of 9.5% and without mortalities. BDI formed the major complication observed in eleven patients (3.3%), nine of them presented as bile leak while two presented by obstructive jaundice. Two patients had major BDI (Strasberg type E3 & E1) underwent subsequent Roux-en-Y hepaticojejunostomy. Bleeding was encountered in two patients, four had post-operative intra-abdominal infection (1.2%), four has port site infection (2.1%) two of them diagnosed as mycobacterium

infection and received anti-tuberculosis drugs. Port site hernia was observed in eight patients (2.4 %) most of them presented several months after surgery. Factors that showed statistically significant association with conversion were male gender ($p=0.001$), acute calcular cholecystitis ($p=0.003$), preoperative ERCP ($p=0.012$), contracted GB by US ($p=0.025$) while impacted GB stone was only identified as risk by bivariate analysis ($p=0.024$) as shown in Tables 3 and 4.

Table 3: Bivariate Analysis of Risk Factors of Conversion from Laparoscopic Cholecystectomy to Open Cholecystectomy, Aden, 2022

Variable	Category	No conversion		Conversion		p
		No.	%	No.	%	
Gender	Male	45	84.9	8	15.1	0.001
	Female	276	97.5	7	2.5	
Age in years	14-19	5	83.3	1	16.7	0.253
	20-39	119	96.7	4	3.3	
	40-59	128	96.2	5	3.8	
	60-70	46	93.9	3	6.1	
	> 70	23	92.0	2	8.0	
Acute calcular cholecystitis	Yes	20	80.0	5	20	0.003
	No	301	96.8	10	3.2	
Previous (lower) abdominal surgery	Yes	44	100	0	0.0	0.234
	No	277	94.9	15	5.1	
Contracted GB	Yes	4	66.7	2	33.3	0.025
	No	317	96.1	13	3.9	
Impacted GB stone	Yes	12	80.0	3	20.0	0.024
	No	309	96.3	12	3.7	
GB wall thickness	≥ 4 mm	33	89.2	4	10.8	0.070
	< 4 mm	288	96.3	11	3.7	
Preoperative ERCP	Yes	9	75	3	25	0.012
	No	312	96.3	12	3.7	

Table 4: Multivariate Logistic Regression Analysis of Predictors for Conversion in Laparoscopic Cholecystectomy, Aden, 2022

Variable	Category	S.E	Odds ratio	95 % CI		p
				Lower	Upper	
Gender	Female		1			
	Male	0.758	18.876	4.270	83.448	<0.001
Acute calcular cholecystitis	No		1			
	Yes	0.836	9.365	1.820	48.186	0.007
Contracted GB	No		1			
	Yes	1.221	54.093	4.938	592.567	0.001
Impacted stone	No		1			
	Yes	1.010	5.408	0.747	39.172	0.095
Previous ERCP	No		1			
	Yes	1.027	29.939	4.002	223.955	0.001

Independent predictors for BDI by both bivariate and multivariate logistic regression analysis were acute calcular cholecystitis,

contracted GB on US and thickened GB wall ≥ 4 mm on preoperative US as showed in Tables 5 and 6.

Table 5: Bivariate Analysis of Risk Factors for Bile Duct Injury in Laparoscopic Cholecystectomy, Aden, 2022.

Variable	Category	Bile duct injury		No injury		p
		No.	%	No.	%	
Gender	Male	2	3.8	51	96.2	0.687
	Female	9	3.2	274	96.8	
Age in years	1419	1	16.7	5	83.3	0.306
	20-39	3	2.4	120	97.6	
	40-59	4	3.0	129	97.0	
	60-70	2	4.1	47	95.9	
	> 70	1	4.0	24	96.0	
Acute calcular cholecystitis	Yes	4	16	21	84.0	0.006
	No	7	2.3	304	97.7	
Previous abdominal surgery	Yes	0	0.0	44	100	0.371
	No	11	3.8	281	96.2	
Contracted GB	Yes	2	33.3	4	66.7	0.014
	No	9	2.7	321	97.3	
Impacted GB stone	Yes	1	6.7	14	93.3	0.400
	No	10	3.1	311	96.9	
GB wall thickness	≥ 4 mm	6	16.2	31	83.8	<0.001
	< 4 mm	5	1.7	294	98.3	
Preoperative ERCP	Yes	1	8.3	11	91.7	0.334
	No	10	3.1	314	96.9	

Table 6: Multivariate Logistic Regression Analysis of Predictors of Bile Duct Injuries in Laparoscopic Cholecystectomy, Aden, 2022.

Variable	Category	S.E	Odds ratio	95 % CI		p
				Lower	Upper	
Acute calcular cholecystitis	No	0.666	1	2.242	30.525	0.002
	Yes		8.272			
Contracted GB	No	0.930	1	2.884	110.291	0.002
	Yes		17.833			
GB wall thickness	< 4 mm	0.634	1	3.283	39.453	< 0.001
	≥ 4 mm		11.381			

Discussion

LC is the procedure of choice for gallstone disease, its wound infection and cardiopulmonary complication rates are less than open procedure but it remains accompanying with higher rate of bile duct injuries [3]. The overall complication rate of LC is approximately 10% with higher risk of biliary injury (0.1%-1.5%) compared to open approach (0.1%-0.2%) [2]. The mortality rate is about 0.1% [2,3]. The overall incidence of BDI when minor injuries were included was 1.5 %, however; the rate decreases to 0.1 % if only the most serious cases of BDI that required reconstruction surgery were included^[4]. Major biliary or vasculobiliary injury is associated with prolonged morbidity, and decreased overall survival. While incidence of biliary injury after LC has shown a declining trend, it may still twice that of open cholecystectomy [2].

The current study included 336 patients from different hospitals at Aden city Yemen, it showed a BDI rate of 3.3 % and 4.5% conversion rate and without mortalities. Although the conversion rate was higher than most of the reported worldwide

studies [4,6]. This is probably because of the early experience of the surgeons and their care to avoid the risk of injuries during the difficult operations. A similar rate was reported by Dimitrios *et al* in their systematic review of the literature (1995-2021) who found an overall conversion rate of 4.8% [7].

In a prospective multicenter observational study conducted by the Indian Association of Gastro-Intestinal Endo Surgeons (IAGES) to assess morbidity and mortality of LC in India, LC has 30-day morbidity of 11.1%, 30-day mortality of 0.2%, conversion to open rate of 1.4%, and BDI rate of 0.3% in India [6]. Likewise, El-Dhuwaib *et al.* in England; collected data of all LC and attempted LC operation in England (2013). The rate of major BDI that underwent bile duct reconstruction surgery was 0.09%. One year mortality following LC was 0.6% and overall conversion rate was 4.3% [4]. On the other hand, in North America; Mangieri *et al* extracted all LC performed between 2012 and 2016 with a BDI rate of 0.19%. There was a low conversion rate of 0.04%, however; the converted cases there

had a nearly hundredfold increase in BDI [5].

The current series showed a female to male ratio of 5:1, and female preponderance (84.2%) which is consistence with other studies^[8,9]. Although males represented a minority (15.8%) in the study population, they showed higher incidence of conversion to open surgery ($p=0.001$). It is proposed that males are less likely than females to seek medical help^[10]. Another thought is that men can tolerate the symptoms more than women and seeks medical help lately with more advanced disease [11,12]. Another proposed cause is that, the fibrosis is more extensive in men. This is supported by the finding of more inflammatory cells and tissue collagen within the GB wall in men than in women [13].

In the current study, age did not show a statistically significant relation with conversion to open surgery nor to BDI. Similar results were reported; Kar & Atay did not found age to be a risk factor [11], and Yetkin *et al* too reported that LC can be applied in elderly patients without increase in surgical risks [14]. Similar finding was reported by Kwon & Matsui [15]. However; other authors reported old age as a risk factor [10,16,17]. It is proposed that older people have a longer history of gallstone disease & higher number of cholecystitis attacks leading to thickening and fibrosis at GB bed and Calot's triangle with subsequent difficult dissection & higher conversion rate. The limited physiologic functional reserves in advanced age and the associated chronic comorbidities are the causes for the increased morbidity and mortality, when comorbidities are

removed or absent, those advanced age groups did not show increased incidence of morbidity or mortality from other age groups [14]. In the current study, the lower age average and lower selected comorbid operated patients in the study could explained this safe association.

Acute calcular cholecystitis was present in 7.4% of the operated patients. It was identified as independent predictor for conversion and bile duct injuries. Bile duct injury was encountered in 11 patients (3.3%). Of these, 57% had acute cholecystitis. It is reported that because of the potentially severe consequences of BDIs, all efforts should be made to minimize the risk of occurrence. An exhaustive preoperative work-up prior to cholecystectomy is mandatory in order to detect at-risk conditions and to perform optimal strategies based on anatomical factors, the patient's clinical status, disease factors, and the surgeon's experience [18,19]. Although LC is the preferable approach also for acute cholecystitis and is associated with lower mortality and morbidity rates [20,21]. It is reported too that the risk of conversion to open surgery appears to be higher with many factors including fever, gangrenous cholecystitis, severe acute and chronic cholecystitis, duration of complaints >48 hours, and emergency LC. Conversion to open surgery may be considered for patient safety if the operating surgeon cannot manage a difficult LC, however; there is no evidence to support that conversion to open per se will avoid or reduce the risk of BDI [18,22]. Moreover, meta-analysis of data from randomized controlled trials and population-based studies showed higher BDI rates in

acute conditions, supporting the increasing BDI risk with increasing severity of local inflammation, such as in the case of acute cholecystitis [23,24].

The CVS technique was practiced to guarantee the safest approach to LC by promoting the recognition of GB elements, mainly the hepatocystic triangle (the cystic duct, common bile duct, and liver). The literature has demonstrated that when the CVS is identified, the risk of iatrogenic intraoperative complications is minimized. Thus, routine use of CVS is recommended over other technique [18,25]. It has been reported that injuries of the common bile duct are more common during the early learning curve in laparoscopic cholecystectomy [26]. Whenever a CVS cannot be achieved and the biliary anatomy cannot be clearly defined, alternative techniques such as the “fundus-first (top-down)” approach or subtotal cholecystectomy should be considered [18,27]. Adequate time operating on patients presenting with symptomatic acute cholecystitis have been proposed, ranging from no more than 72 h up to 10 days. Further delays are associated with disease progression, and unfavorable conditions for safe surgical interventions exist [22]. Indeed, an increase in the complication rate and need of conversion to open cholecystectomy has been reported when the time from symptom appearance to surgery was prolonged, with the latest time point to safely operate on acute cholecystitis patients being 10 days from symptoms appearance [22,28].

A good preoperative US is very valuable in predicting difficult elective LC. GB wall thickness >4

mm, signs of the contracted bladder, and bile duct diameter greater than 6 mm have been described in the literature as important predictive factors in difficult LC and the need for conversion to open surgery [12,13]. In the current study, US findings were of significant effect in association to prediction of risk for the studied patients. Contracted GB was found to be independent predictor for conversion and bile duct injuries. An impacted stone at GB neck was associated with conversion whereas GB wall thickness ≥ 4 mm was not associated with conversion but associated with bile duct injuries. Contracted GB was found by Tongyoo *et al* [13] to be associated with 37.5 % conversion rate.

GB stone impaction was considered significant in the study conducted by Goonawardena *et al* [29]. Impacted stone may be associated with edematous inflammatory tissue in Calot's triangle or hindering grasping by the laparoscopic instruments [13]. A thickened GB wall was determined as significant factor in several studies [13,2].

ERCP with endoscopic sphincterotomy & common bile duct (CBD) stenting followed by LC is accepted as the treatment of choice for patients with choledochocystolithiasis [30]. In this series, there were 12 patients had previous ERCP before LC. Patients with preoperative ERCP had statistically significant risk association for conversion, but not to bile duct injury. A conversion rate that is higher than that reported by Abraham *et al* [16] (8.8%) and by Reinders *et al* [30] (6.5 %.). It is thought that the disruption of the sphincter of Oddi leads to reflux and

bacterial colonization of the biliary tract leading to inflammation and subsequent scarring of the hepatoduodenal ligament hindering dissection of Calot's triangle [30]. The theory of reflux and bacterial colonization is supported by the finding that the bile in patients who have undergone a sphincterotomy is colonized in approximately 60% of patients [13]. Furthermore, the instrument insertion into CBD is suspected of inducing inflammation and adhesion [13].

Conclusion

The authors concluded that factors associated with conversion from LC to open approach were male gender, acute calcular cholecystitis, preoperative ERCP and the preoperative US findings of contracted GB or impacted GB stone while the predictors for BDI were acute calcular cholecystitis, contracted GB and thickened GB wall ≥ 4 mm on preoperative US. A hospital protocol must be made using a prediction models for LC operations. Knowing predictive factors for conversion and BDI will aid to select the safe laparoscopic operations and to prepare skilled surgical team and good operation sets for performing the procedure in order to minimize the need for conversion and to decrease the BDI rates.

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