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ORIGINAL ARTICLE

# How to Predict Postoperative Complications After Early Laparoscopic Cholecystectomy for Acute Cholecystitis: the Chole-Risk Score

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## Abstract

**Background** Early laparoscopic cholecystectomy (ELC) is the gold standard treatment for patients with acute calculous cholecystitis (ACC); however, it is still related to significant postoperative complications. The aim of this study is to identify factors associated with an increased risk of postoperative complications and develop a preoperative score able to predict them.

**Methods** Multicentric retrospective analysis of 1868 patients with ACC submitted to ELC. Included patients were divided into two groups according to the presentation of increased postoperative complications defined as postoperative complications ≥ Clavien-Dindo IIIa, length of stay greater than 10 days and readmissions within 30 days of discharge. Variables that were independently predictive of increased postoperative complications were combined determining the Chole-Risk Score, which was validated through a correlation analysis.

**Results** We included 282 (15.1%) patients with postoperative complications. The multivariate analysis predictors of increased morbidity were previous percutaneous cholecystostomy (OR 2.95, $p$=0.001), previous abdominal surgery (OR 1.57, $p$=0.031) and diabetes (OR 1.62, $p$=0.005); Charlson Comorbidity Index >6 (OR 2.48, $p$=0.003), increased total bilirubin > 2 mg/dL (OR 1.88, $p$=0.002), dilated bile duct (OR 1.79, $p$=0.027), perforated gallbladder (OR 2.62, $p$<0.001) and severity grade (OR 1.93, $p$=0.001).

The Chole-Risk Score was generated by grouping these variables into four categories, with scores ranging from 0 to 4. It presented a progressive increase in postoperative complications ranging from 5.8% of patients scoring 0 to 47.8% of patients scoring 4 ($p$<0.001).

**Conclusion** The Chole-Risk Score represents an intuitive tool capable of predicting postoperative complications in patients with ACC.

**Keywords** cholecystitis · cholecystectomy · early laparoscopic cholecystectomy · postoperative complication

## Introduction

Acute calculous cholecystitis (ACC) is the most common complication of gallstone disease, and laparoscopic cholecystectomy is the gold standard treatment. Several prospective studies have demonstrated that same-admission early laparoscopic cholecystectomy (ELC) for ACC is safe compared to delayed laparoscopic cholecystectomy (DLC).[1–5]

There is still controversy regarding the indication of ELC in high-risk patients with significant comorbidities, in cases of severe inflammation of the gallbladder and in patients with ACC and suspicious of a choledocholithiasis. The advantages of ELC in high-risk patients with severe comorbidities have been recently questioned, with Tokyo Guidelines 2018 (TG18)[6] proposing an initial conservative management of these cases, assessing the benefits of ELC according to specified criteria. However, the recent CHOCOLATE trial[7]

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demonstrated the advantages of ELC over an initial conservative management. Several authors have related the time from the onset of ACC and factors related to local inflammation of the gallbladder with postoperative complications.[8, 9] The 'golden 72-hour rule' from symptom onset was initially proposed as a safe period for the timing of ELC. Nevertheless, with increased experience in advanced laparoscopic surgery, this rule has been questioned.[10] The risk assessment of concomitant choledocholithiasis as well as the role of intraoperative cholangiogram, intraoperative ultrasound and intraoperative bile duct exploration have been assessed by several retrospective studies.[11–14] However, no clear consensus on the optimal management of patients with ACC and suspicious of a concomitant bile duct stone has been reached yet.

Performing an ELC for ACC can be from a straightforward procedure for an on-call general surgeon to a very challenging procedure for even experienced hepatopancreaticobiliary (HPB) laparoscopic surgeons, depending on disease features, surgeons' experience, centre volumes and resources available. Deciding whether the ELC should be performed by the on-call team, the HPB team or whether the operation should be delayed is still a matter of debate in daily practice. Several preoperative scores assessing the risk of difficult cholecystectomy have been proposed, but they were mainly focused on elective procedures and the risk of intraoperative complications.[15–18] The aim of this study is to identify factors associated with an increased risk of postoperative complications after ELC for ACCs in order to develop a preoperative tool to predict adverse events after surgery.

## Materials and Methods

### Study Design

This is a multicentric retrospective observational study based on a previously published research protocol.[19, 20] The data included consecutive patients who underwent same-admission ELC for ACC during the index admission from 2013 to 2018. The study was approved by the Ethics Committee and was performed following the STROBE Recommendations.[21] The research protocol was registered at https://ClinicalTrials.gov/ with the identifier NCT04511910.

An invitation to participate in this study was sent via the Spanish Association of Surgeons (Asociación Española de Cirujanos, AEC). In order to qualify for participating in the study, centres needed to fulfil the criteria set by the TG18 defining 'advanced centres'[6]: (a) centres performing same-admission ELC as reference treatment of ACC, (b) centres with experience in advanced laparoscopic procedures and (c) centres with intensive care unit available. At an 'advanced centre', an ELC could be considered not only for grade I cholecystitis but also for more challenging grade II ACC, regardless of symptom duration.[6]

### Definition and Eligibility Criteria

Diagnosis of ACC was based on TG18 criteria. The data included consecutive patients operated on between January 2010 and September 2018 with the following inclusion criteria: (a) diagnosis of ACC as defined by TG18 criteria including local signs such as Murphy's sign and right upper quadrant mass, pain or tenderness and systemic signs of fever, elevated C-reactive protein and elevated white blood cell count[6, 22, 23]; (b) ELC defined a laparoscopic cholecystectomy performed during the index admission; and (c) surveillance up to a minimum of 30 postoperative days. Exclusion criteria were acute cholecystitis not related to a gallstone aetiology (i.e. acalculous cholecystitis, biliary malignancy).

### Management

Patients diagnosed with ACC were treated with empiric antibiotics according to guidelines.[23, 24] ELC was performed with a standard four-trocar technique,[9] achieving the critical view of safety as described by Strasberg et al..[25] A right subcostal incision was performed if conversion to open surgery was required. All interventions were performed either by surgical residents supervised by a consultant specialist surgeon with experience in minimally invasive surgery or by the consultant surgeon. The on-call resident was involved in the procedure, performing either a part of or the entire intervention under supervision of the consultant. All resected gallbladder specimens were confirmed as ACC after histopathological examination.

### Data Collection

Our database included the following variables: age, gender, body mass index (BMI), Charlson's comorbidity index (CCI),[26] previous abdominal surgeries, previous percutaneous cholecystostomy, duration of symptoms from the onset to the day of the surgical procedure, severity grade of ACC according to TG18 criteria,[23] anaesthetic risk score (American Society of Anaesthesiologists' classification [ASA]),[27] laboratory findings (including liver panel, analysed as a continuous and categorical variable, according to previously defined cut-off values,[11–14] radiological findings (including dilated common bile duct defined as a bile duct with a diameter > 6 mm),[28] operative details (approach, duration and intraoperative events), complications within the first 30 postoperative days (i.e. reoperations, mortality and readmissions), duration of antibiotic therapy (AT) and length of stay (LOS). Intraoperative events recorded were iatrogenic bile duct injury, major bleeding (>500 ml) and trocar injuries during ELC. Postoperative complications were recorded according to the Clavien-Dindo classification,[29] and infectious complications were described in accordance with the US Centers for Disease Control and Prevention (CDC) definitions.[30, 31]

Included patients were divided into two groups according to the presentation of increased postoperative complications. Patients who only developed Clavien-Dindo I–II complications were assigned to group 1 (G1), whereas group 2 (G2) included patients with postoperative complications ≥ IIIa. Patients with postoperative LOS greater than 10 days and who required readmission within 30 days from the discharge were also assigned to G2.

### Statistical Analysis

Descriptive data were expressed as counts and proportions for categorical variables, continuous variables were presented as means with standard deviations (SD) if normally distributed, and non-normal variables were presented as medians with interquartile ranges (IQR). Statistical analysis was performed using the $\chi^2$ test for comparison of categorical variables; the Student's *t* and the Mann–Whitney *U* were used for normally and non-normally distributed continuous variables, respectively. The differences were considered significant at two-sided *p* value of <0.05. Variables that returned $p < 0.05$ values from univariate analysis were entered into a multivariate analysis using a logistic regression model, with an odds ratio (OR) of 95% confidence intervals (95% CI) reported as an estimate of the risk. Variables that were independently predictive of the increased morbidity were included in the risk score (Chole-Risk Score). Associations between Chole-Risk Score and increased postoperative complications was tested using $\chi^2$ test and a correlation analysis. All statistical analyses were performed using SPSS® 23.0 for Windows (SPSS Inc., Chicago, Illinois, USA).

## Results

### Assessment of Baseline Characteristics and Preoperative Variable for Patients Submitted to ELC for ACC

We included 1868 patients: 1586 (84.9%) in G1 and 282 (15.1%) in G2. Table 1 shows the baseline characteristics and preoperative details. Patients in G2 were slightly older (66 vs 65 years old, *p*<0.001), accounted for a higher number patients who were male (60.9% vs 52.1%, *p*=0.006), had higher CCI (3 vs 0, *p*<0.001), ASA III/IV patients (43.4% vs 18.5%, *p*<0.001), diabetic patients (30.7% vs 18.2%, *p*<0.001), with increased previous episodes of intraabdominal surgery (34.3% vs 26.9%, *p*=0.011), percutaneous cholecystostomy (7.9% vs 2%, *p*<0.001), more > 7 days of symptom duration (14.6% vs 9.4%, *p*=0.006) and grade II and III severity (*p*<0.001), as per the definition of ACC by TG18.[6]

We detected higher values of leucocyte count (*p*=0.026), bilirubin (*p*=0.001) and liver function tests in G2 without clear clinical relevance. Furthermore, in G2, more patients had increased total bilirubin > 2 mg/dL (18.2% vs 9.3%, *p*<0.001), alkaline phosphatase more than 3 times above normal values (15.7% vs 9.8%, *p*<0.001) and gamma-glutamyl transpeptidase more than 3 times above normal values (24.1% vs 12.6%, *p*<0.001).

In radiology, G2 patients more frequently had free fluid around the gallbladder (41% vs 28.3%, *p*<0.001), pericholecystic abscess (15.1% vs 8.3%, *p*<0.001), perforated gallbladder (16.5% vs 5.4%, *p*<0.001) and dilated bile duct (9.4% vs 5.3%, *p*=0.008).

### Assessment of Surgical Postoperative Complications After ELC for ACC

Patients in G2 group presented an increased rate of conversion to open surgery (21.1% vs 9.9%, *p*<0.001), intraoperative bile duct explorations (2.9% vs 1.1%, *p*=0.042), prolonged surgical time (106 vs 85 min, *p*=0.001), global intraoperative complications (9.6% vs 2.2%, *p*=0.001), bile duct injury (1.4% vs 0.3%, *p*=0.034) intraoperative bleeding >500 ml (5% vs 0.8%, *p*=0.001), bile duct injury (1.4% vs 0.3%, *p*=0.034) without differences in operative time and trocar-related hollow viscus injury (Table 2).

### Multivariate Analysis of Preoperative Variables: Chole-Risk Score Development and Validation

Variables listed in Table 3 represent independent prognostic factors related to the development of increased postoperative complications (G2). The Chole-Risk Score was developed using these variables in 4 groups: (a) previous abdominal interventions such as previous abdominal surgery and previous percutaneous cholecystostomy, (b) patient comorbidities such as diabetes and CCI > 6, (c) predictors of concomitant bile duct disease such as increased total bilirubin > 2 mg/dL and dilated bile duct and (d) predictors of difficult cholecystectomy such as perforated gallbladder and severity grade as shown in Table 3. Each group could score either 0 or 1 if any variables resulted positive. Therefore, Chole-Risk Score ranged from 0 to 4. Table 4 and Fig. 1 show the validation of the Chole-Risk Score with a progressive increase in postoperative complications from 5.8% of patients scoring 0 to 47.8% of patients scoring 4. The score with its risk assessment was made available online at https://www.calconic.com/calculator-widgets/cholerisk/5f00380606e42a00296f59de?layouts=true

**Table 1** Univariate analysis: baseline characteristics and preoperative variables

| | Total (*n*=1868) | G1 (*n*=1586) | G2 (*n*=282) | *p* value |
|---|---|---|---|---|
| Age (years), median (IQR) | 64 (48–75) | 65 (59–74) | 66 (56–75) | **<0.001** |
| Gender, male, *n* (%) | 998 (53.4) | 826 (52.1) | 162 (57.5) | **0.006** |
| Charlson comorbidity index, median (IQR) | 1 (0–3) | 0 (0–1) | 3 (2–4) | **<0.001** |
| Charlson comorbidity index >6, *n* (%) | 79 (4.2) | 44 (2.8) | 35 (12.4) | **<0.001** |
| ASA classification | | | | **<0.001** |
| ASA I-II, *n* (%) | 1453 (77.8) | 1293 (81.5) | 160 (56.7) | |
| ASA III-IV, *n* (%) | 415 (22.2) | 293 (18.5) | 122 (43.3) | |
| BMI | 26 (22–30) | 27 (23–31) | 29 (24–34) | 0.148 |
| Diabetes mellitus, *n* (%) | 375 (20.1) | 289 (18.2) | 86 (30.5) | **<0.001** |
| Previous intraabdominal surgery, *n* (%) | 523 (28) | 426 (26.9) | 97 (34.4) | **0.011** |
| Previous percutaneous cholecystostomy, *n* (%) | 54 (2.9) | 32 (2) | 22 (7.8) | **<0.001** |
| Symptom duration, median (IQR) | 2 (1–4) | 5 (3–9) | 5 (4–9) | 0.142 |
| Symptom duration >7 days, *n* (%) | 190 (10.2) | 149 (9.4) | 41 (14.5) | **0.008** |
| Laboratory characteristics on admission | | | | |
| Leukocyte count (cells/mm$^3$), median (IQR) | 13440 (10600–16900) | 12220 (9920-13745) | 11460 (10030-15190) | **0.026** |
| Total bilirubin (mg/dl), median (IQR) | 0.8 (0.5–1.3) | 0.8 (0.3-1.4) | 1.3 (0.6–1.6) | **0.001** |
| Increased total bilirubin > 2mg/dL, *n* (%) | 200 (10.7) | 148 (9.3) | 52 (18.4) | **<0.001** |
| AST/GOT (U/l), median (IQR) | 24 (18–41) | 20 (17–23) | 24 (19–34) | **0.001** |
| ALT/GPT (U/l), median (IQR) | 27 (18–51) | 18 (13–25) | 27 (17–80) | 0.106 |
| Alkaline phosphatase (U/l), median (IQR) | 82 (63–110) | 95 (82–111) | 96 (74–144) | **<0.001** |
| Increased alkaline phospatase x3 normal value, *n* (%) | 200 (10.7) | 156 (9.8) | 44 (15.6) | **0.007** |
| Gamma-glutamyl transpeptidase (U/l), median (IQR) | 46 (25–110) | 36 (19–105) | 65 (11–117) | **0.002** |
| Increased Gamma-glutamyl transpeptidase x3 normal value, *n* (%) | 267 (14.3) | 200 (12.6) | 67 (23.8) | **<0.001** |
| Radiological characteristics on admission | | | | |
| Gallstone in Hartmann pouch, *n* (%) | 473 (25.3) | 412 (26) | 61 (21.6) | 0.137 |
| Free fluid, *n* (%) | 564 (30.2) | 449 (28.3) | 115 (40.8) | **<0.001** |
| Pericholecystic abscess, *n* (%) | 175 (9.4) | 132 (8.3) | 43 (15.2) | **<0.001** |
| Perforated gallbladder, *n* (%) | 132 (7.1) | 86 (5.4) | 46 (16.3) | **<0.001** |
| Dilated bile duct, *n* (%) | 110 (5.9) | 84 (5.3) | 26 (9.2) | **0.008** |
| Severity grade | | | | **<0.001** |
| Mild cholecystitis (grade I), *n* (%) | 560 (29.9) | 510 (32.1) | 50 (17.7) | |
| Moderate cholecystitis (grade II), *n* (%) | 873 (46.7) | 756 (47.7) | 117 (41.5) | |
| Severe cholecystitis (grade III), *n* (%) | 435 (23.3) | 320 (20.1) | 115 (40.8) | |

*BMI* body mass index, *DM* diabetes mellitus, *ASA* American Society of Anaesthesiologists, *AST/GOT* aspartate aminotransferase, *ALT/GPT* alanine aminotransferasa, *IQR* interquartile range, *SD* standard deviation

## Discussion

The TG18 2018[6] and World Society of Emergency Surgery (WSES) 2016[32] emphasise the role of ELC as the gold standard treatment of ACC; however, it is still arguable which subgroup of patients should be considered at high risk of postoperative complications and should be managed for a nonoperative initial treatment or referred to an HPB Unit for an ELC.

Several factors influencing intraoperative difficulty and perioperative morbidity and mortality of ELC have been suggested, including patient characteristics, laboratory parameters and radiologic findings.[16, 33–35] Patient characteristics like male gender, advanced age and higher BMI could represent a clinical profile with a higher risk of conversion and postoperative morbidity.[16, 33, 35] TG18[6] proposes a complex treatment algorithm for ACC that takes into account patient's comorbidities through the ASA, CCI, the grade of ACC, the availability of advanced laparoscopic techniques and the degree of sepsis in order to elaborate a treatment algorithm. However, the CHOCOLATE trial[7] demonstrated that even high-risk patients should be considered for ELC as the non-operative initial management showed an increased rate of major complication (65% vs 12%, $p<0.001$) and recurrent biliary

**Table 2** Univariate analysis: surgical and postoperative variables

| | Total (*n*=1868) | G1 (*n*=1586) | G2 (*n*=282) | *p* value |
|---|---|---|---|---|
| Surgery characteristics | | | | |
| Conversion to open, *n* (%) | 217 (11.6) | 157 (9.9) | 60 (21.3) | **<0.001** |
| Resident as principal surgeon, *n* (%) | 1162 (62.2) | 1009 (63.6) | 153 (54.3) | **0.003** |
| Intraoperative cholangiography, *n* (%) | 58 (3.1) | 49 (3.1) | 9 (3.2) | 0.933 |
| Intraoperative common bile duct exploration, *n* (%) | 26 (1.4) | 18 (1.1) | 8 (2.9) | **0.042** |
| Operative time (min), median (IQR) | 90 (65–120) | 85 (65–107) | 106 (60–120) | **<0.001** |
| Intraoperative complication, *n* (%) | 62 (3.3) | 35 (2.2) | 27 (9.6) | **<0.001** |
| Bleeding (>500 ml), *n* (%) | 28 (1.5) | 14 (0.9) | 14 (5) | **<0.001** |
| Intraoperative mortality, *n* (%) | 0 (0) | 0 (0) | 0 (0) | – |
| Total complications, *n* (%) | 385 (20.6) | 187 (11.8) | 198 (70.2) | **<0.001** |
| Complications ≥ IIIa Dindo-Clavien | 123 (6.6) | 0 (0) | 123 (43.6) | **<0.001** |
| Bile leakage, *n* (%) | 54 (2.9) | 11 (0.7) | 43 (15.2) | **<0.001** |
| Haemorrhage, *n* (%) | 18 (1) | 6 (0.4) | 12 (4.3) | **<0.001** |
| Infectious postoperative complications, *n* (%) | | | | |
| SSI–incisional, *n* (%) | 90 (4.8) | 57 (3.6) | 33 (11.7) | **<0.001** |
| SSI–organ/space, *n* (%) | 72 (3.9) | 23 (1.4) | 49 (17.4) | **<0.001** |
| Urinary tract infection, *n* (%) | 24 (1.3) | 14 (0.9) | 10 (3.5) | **0.001** |
| Pneumonia, *n* (%) | 32 (1.7) | 8 (0.5) | 24 (8.5) | **<0.001** |
| Mortality | 27 (1.4) | 0 (0) | 27 (9.5) | **<0.001** |
| Antibiotic therapy postoperative global duration, median (IQR) | 4 (3–7) | 3 (2–6) | 10 (7–15) | **<0.001** |
| Reoperation, *n* (%) | 23 (1.3) | 0 (0) | 23 (8.1) | **<0.001** |
| Postoperative stay, median (IQR) | 4 (3–6) | 2 (2–5) | 14 (11–20) | **<0.001** |
| Readmission, *n* (%) | 57 (3) | 0 (0) | 56 (20.0) | **<0.001** |

*IQR* interquartile range, *SD* standard deviation, *SSI* surgical site infection

disease (53% vs 5%, $p<0.001$). Laboratory parameters and ultrasonographic features like the increased inflammatory markers, deranged liver function test enzymes, the presence of pericholecystic fluid and impacted stones have been associated with increased technical difficulties, higher rates of conversion to an open procedure and increased postoperative morbidity.[16, 34] Performing an ELC for ACC can be from a straightforward procedure for an on-call general surgeon to a very challenging procedure for even experienced hepatopancreaticobiliary (HPB) laparoscopic surgeons. The

**Table 3** Multivariate analysis (logistic regression model) of preoperative variables and preoperative Chole-Risk Score

| | *Odds ratio (95% CI)* | *p* value |
|---|---|---|
| *A) Previous abdominal intervention* | | |
| Previous percutaneous cholecystostomy | 2.95 (1.52–5.71) | 0.001 |
| Previous major abdominal surgery | 1.57 (1.04–2.37) | 0.031 |
| *B) Patient comorbidities* | | |
| Diabetes | 1.62 (1.16–2.29) | 0.005 |
| Charlson comorbidity index >6 | 2.48 (1.37–4.51) | 0.003 |
| *C) Predictors of concomitant bile duct disease* | | |
| Increased total bilirubin > 2 mg/dL | 1.93 (1.32–2.82) | 0.002 |
| Dilated bile duct (> 6 mm) | 1.79 (1.06–3.00) | 0.027 |
| *D) Predictors of difficult cholecystectomy* | | |
| Perforated gallbladder on preoperative image | 2.62 (1.68–4.08) | <0.001 |
| Severity grade (1 vs 2–3 according to TG18) | 1.88 (1.26–2.81) | 0.001 |

*OR* odds ratio, *95% CI* 95% confidence interval

**Table 4** Chole-Risk Score validation

| Chole-Risk Score | Total (*n*=1868) *n* | G1 (*n*=1586) *n* (%) | G2 (*n*=282) *n* (%) | *p* value |
|---|---|---|---|---|
| 0 | 321 | 302 (94.2) | 19 (5.8) | **<0.001** |
| 1 | 796 | 705 (88.5) | 91 (11.5) | |
| 2 | 515 | 413 (80.2) | 102 (19.8) | |
| 3 | 207 | 151 (73.1) | 56 (26.9) | |
| 4 | 29 | 15 (52.2) | 14 (47.8) | |

impact of preoperative variables on postoperative complications has been shown to vary according to surgeon expertise and available resources.[36–38] Data from a Scottish national population-based analysis[38] demonstrated that the relative risk of death in patients submitted to laparoscopic cholecystectomy was lower in high-volume centres. That study showed that patients operated in lower volume hospitals were more likely to undergo reoperation (OR 1.74, $p<0.001$) and be readmitted (OR 1.17, $p = 0.008$) than those in high-volume hospitals. However, these differences were only of clinical significance in patients at higher risk. Therefore, an attempt to stratify patients at high risk of postoperative complication could provide precious information in order to tailor their treatment, allocating adequate resources to each specific case.

Several scores have been described, but they mainly focused on elective cholecystectomy and/or technical intraoperative difficulties or complications in terms of operative time, bile duct injury and conversion to open cholecystectomy. The Nassar scale[39] was recently validated by Griffith et al.[17] with the aim of standardising the description of operative findings in terms of disease severity and technical difficulty. Similarly, Madni et al.[40] evaluated intraoperatively anatomy and inflammatory changes of patients with ACC developing the Parkland grading scale, which presented a high correlation with gangrenous changes in the gallbladder wall after the specimen examination. The WSES intraoperative gallbladder scoring[41] is another intraoperative score based on ten intraoperative findings that showed a high correlation with technical difficulties and conversion to open cholecystectomy. However, all these scales exclusively take into account intraoperative findings. Bourgouin et al.[18] proposed the score of operative difficulty in laparoscopic cholecystectomies (DiLCs score) that included sex, previous cholecystitis episodes, fibrinogen, neutrophil and alkaline phosphatase count into a score that predicted difficult cholecystectomies, defined as procedures lasting over 1.5 times the surgeon's individual base time and procedures converted to open surgery. Sutcliffe et al.[15] developed the CholeS score that considered six preoperative factors (age, sex, indication for surgery, ASA, thick-walled gallbladder and common bile duct diameter) as associated with an increased conversion to open cholecystectomy. Panni and Strasberg[16] tried to summarise the available evidence in a review aimed at describing the strengths and weaknesses of a published risk score for laparoscopic cholecystectomy. However, there are no preoperative scores aimed at assessing the risk of perioperative complications in patients with ACC.

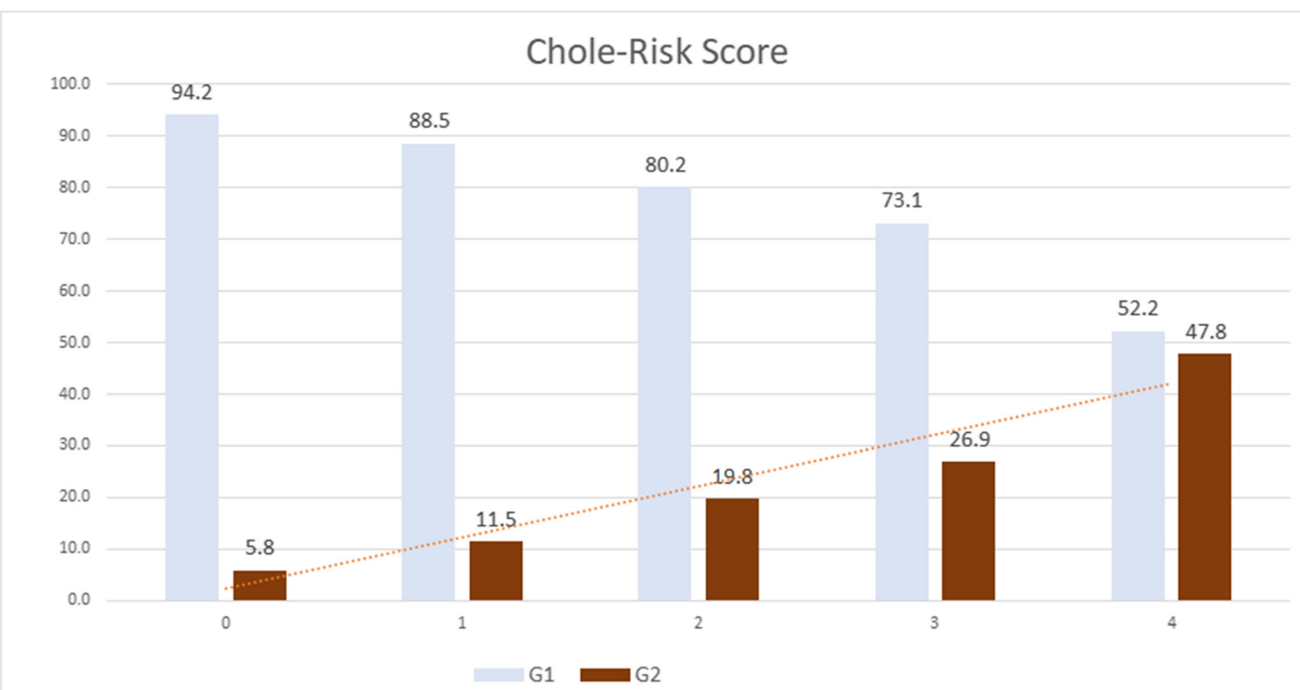


**Fig. 1** Chole-Risk Score validation

Our results confirms the association of multiples variables with increased postoperative complication, and as an attempt to categorise these variables, we grouped them into four main categories. Two were related to subjects' characteristics and previous procedures they underwent and the other two were related to the gallstone disease, influential technical difficulties and possible bile duct explorations. Therefore, the Chole-Risk Score was built on a group of four variables that had shown in our series an independent correlation with perioperative complications in patients with ACC submitted to ELC. The four categories included (a) previous abdominal intervention, (b) patient comorbidities, (c) predictors of concomitant bile duct disease and (d) predictors of difficult cholecystectomy. It must be taken into account that despite its elaborated treatment algorithm, TG18 does not take into account factors like previous abdominal procedures (surgeries and cholecystostomy) and the risk of a possible bile duct exploration. Therefore, the Chole-Risk could represent a simple and easily reproducible score able to predict not only more complex procedures but also the risk of increased perioperative morbidity.

There are some limitations to our study. It is a retrospective review based on patients submitted to ELC, which increases the possibility of selection bias. Postoperative complications could have been influenced by criteria used by each centre to select patients undergoing ELC, and we could not estimate the percentage of patients with ACC submitted to ELC compared to the total cases of ACC admitted to each hospital. Consequently, our series does not take into account those patients managed with a nonoperative initial management. An external validation of the score would be helpful in order to corroborate the correlation we found. Furthermore, as a topic for further research, it would be interesting to compare patients with ACC and high Chole-Risk Score submitted to ELC with an initial nonoperative management of ACC.

## Conclusion

The Chole-Risk Score represents an intuitive and easily reproducible tool able to predict postoperative complications in patients with ACC and submitted to ELC.

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**Author Contributions** MDM proposed the study; MDM, IMG and GP wrote the initial draft that was finally reviewed by EMP. All listed co-authors were integrally involved in the formation of this manuscript via data acquisition and made significant contributions to the drafting and critical revisions of the manuscript. The authors gave final approval prior to submission for publication.

## Declarations

**Conflict of Interest** The authors declare that they have no conflict of interest.

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