

## Retrospective Study

# Which octogenarian patients are at higher risk after cholecystectomy for symptomatic gallstone disease? A single center cohort study

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**Specialty type:** Surgery

**Provenance and peer review:**

Invited article; Externally peer reviewed.

**Peer-review model:** Single blind

**Peer-review report's scientific quality classification**

Grade A (Excellent): 0

Grade B (Very good): 0

Grade C (Good): C

Grade D (Fair): D, D

Grade E (Poor): 0

**P-Reviewer:** Dai YC, China; Sato M, Japan; Zarnescu NO, Romania

**Received:** April 27, 2022

**Peer-review started:** April 27, 2022

**First decision:** May 30, 2022

**Revised:** June 13, 2022

**Accepted:** July 22, 2022

**Article in press:** July 22, 2022

**Published online:** August 26, 2022



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## Abstract

### BACKGROUND

Incidence of gallstones in those aged  $\geq 80$  years is as high as 38%-53%. The decision-making process to select those oldest old patients who could benefit from cholecystectomy is challenging.

### AIM

To assess the risk of morbidity of the "oldest-old" patients treated with cholecystectomy in order to provide useful data that could help surgeons in the decision-making process leading to surgery in this population.

### METHODS

A retrospective study was conducted between 2010 and 2019. Perioperative variables were collected and compared between patients who had postoperative complications. A model was created and tested to predict severe postoperative morbidity.

### RESULTS

The 269 patients were included in the study (193 complicated). The 9.7% of complications were grade 3 or 4 according to the Clavien-Dindo classification. Bilirubin levels were lower in patients who did not have any postoperative complications. American Society of Anesthesiologists scale 4 patients, performing a choledocholithotomy and bilirubin levels were associated with Clavien-Dindo  $> 2$  complications ( $P < 0.001$ ). The decision curve analysis showed that the proposed model had a higher net benefit than the treating all/none options between

threshold probabilities of 11% and 32% of developing a severe complication.

### CONCLUSION

Patients with American Society of Anesthesiologists scale 4, higher level of bilirubin and need of choledocholithotomy are at the highest risk of a severely complicated postoperative course. Alternative endoscopic or percutaneous treatments should be considered in this subgroup of octogenarians.

**Key Words:** Cholecystitis; Gallstones; Choledocholithotomy; Elderly; Post-operative complications

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**Core Tip:** The incidence of gallstone disease is high in octogenarian patients. There are no contraindications in performing cholecystectomy in this population, however, they may be at higher risk of complications. Herein, we will analyze perioperative variables to understand their impact on postoperative courses. Then, we will construct a model in order to help in the selection of patients aged > 80 years who need cholecystectomy.

**Citation:** D'Acapito F, Solaini L, Di Pietrantonio D, Tauceri F, Mirarchi MT, Antelmi E, Flamini F, Amato A, Framarini M, Ercolani G. Which octogenarian patients are at higher risk after cholecystectomy for symptomatic gallstone disease? A single center cohort study. *World J Clin Cases* 2022; 10(24): 8556-8567

**URL:** <https://www.wjgnet.com/2307-8960/full/v10/i24/8556.htm>

**DOI:** <https://dx.doi.org/10.12998/wjcc.v10.i24.8556>

## INTRODUCTION

Extended life expectancy, coupled with the increased incidence of gallstones with aging, progressively leads to more elderly patients being evaluated for possible surgery for symptomatic gallstones[1,2].

The incidence of gallstones in those aged 80 or over is as high as 38%-53%, and it could increase up to 80% for patients over 90 years of age[3-5]. After an initial episode of biliary colic, 20%-40% of patients will experience recurrent episodes[6,7]. Within one year, 14% of patients will develop acute cholecystitis, 5% biliary acute pancreatitis (BAP) and 5% choledocholithiasis[8,9]. Acute Cholecystitis (AC) is the sixth most common gastrointestinal disease encountered in the emergency department and the second most common cause of hospital admission in the United States[10].

With the aid of modern perioperative care and laparoscopic surgery, patients between 65 and 80 years of age are now thought to have operative risks comparable to the younger population[5]. To date, the outcomes regarding the safety of cholecystectomy performed in older patients are controversial[11-13].

Age itself is one of the critical factors influencing mortality and morbidity after cholecystectomy[14, 15]. The greater burden of comorbidities in elderly patients leads to reduced physiological reserve and increased susceptibility to perioperative complications[16]. Outcomes can vary widely, depending on the clinical presentation and whether the procedure is performed electively or as an emergency.

Increasing age has previously been identified as a factor which significantly reduces the likelihood of emergency and elective cholecystectomy being undertaken[12]. One of the reasons quoted for this choice was the reduced life expectancy of this group of patients. The decision about the most appropriate treatment for these patients is always challenging for the surgeon, regardless of the pattern of onset.

The purpose of this study is to assess the risks in terms of morbidity of the octogenarian patients treated with cholecystectomy for symptomatic cholelithiasis (biliary colic, AC, BAP) in order to provide useful data that could help surgeons in the decision process leading to both emergency and elective surgery in this particular population.

## MATERIALS AND METHODS

A single center retrospective cohort study was conducted on patients who underwent cholecystectomy for symptomatic cholelithiasis between September 2010 and October 2019. Exclusion criteria were age < 80 years and cholecystectomies performed during other surgical procedures. Data were extracted from a retrospective institutional review board-approved database (C.E.ROM. prot. 3238/2019; I.5/263) on

hepatobiliary pancreatic surgery.

Diagnosis of cholelithiasis was performed based on imaging studies: ultrasound (US), computed tomography (CT) and/or magnetic resonance (MR). AC was diagnosed and graded according to the Tokyo Guidelines (TG18)[17]. Postoperative complications were defined according to the Clavien-Dindo classification[18]. The analyzed variables included patients- age, sex, American Society of Anesthesiologists scale (ASA), Body Mass Index (BMI), Charlson comorbidity index (CCI)[19], comorbidity, prior abdominal surgery, laboratory test, radiological imaging, Endoscopic Retrograde Cholangio-Pancreatography (ERCP), diagnosis at admission in urgency; disease- cholelithiasis, cholangitis, AC, TG 18 score; and operation-related- timing, admission surgery interval, surgical approach, associated procedures, operative time, afternoon or night procedure, post-operative complication according to Clavien-Dindo classification, length of hospital stay, supported discharge, mortality.

### Indications and procedures

Candidates for elective cholecystectomy were those patients with previous history of cholecystitis, biliary colic and/or biliary pancreatitis in the absence of biliary tract lithiasis. In case of choledocholithiasis in the preoperative work-up, in either election or emergency setting patients were referred for preoperative or intraoperative ERCP. Postoperative ERCP was indicated solely in case of choledocholithiasis diagnosed during intraoperative cholangiography in absence of contraindications for endoscopic treatment. The indications for choledocholithotomy were the failure to resolve choledochal lithiasis endoscopically or percutaneously (including by intraoperative Rendez-vous) and Mirizzi's syndrome type 2.

The laparoscopic approach was performed with the patient placed in the French position. The first 10-12 mm trocar is inserted with an open technique in peri-umbilical area to achieve a 11 mmHg pneumoperitoneum. The other three trocars are positioned under direct vision in the epigastrium (5 mm), 1 Laterally in the right flank (5 mm) and 1 medially in the left flank (10 or 5 mm). In case of open conversion, access with a right subcostal laparotomy was preferred. Antibiotic prophylaxis with 3<sup>rd</sup> gen cephalosporins was administered in all patients. In case of AC a combination of antibiotics was used and continued based on clinical grounds.

In urgency and elective settings the open approach was indicated in high risk patients who had previous gastric surgery or repeated open abdominal surgery, in patients who need a surgical clearance of the common bile duct, in case of anesthetic contraindications to laparoscopy and in case of patient refusal to laparoscopy.

### Statistical analysis

Data were analyzed using MedCalc Statistical Software version 15.8 (MedCalc Software bvba, Ostend, Belgium; <https://www.medcalc.org>; 2015). Continuous variables were shown as median and interquartile range (IQR) while categorical data were presented as numbers and percentages. Differences between complicated and uncomplicated patients were analyzed with the Mann-Whitney *U* test for continuous variables and with the Chi square or Fisher exact tests for the categorical ones.

Logistic regression analyses were performed to investigate the predictors of complications and major complications. The variables who displayed a  $P < 0.05$  at multivariable analysis for Clavien-Dindo  $< 2$  complications were merged in a model and its accuracy was assessed with a receiver operating characteristic (ROC) curve analysis to calculate the Area Under the curve (AUC).

Decision curve analysis (DCA) was constructed using STATA version 15 (STATA Corp., TX, United States). DCA allowed the calculation of a clinical benefit for the prediction model in comparison with default strategies of operating all or no patient [20,21]. The DCA graph has on the y-axis the "net benefit" and on the x-axis the "threshold probability" ( $P_t$ ).

The Net benefit could be calculated as follows:  $\text{Net} = (TP/n - FP/n) \times (P_t / 1 - P_t)$ .

TP and the FP are the number of patients with true- and false-positive results, respectively;  $n$  was the total number of patients, and  $P_t$  is the threshold probability of Clavien-Dindo  $> 2$  complications. Thus, the "decision curve" resulted from plotting the Net benefit against the threshold probability and, in this study, it was used to test the utility of the constructed model in influencing the indication of performing or not the cholecystectomy in the given population. Each graph showed a curve representing the proposed model, one about performing cholecystectomy on all patients (treat all) and one about treating all patients with conservative treatment (treat none).

The study was reviewed by our expert biostatistician Leonardo Solaini, MD.

## RESULTS

Overall, 269 patients (179 urgent *vs* 90 elective cholecystectomies) were included in the analysis. Patients' characteristics are shown in Table 1. Overall, 193 (71.7%) patients had a complicated postoperative course (Table 2). ASA score was significantly higher in the patients who had postoperative complications ( $P = 0.002$ ). Median leukocyte (12850 versus 9300,  $P = 0.009$ ) and platelets

**Table 1 Patients' characteristics and their comparison according to the occurrence of postoperative complications**

Variables	Total cohort (n = 269)	Uncomplicated (n = 76)	Complicated (n = 193)	P value
Age	83	83 (82-85)	83 (82-87)	0.686
Sex (M:F)	126:143	344:200	92:101	0.686
ASA				
1	1 (0.0)	0	1 (0.5)	0.002
2	62 (23.0)	27 (35.5)	35 (18.1)	
3	179 (66.5)	48 (63.2)	131 (67.9)	
4	27 (10.0)	1(1.3)	26 (13.5)	
BMI	24.8 (24-25.1)	26.3 (22.9-28.2)	24.2 (21.1-27.4)	0.062
Charlson comorbidity index	3 (1-4)	3 (2-4)	2 (1-4)	0.145
Prior upper abdomen surgery	34 (12.6)	11 (32.3)	23 (67.7)	0.548
Leucocytes ( $\times 10^9/L$ )	11685 (10520-12957)	9300 (7315-13917)	12850 (8020-18200)	0.009
Platelets ( $\times 10^9/L$ )	236 (183-352)	197 (165-262)	272 (189-340)	< 0.0001
Bilirubin (mg/dL)	1.01 (0.58-1.91)	0.82 (0.41-1.53)	1.11 (0.62-2.1)	0.011
C-reactive protein (mg/L)	82 (19.7-225)	46.4 (9-184.6)	85.7 (22.2-231.0)	0.135
Antiplatelet	110 (40.9)	28 (36.8)	82 (42.5)	0.412
Anticoagulant therapy	64 (23.8)	12 (15.8)	52 (26.9)	0.057
Acute cholecystitis Tokyo grade				0.147
Mild	36 (20.1)	11(14.5)	25 (13)	
Moderate	75 (42.0)	18 (23.7)	57 (29.6)	
Severe	68 (37.9)	10 (13.2)	58 (30.0)	
Diagnosis at admission in urgency				0.374
A.C.	69 (38.5)	19 (27.6)	50 (72.4)	
A.C. + cholangitis	19 (10.6)	1 (5.2)	18 (94.8)	
A.C. + choleperitoneum	25 (14.0)	5 (20)	20 (80)	
A.C. + biliary colic	38 (21.2)	9 (23.7)	29 (76.3)	
A.C. + biliary pancreatitis	28 (15.7)	7 (25)	21(75)	
Preoperative ERCP	23 (8.6)	11 (14.5)	12 (6.2)	0.053
Admission-surgery interval	1 (0-2)	1 (0-2)	1 (0-3)	0.051
Operative time (min)	100 (73-141)	90 (66-120)	105 (75-150)	0.021
Surgical approach				0.012
Laparoscopy		53	115	
Open		6 (7.9)	46 (23.8)	
Converted to open		17 (23.4)	32(16.6)	
Intraoperative cholangiography	161 (58.9)	35 (46.1)	126 (65.3)	0.0005
Choledocholithotomy	15 (5.6)	4 (5.3)	11 (5.7)	1
Transcystic biliary decompression	22 (8.2)	3 (3.9)	19 (9.8)	0.147
Intraoperative ERCP	28 (10.4)	6 (7.9)	22 (11.4)	0.508
Afternoon night-procedure	117 (43.5)	24 (31.6)	93(48.2)	0.014
Length of hospital stay	5 (3-8)	3 (2-6)	6 (4-9)	< 0.0001
Supported discharge	47 (17.5)	9 (11.9)	38 (19.7)	0.154

**Table 2 Detailed postoperative complications according to the Clavien Dindo scale**

	Election	Urgency
Grade 1	31	54
Nausea and vomiting	18	6
Pain	13	48
Grade 2	19	59
Pneumonia	6	13
Mild pancreatitis	0	7
Ileus-delayed flatus	5	16
Septic status	0	12
Urinary problems	8	11
Grade 3	3	13
Bile leak	0	3
Cholangitis/retained CBD stone	1	6
Bleeding	1	3
Respiratory failure	1	1
Grade 4	0	10
Acute myocardial infarction	0	1
Arrhythmia	0	3
Respiratory failure	0	2
Acute renal failure	0	4
Grade 5	0	4
Acute myocardial infarction	0	3
Pulmonary failure	0	1

CBD: Common bile duct.

(272000 vs 197000,  $P < 0.0001$ ) counts at admission were higher in the complicated group. Bilirubin levels were lower in patients who did not have any postoperative complications (0.82 vs 1.11,  $P = 0.011$ ). The open approach (23.8% vs 13.0%) was more common in the group who had postoperative complications ( $P = 0.012$ ). The complicated group had more intraoperative cholangiography (46.1 vs 65.3%). The uncomplicated group had more cholecystectomies which were performed during afternoon/night (31.6 vs 48.2%,  $P = 0.014$ ).

The 9.7% ( $n = 26$ ) of complications were grade 3 or 4 according to the Clavien-Dindo classification. The in-hospital mortality rate was 1.5% ( $n = 4$ ) while the 90 d mortality rate was 3.9% ( $n = 7$ ). The three patients who died after discharge but within 90 days of surgery had had a postoperative course with Clavien-Dindo grade  $< 3$  (Table 2). All cases of postoperative deaths occurred after open or converted urgent cholecystectomy.

At 24 mo follow-up, 195 were alive (85.9%) while 32 (14.1%) died for unrelated causes. For 23 (8.8%) patients last follow-up was at 90 days. At multivariable analysis, performing an intraoperative cholangiography (2.99, 1.43-6.24;  $P = 0.003$ ), the diagnosis of cholangitis at admission (12.7, 1.61-100.1;  $P = 0.016$ ), platelets count (1.00, 1.00-1.01;  $P = 0.0008$ ), the laparoscopic approach (0.10, 0.02-0.46;  $P = 0.003$ ) were significantly associated with postoperative complications (Table 3).

ASA 4 patients (12.6, 4.27-37.3;  $P < 0.0001$ ), performing a choledocholithotomy (10.2, 2.04-51.1;  $P = 0.005$ ) and bilirubin levels (1.4, 1.33-1.75;  $P = 0.002$ ) were significantly associated with Clavien-Dindo  $> 2$  complications (Table 4) for the whole population.

The ROC curve analysis showed that the model including the three variables to predict Clavien-Dindo  $> 2$  complications had an AUC of 0.79 (0.73-0.85) (Figure 1).

**Table 3 Univariate and multivariate analysis for postoperative complications**

Variables	Univariate analysis		Multivariate analysis	
	OR (95%CI)	P value	OR (95%CI)	P value
Age	1.00 (0.93-1.08)	0.864		
Sex	0.85 (0.50-1.46)	0.562		
ASA				
1	NA	NA		
2	0.51 (0.28-0.93)	0.027		
3	Ref.	1		
4	9.53 (1.26-72.1)	0.029		
BMI	0.92 (0.85-1.01)	0.072		
CCI	0.82 (0.43-1.60)	0.611		
Prior upper abdomen surgery	0.79 (0.36-1.72)	0.559		
Leucocytes	1.00 (1.00-1.00)	0.009		
Platelets	1.00 (1.00-1.00)	0.013	1.00 (1.00-1.00)	0.0008
Bilirubin	1.23 (0.97-1.57)	0.081		
C-reactive protein	1.00 (0.99-1.00)	0.195		
Antiplatelet	1.33 (0.77-2.31)	0.311		
Anticoagulant therapy	1.922 (0.96-3.85)	0.065		
Acute cholecystitis Tokyo grade				
Mild	1.55 (0.67-3.35)	0.324		
Moderate	2.19 (1.11-4.32)	0.023		
Severe	4.54 (2.00-10.3)	0.0003		
Biliary colic	3.43 (1.70-6.93)	0.0006		
Biliary pancreatitis	1.24 (0.51-3.04)	0.635		
Gallbladder cancer	1.95 (0.22-17.1)	0.543		
Choleperitoneum	1.61 (0.58-4.45)	0.36		
Cholangitis	12.0 (1.59-89.7)	0.019	12.7 (1.61-100.1)	0.016
Preoperative ERCP	0.38 (0.16-0.91)	0.03		
Admission-surgery interval	1.04 (0.95-1.14)	0.326		
Laparoscopy	0.28 (0.11-0.69)	0.005	0.10 (0.02-0.46)	0.003
Conversion to open surgery	1.81 (0.37-1.42)	0.354		
Choledocholithotomy	1.07 (0.33-3.46)	0.914		
Intraoperative cholangiography	2.12 (1.23-3.64)	0.007	2.99 (1.43-6.24)	0.003
Intraoperative ERCP	1.47 (0.57-3.78)	0.423		
Transcystic biliary decompression	2.57 (0.73-8.95)	0.138		
Afternoon night procedure	2.12 (1.21-3.74)	0.009		

ASA: American Society of Anesthesiologists; BMI: Body mass index; ERCP: Endoscopic retrograde cholangio-pancreatography; CCI: Charlson comorbidity index; NA: Not available.

The decision curve analysis is shown in **Figure 2**. According to the graph, the treating all strategy may be harmful in terms of Clavien-Dindo > 2 complications in patients with threshold probabilities > 13%. The proposed model showed a higher Net benefit than the treating all/none options between threshold probabilities of 11% and 32% of developing a Clavien-Dindo > 2 complication.

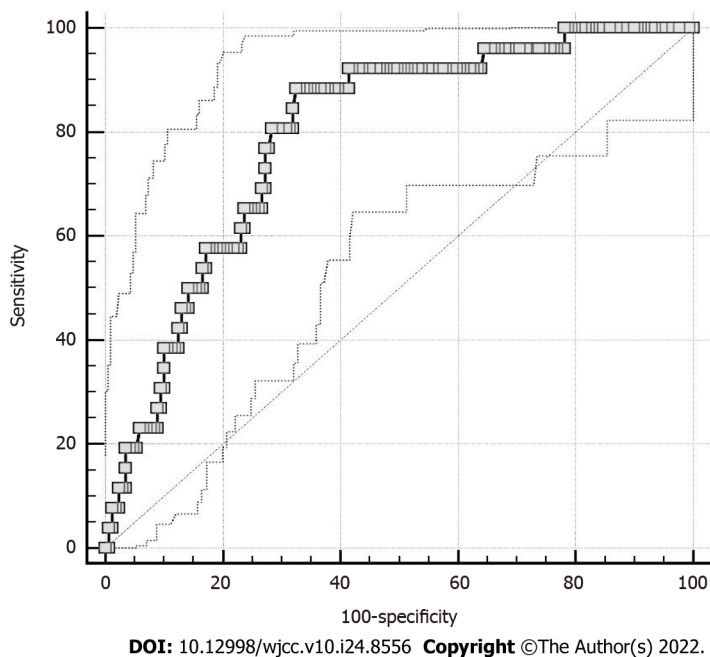
**Table 4 Univariate and multivariate analysis for postoperative complications with Clavien-Dindo grade > 2**

Variables	Univariate analysis		Multivariate analysis	
	OR (95%CI)	P value	OR (95%CI)	P value
Age	1.08 (0.98-1.18)	0.122		
Sex	0.64 (0.30-1.38)	0.255		
ASA				
1	NA			
2	0.14 (0.02-1-12)	0.064		
3	Ref.	1		
4	6.14 (2.48-15.3)	0.001	12.6 (4.27-37.3)	< 0.0001
BMI	1.12 (1.00-1.26)	0.05		
CCI	1.19 (0.87-4.21)	0.237		
Prior upper abdomen surgery	1.92 (0.72-5.12)	0.193		
Leucocytes	1.00 (1.00-1.01)	0.021		
Platelets	1.00 (1.00-1.00)	0.545		
Bilirubin	1.37 (0.44-4.28)	0.014	1.41 (1.33-1.75)	0.002
C-reactive protein	1.00 (0.99-1.01)	0.252		
Antiplatelet	0.96 (0.44-2.08)	0.916		
Anticoagulant therapy	2.03 (0.91-4.53)	0.083		
Acute cholecystitis Tokyo grade				
Mild	3.33 (0.71-15.7)	0.128		
Moderate	3.38 (0.86-13.2)	0.08		
Severe	8.02 (2.21-29.0)	0.001		
Biliary colic	0.79 (0.33-1.87)	0.599		
Biliary pancreatitis	0.26 (0.03-1.98)	0.194		
Choleperitoneum	2.89 (1.05-7.95)	0.039		
Cholangitis	1.37 (0.44-4.28)	0.579		
Preoperative ERCP	0.74 (0.16-3.33)	0.696		
Admission-surgery interval	1.05 (0.99-1.11)	0.115		
Laparoscopy	0.18 (0.08-0.40)	< 0.001		
Conversion to open surgery	1.81 (0.75-4.35)	0.185		
Choledocholithotomy	4.58 (1.45-14.5)	0.009	10.2 (2.04-51.1)	0.005
Transcystic biliary decompression	5.81 (2.20-15.4)	0.0004		
Intraoperative cholangiography	0.86 (0.40-1.86)	0.706		
Intraoperative ERCP	1.38 (0.44-4.28)	0.579		
Afternoon night procedure	1.82 (0.84-3.91)	0.126		

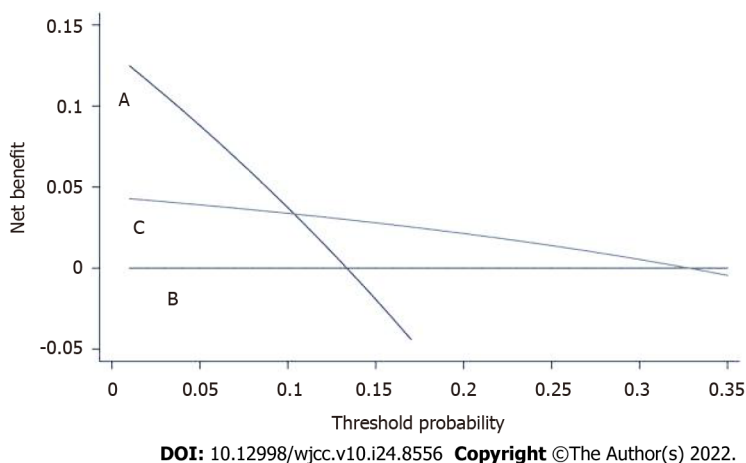
ASA: American Society of Anesthesiologists; BMI: Body mass index; ERCP: Endoscopic retrograde cholangio-pancreatography; CCI: Charlson comorbidity index; NA: Not available.

## DISCUSSION

Even though gallstones increase with aging, older patients are less likely to undergo cholecystectomy[1, 22]. In fact, it has been estimated that less than a quarter of elderly patients who meet the criteria for elective cholecystectomy undergo surgery[1,22]. This is because increasing age is a negative predictor after cholecystectomy, due to the higher perceived surgical risks, especially after hospitalization for



**Figure 1** Receiver operating characteristic curve representing the accuracy of the model.



**Figure 2** Decision curve analysis of Clavien-Dindo > 2 complications following cholecystectomy for gallstone disease. Decision curve analysis included three main strategies: to perform cholecystectomy on all patients; the net benefit of surgery to none patients; to treat the patients according to the proposed model (Net Benefit: CL2). A: Treat all; B: Treat none; C: Proposed model.

complications of gallstones[1]. In this clinical arena, the availability of a tool to support the surgeon in his decision making is of utmost importance.

Cholecystectomy for symptomatic gallstone disease is associated with a high postoperative complication rate in octogenarians. However, it must be highlighted that only 9.7% of patients had a severe complication, indicating that cholecystectomy could remain a treatment option in this population. In line with this assumption, the NICE 2014[23] and TG18[17] guidelines did not suggest an age cut-off to surgically treat symptomatic gallstone disease or cholecystitis.

Other reports showed similar high morbidity rates ranging between 14.7% and 51% [24-27].

Only 3 studies with populations with similar characteristics reported complications graded according to the Clavien-Dindo classification and all found that the majority of complications were Clavien-Dindo grade 1-2 characteristics [28-30].

The feasibility of cholecystectomy in octogenarians was evaluated in different studies that confirmed its safety, but in the investigated “all comers” groups the surgical treatment in an elective setting always represented more than half of the cases[28]. Differently, the population analyzed in this study was characterized by a limited number of patients (33.5%) treated electively with cholecystectomy.

In addition, according to our analysis, cholecystectomy seemed to be associated with acceptable safety parameters in moderate-severe acute cholecystitis. As such, 90 d mortality in our cohort was 2.6%. This is similar to what has been reported by the two largest single-center studies which showed



in-hospital mortality ranging between 4% to 4.8% [28,31]. This was also confirmed by a recent systematic review comparing the outcomes of patients with 65-79 *vs*  $\geq 80$  years which showed a mortality rate of 0%-4.6% in the older age group [5].

A severely complicated postoperative course, may have a dramatic impact on the elderly patients who may not return to their previous level of activity [32].

Our analysis could find those factors which could help in predicting those patients at risk of having a severely complicated postoperative course.

According to the decision curve analysis our model may be of use in selecting those elderly patients at the lowest risk of severe complications for whom cholecystectomy should be performed.

We found that ASA 4 patients with elevated bilirubin levels and in need of choledocholithotomy had the highest risk of developing a Clavien-Dindo  $> 2$  complication. The risk of a Clavien-Dindo  $> 2$  complication was nearly 80% for this subgroup of patients.

This may indicate the need of considering alternative non-operative approaches for this subgroup of patients, preferring endoscopic/percutaneous options.

Our paper appears to be the first in the literature to document a statistically significant correlation between the use of choledocholithotomy and complications. [33,34] This may be due to the fact that our analysis focused on a very select population of patients with  $> 80$  years of age. This finding may suggest considering a surgical-endoscopic 'rendez-vous' procedure as an alternative to choledocholithotomy [35]. However, additional studies on this approach on the oldest-old populations are warranted to confirm this hypothesis.

The limitations of this study are linked to its retrospective nature whose outcomes may be confounded by selection bias. As such, the cohort may include the fittest patients, for whom a definitive treatment like cholecystectomy may not represent a major risk. In addition, we could not provide data on frailty which may be another factor to consider when dealing with the oldest-old patients. This might have helped in creating an even more accurate model in predicting patients at risk for severe postoperative complications following cholecystectomy for gallstone disease. Finally, since the study is based on a surgical database, we could not consider those patients treated only with percutaneous/endoscopic procedures which might be considered a treatment option for a subpopulation of octogenarians.

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## CONCLUSION

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ASA 4 patients with higher levels of bilirubin at admission who may need a choledocholithotomy are at the highest risk of a severely complicated postoperative course. These factors should be included in the decision-making process in defining the ideal elderly patients to be submitted to cholecystectomy for cholelithiasis in either an emergency or elective setting.

## ARTICLE HIGHLIGHTS

### **Research background**

Incidence of gallstones in those aged  $\geq 80$  years is as high as 38%-53%. This population is at higher risk of complication following cholecystectomy with postoperative morbidity rates up to over 50%.

### **Research motivation**

The decision-making process for selecting patients undergoing surgery is challenging. A model which can identify the patients at the highest risk would be helpful for selecting the ideal candidate for cholecystectomy in a population aged  $\geq 80$  years.

### **Research objectives**

The purpose of this study is to assess the perioperative risk of the octogenarian patients treated with cholecystectomy and to create a model that could help surgeons in the decision-making process leading to surgery in this population.

### **Research methods**

An institutional review board-approved database was exploited to analyze all patients aged  $\geq 80$  years who had cholecystectomy between 2010 and 2019. Logistic regression analysis was performed to identify the perioperative variables associated with postoperative complications. Then a model was created and tested to predict severe postoperative morbidity.

### **Research results**

Clavien-Dindo complications rate  $> 2$  was 9.7%. A model including American Society of Anesthesi-

ologists (ASA) scale 4 patients, performing a choledocholithotomy and bilirubin levels were associated with Clavien-Dindo > 2 complications ( $P < 0.001$ ). The decision curve analysis showed that the proposed model had a higher net benefit than the treating all/none options between threshold probabilities of 11% and 32% of developing a severe complication.

### Research conclusions

Patients with ASA 4, higher level of bilirubin and need of choledocholithotomy are at the highest risk of a severely complicated postoperative course.

### Research perspectives

Future analyses confirming these results should focus on alternative endoscopic or percutaneous treatments that may be more suitable treatments for this subgroup of octogenarian.

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## ACKNOWLEDGEMENTS

Thanks to Dr. Angelo Paolo Ciarrocchi for revising the language editing.

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## FOOTNOTES

**Author contributions:** All authors contributed to the study conception and design; Material preparation, data collection and analysis were performed by D'Acapito F, Solaini L, Di Pietrantonio D, Tauceri F, Mirarchi MT, Antelmi E, Flamini F, Amato A, Framarini M and Ercolani G; The first draft of the manuscript was written by D'Acapito F, Solaini L and Ercolani G; All authors commented on previous versions of the manuscript, read and approved the final manuscript; and D'Acapito F and Solaini L contributed equally to this paper.

**Institutional review board statement:** The study was reviewed and approved by the Ethics Committee of ROMAGNA CEROM (10/04/2019) (Approval No. 3238/2019 I.5/263).

**Conflict-of-interest statement:** The authors have no conflicts of interest to declare.

**Data sharing statement:** The datasets generated during and/or analyzed during the current study are not publicly available due privacy policies but are available from the corresponding author on reasonable request.

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**S-Editor:** Ma YJ

**L-Editor:** A

**P-Editor:** Yuan YY

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