BMC Surgery

RESEARCH

Open Access

Optimal timing for cholecystectomy: unveiling insights from a decade-long study on acute cholecystitis and symptomatic cholecystolithiasis

Azhy Muhammed Dewana[1*], Amanj Jalal Namq[1], Baderkhan Saeed Ahmed[1] and Ahmed Abdulkadir Baban[1]

Abstract

Background Acute calculus cholecystitis affects 10 to 20% of untreated individuals. Thus, the surgical community has argued for decades over whether an earlier or later cholecystectomy is better for this condition.

Objectives To compare surgical results, morbidity, and mortality and determine the best timing for surgical intervention among patients with gallstones.

Patients and methods This prospective cohort study was conducted in Erbil Teaching Hospital, Erbil, Iraq, from January 2013 to December 2023 on 767 patients with acute cholecystitis or symptomatic cholecystolithiasis. Patients underwent various types of cholecystectomy (early, intermediate, late, and elective) based on when surgery was conducted after the onset of symptoms. Then, medical treatments were advised, and they were followed up for six weeks. Finally, patients' physical health, postoperative infection severity and complications were assessed, despite reporting patients' age, gender, operation type, chances of conversions, durations of procedure, and hospital stay.

Results Most patients were females (72.1%), experienced laparoscopic technique (98.44%), and had ASA II ($n=548$, 71.44%). The mean age of patients was 48.40 ± 67.14 years, the mean operation time was 50 ± 30.89 min, and the mean hospitalization time before and after operation was 1.0 ± 0.47 and 2.75 ± 1.63 days, respectively. Most patients from the intermediate group ($n=83$) opted for a postponed strategy. Chronic inflammation (grade 0 infection severity) was highest in most patients of the delayed (67.2%) and intermediate groups (53.01%). Most patients had no complications (score 0), and the least had severe complications.

Conclusion Delayed surgical intervention was harmless and may even be superior to immediate treatment for acute cholecystitis. The morbidity and mortality hazard remains high even in the most severe cases, especially for individuals who received early and intermediate therapy.

Keywords Gallstones, Acute cholecystitis, Cholecystolithiasis, Laparoscopic cholecystectomy

Introduction

Gallstone disease is more common in women than men. Gallstones affect 10–15% of adults in developed countries. Acute calculus cholecystitis (ACC), the most severe form of gallstone disease, can develop in 20% of symptomatic individuals, and it affects 10–20% of untreated individuals [1]. The risk for gallstone-related morbidities

*Correspondence:
Azhy Muhammed Dewana
azhy.rwandizy@hmu.edu.krd
[1] Department of Surgery, College of Medicine, Hawler Medical University, Erbil, Iraq

© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

was 14%, 19%, and 29% at six weeks, 12 weeks, and 1.0 years, respectively, for patients who had ACC but did not undergo surgery. Repeated symptom sufferers are more likely to develop biliary colic (70%), biliary tract blockage (24%), or pancreatitis (6%) [2].

The optimal time for ACC surgery has long been a contentious topic of discussion. Few studies have compared the effectiveness of surgical and non-invasive treatments, especially for individuals with high surgical risks. Therapeutic options, the type of surgical procedure, the categorization and strategic planning of a more significant surgical risk population, and other aspects have been the subject of debate, as have the necessity and technique for diagnosing the existence of probable coexisting biliary duct stones during ACC [3, 4].

It is difficult to distinguish between supposed gall bladder inflammation and other ACC symptoms. The ACC scoring system has yet to be authorized, and it is challenging to decide due to the wide range of therapy options available for a given grade on cholecystitis severity. To investigate these claims and provide guidelines for the diagnosis and therapy of ACC, the World Society of Emergency Surgery (WSES) convened a consensus conference (CC) [5].

The surgical community has argued for decades over whether an earlier or later cholecystectomy (CCY) is better for this condition. During the first stages of biliary colic, Graham et al. were the first to call for immediate surgical intervention [6]. Their death rate in 1938 was 3.59%, compared to 10% in areas with a delayed strategy. According to a Cochrane meta-analysis, early laparoscopic cholecystectomy (ELC) appears harmless and might reduce the entire stay in the hospital [7]. Another meta-analysis found no distinction between ELC and conventional therapy regarding mortality, bile duct damage, bile leaks, or conversions [8]. They concluded that ELC is preferable to delay laparoscopic cholecystectomy (DLC) [9], as it is effective and safe [10] and might be better [11].

We argue the results of the previous studies to avoid patients with severe cholecystitis, which may not be generalizable to real-world clinical circumstances since our clinical experience differs from theirs. All last clinical work has been done in a controlled laboratory [12]. Thus, we combined the findings of histopathological analysis, the STROBE recommendations, and the Clavien-Dindo morbidity scores in most of our CCY patients [13, 14] to compare surgical results, morbidity, and mortality and determine the best timing for surgical intervention.

Patients and methods

Study design and setting

This prospective cohort study was conducted in Erbil Teaching Hospital, Erbil, Iraq, from January 2013 to December 2023 on 767 patients who had ACC or symptomatic cholecystolithiasis and underwent various types of CCY based on the onset of appearing symptoms (Fig. 1).

Inclusion criteria

Patients aged 18–80 years old suffered from ACC or symptomatic cholecystolithiasis.

Exclusion criteria

Patients with previous abdominal surgery were excluded to minimize potential confounding factors. Prior surgical interventions can lead to adhesions, anatomical distortions, and altered physiological responses, which may significantly affect the study outcomes. Also, patients with uncontrolled coagulopathy were excluded due to safety concerns and potential impact on study parameters. Coagulopathy increases the risk of bleeding complications and may necessitate additional interventions that could influence the primary outcomes.

Study protocol

The patient's age and gender were reported, and a diagnosis of AC was made (clinical, laboratory, and imaging findings) using the Tokyo Guidelines (TG18) diagnostic criteria [15]. Still, when a definite diagnosis could not be made, the patient was reassessed every 6—12 h. Ultrasonography (US) was used for initial diagnosis to identify

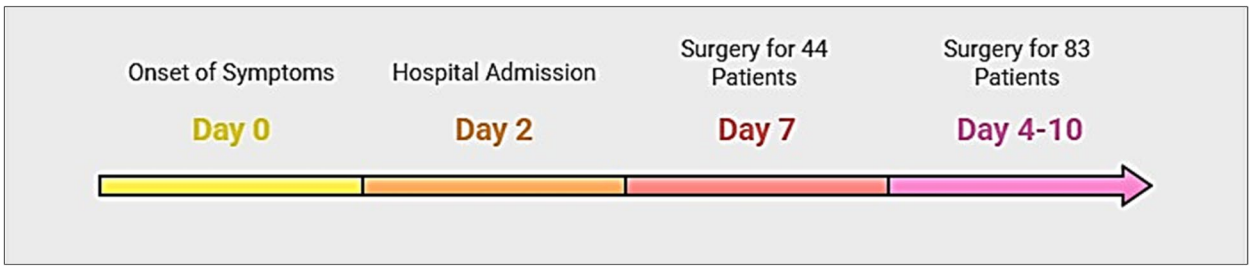

Fig. 1 Patients journey from symptoms to surgery

gallbladder wall thickening, pericholecystic fluid, and the presence of gallstones. In cases where US findings were inconclusive, additional imaging such as Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) was used to support the diagnosis. For reassessment of patients, repeat imaging was performed when clinically indicated, such as in cases of worsening symptoms or suspicion of complications (e.g., gallbladder perforation and abscess formation).

The diagnostic criteria depend on the appearance of ≥ 3 of the following indications by the patient: discomfort in the right hypochondrium, an optimistic Murphy's sign, a high white blood cell count (WBC; $> 11 \times 10^9$ cells/L), and a high temperature. The classification of early, intermediate, delayed, and elective CCY was based on a combination of institutional protocols and existing literature. Consequently, the patients were divided into four groups based on when surgery was conducted after the onset of symptoms. Surgical intervention within the first 72 h was considered an early CCY group, and within 4–10 days of symptom onset was considered intermediate CCY. Surgery that was postponed until the symptomless period (6–12 weeks following the beginning of symptoms) was considered delayed CCY. However, patients with colicky pain and not found to have AC (symptomatic cholecystolithiasis) were considered as elective CCY group. These classifications were used to assess the impact of surgical timing on patient outcomes, and the specific timeframes followed our institution's guidelines for the management of AC.

Surgical operation

Under general anaesthesia, four ports laparoscopic approach through 10 mm ports via umbilical and epigastric incision and two 5 mm ports through hemi-abdomen were made. After 12 mmHg pneumo-peritoneum by CO_2, the gall bladder was retracted, and the Calot's triangle was skeletonized. Then, titanium clips were used to clip the cystic artery and duct. After complete dissection of the gall bladder from its bed, it was placed in a retrieval pouch and retrieved via the epigastric incision under direct vision. Minor bleeding was cauterized and drained left sub-hepatically when needed. Finally, medical treatments were applied, and patients were followed up for six weeks. Moreover, patients' physical health was classified according to the American Society of Anaesthesiologists (ASA) risk score, and patients were scored according to the severity of the systemic illness. ASA I refers to persons in good health; ASA II describes those with moderate systemic disease; ASA III describes those with severe systemic sickness; and ASA IV describes those with fatal systemic illness. Furthermore, the onset of symptoms, laparoscopy procedures, chances of conversions, durations of procedures, hospital stay before and after CCY, fatalities, and comorbidities were taken into consideration. Additionally, the diagnostic histopathology grades were classified as 0 (chronic inflammation), 1 (acute inflammatory erosive disorder), 2 (abscess, empyema, ulcer-phlegmonous alterations, and necrosis), 3 (covered perforation from acute inflammation, with or without peritonitis).

The Clavien–Dindo complication score (0–5) [16] was utilized to categorize the complications observed among groups, such as wound infections, bile leaks, and intra-abdominal abscesses. A grade zero indicates the absence of complications. In contrast, grade 1 indicates any change from the expected postoperative course that does not necessitate further medical treatments, such as medication, surgery, endoscopy, or imaging. Grade 2 complications allowed for therapeutic regimes, such as antiemetics, antipyretics, analgesics, and physiotherapy, but not pharmacological treatment with medications or blood transfusions. Grade 3 complications necessitate procedures, such as surgery, endoscopy, or radiology, while grade 4 is life-threatening and requires intermediate or intensive care. Finally, grade 5 complications result in the patient's death. Mild complications are classified as Clavien-Dindo, grades 1 and 2, whereas severe complications are classified as grades 3–5.

Patients' outcome

Primary outcome

The primary outcome measure was to evaluate and compare postoperative complications based on the Clavien-Dindo classification and the timing of the CCY (early, intermediate, delayed, or elective).

Secondary outcomes

They include mortality within six weeks after surgery, laparoscopic-to-open conversion rate, hospital stay time immediately before and also after surgery, duration of surgery and any operative complications, readmission rates and need for re-intervention, correlation between histopathological findings and clinical severity after surgery, and lastly comparison of results according to the ASA classification and histopathological grades.

Follow-up protocol

-Initial follow-up within 6 weeks post-operation

Using the Clavien-Dindo scale, the patients were regularly monitored for postoperative complications. If a patient's symptomatology has worsened, he/she can be monitored more frequently with clinical evaluations and advanced imaging techniques. Generally, a patient demonstrably doing well would not be subjected to any further testing.

-Scheduled reassessments

Patients who exhibit chronic or deteriorating complaints would have additional imaging examinations (US, CT, or MRI). For the latter group, which has yet to arrive at a clear diagnosis, further evaluations must be instituted every 6–12 h.

-Histopathology and clinical evaluations

Histopathology grades were used to evaluate the severity of inflammation and the development of complications. The ASA classification was chosen to segregate the patient's health state, reflecting their general physical health status.

-Hospital readmissions and long-term monitoring

Patients were discharged after conservative treatment and monitored for potential readmissions. Readmission was considered for patients showing untreated clinical indicators.

Statistical analysis

Two R software platforms, R1.1–2 and R3.3.2, were used to analyze the data. A Kruskal–Walli's test was used to compare the non-parametric data (histology, the level of histologic changes, and the ASA risk category) among groups. Dunn's test with Bonferroni correction for multiple comparisons was also applied for post hoc pairwise comparisons. Two-tailed tests yielded significant results at the $p \leq 0.05$.

Results

Based on the onset of appearing symptoms, most patients underwent elective CCY ($n=488$, 63.6%), followed by delayed CCY ($n=134$, 17.5%), then intermediate CCY ($n=83$, 10.8%), and early CCY ($n=62$, 8.1%). Regarding the gender distribution among patients, most of them were females ($n=553$, 72.1%), and the least were males ($n=214$, 27.9%), with significant differences between them ($p \leq 0.05$). The mean age of the patients was 48.40 ± 17.14 years, with the delayed CCY group having the oldest population (54.61 ± 21.8 years) and the intermediate CCY group having the youngest population (42 ± 17.9 years). Thus, a significant difference was seen between patients' age in different groups ($p=0.002$). Regarding the patient's physical health, most of them were classified as ASA II ($n=548$, 71.44%), followed by ASA I ($n=138$, 17.99%), then ASA III ($n=63$, 8.21%), and most minors as ASA IV ($n=18$, 2.34%). Significant differences existed between the study groups for the ASA classification ($p=0.0002$). The mean operation time was 50 ± 30.89 min, in which the elective CCY group reported the shortest time (40 ± 23.07 min). In contrast, the delayed CCY group reported the most extended duration (56 ± 29.49 min), with a significant difference among groups ($p=0.003$). Among patients, only 12 required open surgery (1.56%), while the rest underwent laparoscopic technique ($n=755$, 98.44%) ($p \leq 0.05$). The need for hospitalization before CCY was 1.0 ± 0.47 days, of which the intermediate CCY group had the longest (3.0 ± 0.97 days), followed by the early CCY group (1.0 ± 0.94 days). At the same time, neither delayed nor elective CCY groups stayed before the operation ($p \leq 0.005$). Whereas the mean hospitalization among groups after the CCY was 2.75 ± 1.63 days, with the highest duration in the early CCY group (4.0 ± 3.16 days), followed by the delay CCY group (3.0 ± 1.0 days) ($p=0.002$) (Table 1 and Fig. 2).

Regarding the intermediate group, 19 patients (22.89%) opted for a postponed strategy; they left the hospital six days after admission but underwent surgery due to not improving their clinical indicators. The average time between the beginning of symptoms and admission to the hospital for these patients was two days. Simultaneously, 20 patients (24.09%) were readmitted despite being able to be discharged following successful conservative treatment. Moreover, in the same group, as a result of the need for diagnostic procedures (endoscopic retrograde cholangiopancreatography, gastroscopy, and cardiology procedures), as well as the presence of comorbidities (acute pancreatitis and coagulopathy), 44 patients (53.01%) ultimately underwent surgery following seven days of hospitalization (onset of symptoms after 48 h). Hospitalization occurs on average two days following the beginning of symptoms; therefore, this is the standard time frame between the two scenarios. Following a re-evaluation in the operating room, surgery was performed on 83 patients, with a median time from symptom start to surgery of 4–10 days.

Regarding the histopathological grading for infection severity of the operation sites after CCY, acute/chronic inflammations, erosive disorder, ulceration, abscess, empyema, necrosis, and covered perforation with/without peritonitis were observed as complications of severe cholecystitis among patients. Of which, chronic inflammation (grade 0 infection severity) was highest in most patients of the delayed ($n=90$, 67.2%) and intermediate CCY groups ($n=44$, 53.01%). However, covered perforation from acute inflammation, with/without peritonitis (grade 3 infection severity), reported the lowest among all CCY groups. Thus, significant differences were observed between all grades regarding infection severity and CCY types ($p=0.012$) (Table 2).

Concerning postoperative complications among groups using Clavien–Dindo complication scores, most patients in all groups had no complications (score 0), and the minor patients had grade 5 complications that resulted in

Table 1 Patients' social and clinical characteristics

Variable	Patients Group underwent Cholecystectomy				Total ($n=767$)	*p*-value
	Early ($n=62$)	Intermediate ($n=83$)	Delayed ($n=134$)	Elective ($n=488$)		
Frequency (%)						
Gender						
Female	33 (53.3)	49 (59)	92 (68.8)	379 (77.66)	553 (72.1)	≤ 0.05*
Male	29 (46.7)	34 (41)	42 (31.2)	109 (22.34)	214 (27.9)	
ASA risk score						
I	14 (22.6)	19 (22.9)	28 (20.9)	77 (15.77)	138 (17.99)	0.0002*
II	30 (48.4)	49 (59.03)	87 (64.9)	382 (78.3)	548 (71.44)	
III	11(17.74)	6.0 (7.22)	18 (13.43)	28 (5.73)	63 (8.21)	
IV	7.0 (11.3)	9.0 (10.84)	1.0 (0.74)	1.0 (0.2)	18 (2.34)	
Operation type						
Laparoscopic technique	59(95.16)	80 (96.38)	132 (98.50)	484 (99.18)	755 (98.44)	≤ 0.05*
Conversion to open	3.0 (4.83)	3.0 (3.61)	2.0 (1.5)	4.0 (0.82)	12 (1.56)	
Mean ± SD						
Age (Years)	48 ± 22.04	42 ± 17.9	54.61 ± 21.8	49 ± 21.63	48.40 ± 67.14	0.002*
Operation time (Minute)	54 ± 38.28	50 ± 32.73	56 ± 29.49	40 ± 23.07	50 ± 30.89	0.003*
Hospital stay (Days)						
Before surgery	1.0 ± 0.94	3.0 ± 0.97	0.0 ± 0.0	0.0 ± 0.0	1.0 ± 0.47	≤ 0.05*
After surgery	4.0 ± 3.16	2.0 ± 1.37	3.0 ± 1.0	2.0 ± 1.0	2.75 ± 1.63	0.002*

ASA American Society of Anaesthesiologists

*: Significant difference

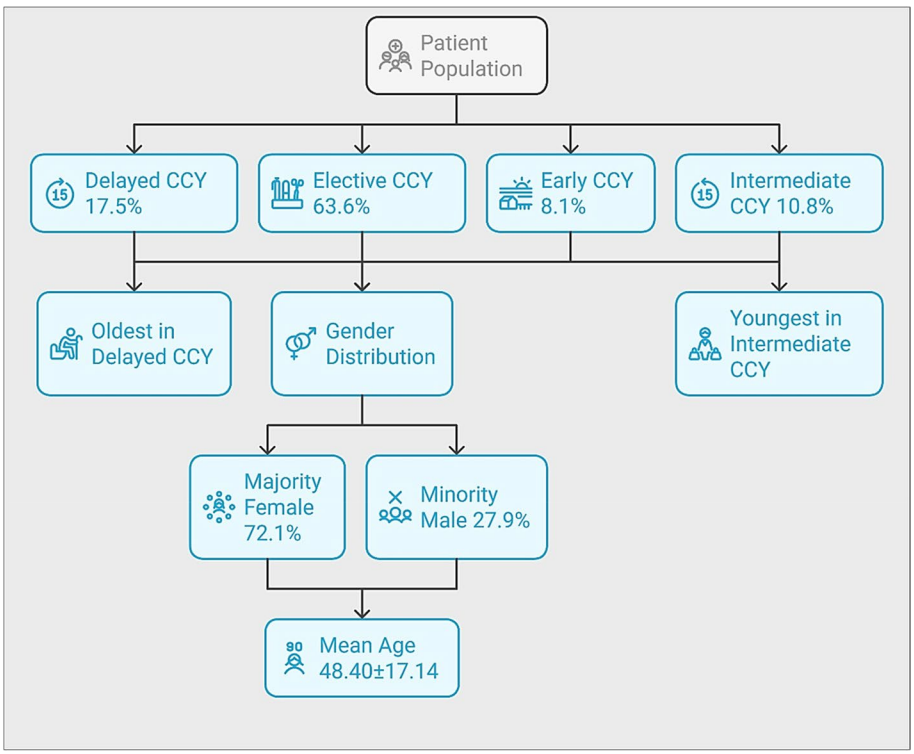

Fig. 2 Patients distribution and sociodemographic. CCY: Cholecystectomy

Table 2 Postoperative infection severity grade according to the histopathological change

Infection severity grade	Patients Group underwent Cholecystectomy			*p*-value
	Early ($n=62$)	Intermediate ($n=83$)	Delayed ($n=134$)	
Frequency (%)				
0	14 (22.6)	44 (53.01)	90 (67.2)	0.012*
1	20 (32.3)	21 (25.3)	28 (20.9)	
2	21 (33.9)	12 (14.5)	8.0 (5.97)	
3	7.0 (11.3)	6.0 (7.2)	8.0 (5.97)	

Grade 0: Chronic inflammation, 1: Acute cholecystitis, 2: Acute cholecystitis with abscess formation and sores, 3: Acute inflammatory rupture with or without perforation

*: Significant difference

the patient's death ($n=3$, two patients in early and 1 in intermediate CCY group) (Table 3). The causes of death were severe sepsis, multi-organ failure, and cardiovascular complications following extensive gallbladder infection and peritonitis. Additionally, there was a 3.2% drop in the complication score in the early CCY group, 1.2% in the intermediate CCY group, and no change in the delayed and elective CCY groups, according to the modified linear rank statistics.

Discussion

Clinical experience suggests that early surgery for ACC carries the most risk, and this prospective study confirmed that, contradicting previously reported results. These findings may differ from those of other studies since only mild instances of cholecystitis were included in other investigations [11]. In contrast to earlier research, this study's early CCY group included a sizeable number of severe cases, as validated by pathology reports [17].

There is ongoing discussion over how best to categorize the severity of ACC. Based on the grading scores and associated therapy suggested by the latest Tokyo Guidelines (TG18), ELC is the treatment for ACC of grade I (low severity). At the same time, prompt CCY is advised for ACC of grade II (moderate severity) in specialized facilities. However, percutaneous or surgical gallbladder drainage should be performed immediately in cases of ACC of grade III to address organ failure and severe local inflammation. Due to the challenges associated with performing an early CCY, medical management and postponement of the procedure are often needed. When CCY is warranted, delayed/elective CCY should be carried out [18].

The TG18 categorization was called into doubt by the World Society of Emergency Surgery- 2022 Guidelines because of a lack of clinical validation. To date, no randomized controlled trial has evaluated the effectiveness of varying the extent of surgical intervention for patients with ACC, as it's impossible to randomly assign people who need immediate care. In the current study, patients in the early CCY group that required immediate treatment would not have been arbitrarily divided into early or late arrivals [19]. In contrast to previously reported studies, we did not find increased mortality (2.9%) among treated patients in this group, which is similar to that of the German death rate (2.8%) for emphysematous cholecystitis [20]. Another healthcare institution discovered the same rate of death (3.0%) in the highest category [19]. The biggest flaw of this study is its prospective nature; thus, senior surgeons' subjective decisions on

Table 3 Clavien–Dindo complication score

Score	Patients Group underwent Cholecystectomy			
	Early ($n=62$)	Intermediate ($n=83$)	Delayed ($n=134$)	Elective ($n=488$)
Frequency (%)				
0	44 (70.96)	54 (65.1)	104 (77.6)	421 (86.3)
1	4.0 (6.5)	13 (15.7)	19 (14.17)	26 (5.3)
2	9.0 (14.5)	9.0 (10.84)	7.0 (5.22)	23 (4.7)
3	2.0 (3.2)	4.0 (4.8)	2.0 (1.5)	17 (3.5)
4	1.0 (1.6)	2.0 (2.4)	2.0 (1.5)	1.0 (0.2)
5	2.0 (3.2)	1.0 (1.2)	0.0 (0.0)	0.0 (0.0)

0: No complication, 1: Complications necessitate the use of further medical treatments, 2: Complications allowed therapeutic regimes, 3: Complications necessitate procedures, 4: Life-threatening complications and require the intermediate or intensive cares, 5: Complication results in patients' death

patient grouping and treatment strategy introduced bias [21]. As previously stated, a trial comparing an early vs. delayed approach is not possible in cases of severe ACC (emphysematous, perforated, abscessed, gangrenous, or necrotizing). Treatment bias cannot be addressed without validating the distinction between mild, moderate, and severe cases. An ACC diagnosis by a senior surgeon is more reliable than one based solely on patient history, physical findings, or laboratory results [22, 23]. This research's histologic findings in the CCY tissues corroborate the clinical intuition underlying the emergency strategy. The early approach, in other words, is an urgent matter. Another possible issue in this study is that we had little say in the kind and validity of the initial measures used. The already available data can be lacking critical information, incorrect, or measured in a way that is not optimal for providing an answer to the study question [24]. Otherwise, assessments of our record-keeping show physicians' high degree of conformity to predetermined norms. We are confident in these findings and the reliability of the standard metrics included in this analysis (such as operative technique, histopathology, rate of conversion, operative time, and length of stay in the hospital).

Regarding the correlation of histopathological outcomes with surgical timing and outcomes, in elective and delayed CCY groups; a predominant proportion exhibited chronic inflammation (grade 0) implies that these groups did surgery at a stage where the inflammatory process must have stabilized, which emanated in fewer intraoperative complications and a better postoperative period of recovery. Regarding the early and intermediate CCY groups; the latter group had more acute inflammatory changes, empyema, and necrosis, especially in cases where surgery was performed between 24—48 h post-symptom onset that correlated with longer operative times, longer postoperative hospital stays, and a greater incidence of Clavien-Dindo complications including the three deaths that were observed owing to extremely severe infection and poor multiple organ failures. Whereas in the intermediate CCY group, patients were found to have a mixed bag of histopathological findings, for some had to delay the surgery owing to the failure of conservative management or comorbidities. The higher proportion of those with infection-related complications in the group necessitated a more prolonged period of hospitalization. Taken together, these findings indicate that surgical timing effectively influenced the severity of histopathological changes, consequent management difficulties, and the recovery period of the patients.

Clinical decision-making was not standardized in this study but instead left to the discretion of each participant and the potentially biased view of each attending surgeon. This leaves our research vulnerable to the biases of particular surgeons. Hence, this study demonstrates that early CCY is associated with a lower complication rate and improved outcomes than delayed or elective procedures. These findings support the growing body of evidence advocating for early surgical intervention in AC, aligning with TG18 and American College of Surgeons guidelines, which recommend ELC in suitable patients to reduce morbidity and hospital stay. Thus, from a clinical decision-making perspective, patients with stable vital signs and no severe comorbidities should undergo early surgery to minimize complications and expedite recovery.

In contrast, intermediate and delayed surgeries should be considered cautiously, primarily for patients requiring initial stabilization or when early surgery is not feasible. Finally, elective CCY should be limited to cases where inflammation has subsided, and surgery can be planned safely. By integrating these findings into surgical decision-making, healthcare providers can optimize patient outcomes and resource utilization. We have strengthened the discussion section to reflect these points, emphasizing the alignment with international guidelines and the importance of early surgical intervention whenever feasible.

Since this study was conducted at a single location (Erbil City), it is paramount. When contrasting the death rates of the early and delayed CCY groups, however, we find that the GRADE approach can be helpful when dealing with situations that have a significant impact, as it enables better decision-making—observational research findings are to be treated as rigorously as those from randomized controlled trials [25]. Overall, we believe this study reflects an actual medical practice situation despite the study's limitations.

While we attempted to minimize bias through careful patient selection and standardized management protocols, formal statistical adjustments for these potential confounders were not performed. However, we ensured consistency using objective diagnostic criteria and uniform treatment approaches. Additionally, subgroup analyses based on clinical severity (e.g., mild vs. severe cases) were considered to provide further insight.

This study has several limitations. While efforts were made to minimize confounding, factors such as comorbidities and disease severity may have influenced outcomes and were not fully adjusted. Additionally, the exclusion of patients with previous abdominal surgery and uncontrolled coagulopathy, though justified for surgical safety, may have impacted generalizability. Imaging was not explicitly included in the reassessment criteria, which could have influenced diagnostic consistency. Lastly, while the Clavien-Dindo classification

was used for complication analysis, future studies with a larger dataset could provide a more detailed exploration of specific complications and their impact on surgical outcomes.

Conclusions

Delayed surgical intervention was harmless and may even be superior to immediate treatment for AC. Delayed CCY is likely not associated with increased morbidity, and therefore, selected patients with AC may safely undergo it as an alternative to early or intermediate surgery. The group that had delayed surgery had a higher proportion of chronic inflammations and lower complication rates than the early and intermediate CCY groups; hence, the surgical delay would allow for additional stabilization before surgery, meaning decreased intraoperative risk.

Acknowledgements
The authors would like to thank the surgeons at the Hawler Teaching Hospital, Erbil, Iraq, who contributed to this study and the patients and their families who generously shared their clinical information.

Clinical trial number
Not applicable.

Authors' contributions
AMD: Wrote the introduction, prepared the reference, checked data, drafted the study method, and wrote the discussion. AJN: Collected and revised statistics. BSA: Collected the data and drafted the tables. AAB: Methodology, study registration, and revised the final draft of the manuscript. All authors reviewed the manuscript.

Funding
The authors have not received any funding in any form.

Data availability
The dataset used and analyzed in this study is available with the corresponding author and can be provided upon request.

Declarations

Ethics approval and consent to participate
All procedures, including patient selection and data collection, were approved by the Ethical Committee of the College of Medicine, Hawler Medical University, Erbil, Iraq. Before any of it occurred, written informed consent was obtained from the patients for the surgery, research participation, and publication of results. The Helsinki Declaration of 1964 and its later revisions were followed throughout all study phases to ensure the highest level of ethical conduct. The hospital admission consent already included provisions for protecting patient data and authorization for the data review process.

Consent for publication
Not applicable, no personal information or images of any kind are included in the research. Requested access to the raw data used in this study will not reveal any personally identifiable information about any participant.

Competing interests
The authors declare no competing interests.

Received: 10 January 2025 Accepted: 14 March 2025
Published online: 07 May 2025

References

1. Rajah KH. Acute Cholecystitis: An Update. 2024:127–137.
2. de Mestral C, Rotstein OD, Laupacis A, Hoch JS, Zagorski B, Nathens AB. A population-based analysis of the clinical course of 10,304 patients with acute cholecystitis discharged without cholecystectomy. J Trauma Acute Care Surg. 2013;74(1):26–31.
3. Benedetto U, Singh SSA, Spadaccio C, Moon MR, Nappi F. A narrative review of the interpretation of guidelines for treating infective endocarditis. Annals Transl Med. 2020;8(23):1623.
4. Buller DM, Hennessey AM, Ristau BT. Open versus minimally invasive surgery for suspected adrenocortical carcinoma. Translational Andrology and Urology. 2021;10(5):2246.
5. Campanile FC, Catena F, Coccolini F, Lotti M, Piazzalunga D, Pisano M, Ansaloni L: New" patient-related" guidelines for treating acute cholecystitis. In., vol. 6: Springer; 2011: 1–3.
6. Blythe J, Herrmann E, Faust D, Falk S, Edwards-Lehr T, Stockhausen F, Hanisch E, Buia A. Acute cholecystitis–a cohort study in a real-world clinical setting (REWO study, NCT02796443). Pragmat Observational Res. 2018;9:69–75.
7. Özkardeş AB, Tokaç M, Dumlu EG, Bozkurt B, Çiftçi AB, Yetişir F, Kılıç M. Early versus delayed laparoscopic cholecystectomy for acute cholecystitis: a prospective, randomized study. Int Surg. 2014;99(1):56–61.
8. Cao AM, Eslick GD, Cox MR. Early cholecystectomy is superior to delayed cholecystectomy for acute cholecystitis: a meta-analysis. J Gastrointest Surg. 2015;19(5):848–57.
9. Cao AM, Eslick GD, Cox MR. Early laparoscopic cholecystectomy is superior to delayed acute cholecystitis: a meta-analysis of case–control studies. Surg Endosc. 2016;30:1172–82.
10. Wu X-D, Tian X, Liu M-M, Wu L, Zhao S, Zhao L. Meta-analysis comparing early versus delayed laparoscopic cholecystectomy for acute cholecystitis. Journal of British Surgery. 2015;102(11):1302–13.
11. de Mestral C, Rotstein OD, Laupacis A, Hoch JS, Zagorski B, Alali AS, Nathens AB. Comparative operative outcomes of early and delayed cholecystectomy for acute cholecystitis: a population-based propensity score analysis. Ann Surg. 2014;259(1):10–5.
12. Pitt HA: Patient value is superior with early surgery for acute cholecystitis. In., vol. 259: LWW; 2014: 16–17.
13. Takeda Y, Tomimaru Y, Yokota Y, Noguchi K, Noura S, Imamura H, et al. Outcomes of laparoscopic cholecystectomy for xanthogranulomatous cholecystitis. Molecular and Clinical Oncology. 2019;11(3):279–84.
14. Kuipers H, de Savornin LE, van Dooren M, Braat A, Daams F, van Dam R, et al. Extended resections for advanced gallbladder cancer: results from a nationwide cohort study. Ann Surg Oncol. 2021;28:835–43.
15. Yokoe M, Hata J, Takada T, Strasberg SM, Asbun HJ, Wakabayashi G, et al. Tokyo Guidelines 2018: diagnostic criteria and severity grading of acute cholecystitis (with videos). J Hepatobiliary Pancreat Sci. 2018;25(1):41–54.
16. Manekk RS, Gharde P, Gattani R, Lamture Y. Surgical complications and its grading: a literature review. Cureus. 2022;14(5):e24963.
17. Roulin D, Saadi A, Di Mare L, Demartines N, Halkic N. Early versus delayed cholecystectomy for acute cholecystitis: Are the 72 hours still the rule? A randomized trial Annals of Surgery. 2016;264(5):717–22.
18. Dindo D, Demartines N, Clavien P-A. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004;240(2):205–13.
19. Ansaloni L, Pisano M, Coccolini F, Peitzmann AB, Fingerhut A, Catena F, et al. 2016 WSES guidelines on acute calculous cholecystitis. World Journal of Emergency Surgery. 2016;11:1–23.
20. Ambe PC, Jansen S, Macher-Heidrich S, Zirngibl H. Surgical management of empyematous cholecystitis: a register study of over 12,000 cases from a regional quality control database in Germany. Surg Endosc. 2016;30:5319–24.
21. Fry DE, Pine M, Nedza S, Locke D, Reband A, Pine G. Hospital outcomes in inpatient laparoscopic cholecystectomy in Medicare patients. Ann Surg. 2017;265(1):178–84.
22. Lee S, Chung C-W, Ko KH, Kwon SW. Risk factors for the clinical course of cholecystitis in patients who undergo cholecystectomy. Korean Journal of Hepato-Biliary-Pancreatic Surgery. 2011;15(3):164.
23. Campanile FC, De Angelis M, Santucci E, Vecchioni I: Acute cholecystitis. In: *Emergency laparoscopic surgery in the elderly and frail patient.* edn.: Springer; 2021: 73–85.

24. Manja V, Lakshminrusimha S. Epidemiology and clinical research design, part 1: study types. NeoReviews. 2014;15(12):e558–69.
25. Faraoni D, Schaefer ST. Randomized controlled trials vs. observational studies: why not just live together? BMC Anesthesiol. 2016;16:1–4.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.