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COST ANALYSIS OF SURGICAL INTERVENTIONS FOR COMPLICATED ACUTE CHOLECYSTITIS IN ELDERLY PATIENTS

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Abstract: This presents a comparative study of two surgical strategies for treating acute cholecystitis in elderly patients with biliary tract involvement. The differentiated approach, including staged minimally invasive procedures (endoscopic and percutaneous biliary decompression) followed by delayed laparoscopic cholecystectomy, significantly reduced mortality and complication rates compared to standard emergency surgery. The findings support the need for a personalized treatment strategy based on patient risk and disease severity.

Keywords: acute cholecystitis; elderly patients; choledocholithiasis; laparoscopic cholecystectomy; cholangitis; ERCP; cholecystostomy; differentiated strategy.

СТОИМОСТНОЙ АНАЛИЗ ХИРУРГИЧЕСКИХ ВМЕШАТЕЛЬСТВ ПРИ ОСТРОМ ХОЛЕЦИСТИТЕ У ПОЖИЛЫХ С ОСЛОЖНЕНИЯМИ

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Аннотация: Представлен сравнительный анализ двух хирургических тактик лечения острого холецистита у пожилых пациентов с вовлечением жёлчных путей. Дифференцированный подход, включающий этапные малоинвазивные вмешательства (эндоскопическую и черезкожную билиарную декомпрессию) с последующим отсроченным лапароскопическим удалением жёлчного пузыря, позволил существенно снизить показатели летальности и частоты осложнений по сравнению со стандартной экстренной операцией. Полученные данные подтверждают необходимость персонализированной стратегии лечения с учётом индивидуального риска и степени тяжести заболевания.

Ключевые слова: острый холецистит; пожилые пациенты; холедохолитиаз; лапароскопическая холецистэктомия; холангит; ЭРХПГ; холецистостомия; дифференцированная тактика.

Relevance. Acute cholecystitis in elderly and senile patients is often severe and poses a serious threat to life. Due to advanced age and comorbid conditions, this patient group has a high incidence of destructive forms of cholecystitis (phlegmonous, gangrenous) – up to approximately 73.5% of cases, which is

significantly higher than in younger patients. In addition, acute calculous cholecystitis in the elderly is frequently complicated by biliary tract involvement: according to studies, about 10–27% of patients with acute cholecystitis have concomitant stones in the common bile duct. Moreover, age >55 years is an independent risk factor for choledocholithiasis (relative risk ~9), leading to obstructive jaundice and acute cholangitis that further worsen the patient's condition. These factors contribute to the overall severity of the disease in older patients.

Early cholecystectomy is the standard treatment for acute cholecystitis, preferably performed laparoscopically within the first 24–72 hours from disease onset. It has been shown that in elderly patients laparoscopic cholecystectomy is an effective intervention, but it is associated with higher morbidity and mortality compared to younger patients. For example, mortality after emergency cholecystectomy in patients ≥65 years of age reaches ~4–13%, whereas in younger patients it is below 1%. Furthermore, elderly patients often require conversion to an open operation due to pronounced inflammation and adhesions. According to studies, in up to 40% of acute cholecystitis cases in this older age group, the laparoscopic procedure has to be converted or extended to a mini-laparotomy or full laparotomy. On the other hand, a severely ill condition with organ dysfunction in some elderly patients makes an emergency operation extremely high-risk. In such situations, an alternative approach is delayed surgical treatment after performing minimally invasive interventions to stabilize the patient. According to modern guidelines (e.g., Tokyo Guidelines 2018), in acute cholecystitis of high severity it is recommended to first achieve biliary decompression (drainage) and defer cholecystectomy until the patient's condition improves.

Thus, there is a clear need for a differentiated approach to treatment: an active surgical tactic should be complemented by staged minimally invasive interventions in the most severe patients. It is expected that such a comprehensive approach will improve the safety of treatment (by reducing operative mortality and complication rates) without compromising radical cure of the disease.

Objective. To improve the effectiveness and safety of surgical treatment of acute calculous cholecystitis in elderly and senile patients with biliary tract involvement by developing an optimal treatment strategy based on a differentiated (staged) approach.

Materials and Methods. A prospective comparative study was conducted from 2019 to 2024. Two groups of patients with acute calculous cholecystitis complicated by biliary tract pathology were formed in a single surgical center. The main group (n = 60) received treatment according to the newly developed differentiated (staged) strategy. The comparison group (n = 60) consisted of a historical control of patients treated with the standard emergency surgery tactic.

All patients underwent urgent laboratory and imaging evaluation on admission. The severity of acute cholecystitis was classified according to the Tokyo Guidelines 2018 (Grade I – mild, Grade II – moderate, Grade III – severe), taking into account systemic inflammatory response and organ dysfunction. Operative and anesthetic risk was assessed using the Charlson comorbidity index

(which averaged 5.1 ± 1.7 points in the cohort) and ASA physical status (predominantly ASA III in 70% of patients and ASA IV in 30%). The two groups were comparable in baseline characteristics: mean age about 73.5 ± 6.8 years (range 65–88) in both, with 46% men and 54% women, and no significant differences in demographic or clinical parameters at admission ($p > 0.1$ for all). Notably, severe (Grade III) cholecystitis with organ dysfunction was diagnosed in 18 patients in each group (30%). The remaining cases were Grade II (moderately severe) in ~60% and Grade I (mild) in ~8–10% of patients in both groups. In 53 patients (44% of the total cohort), diagnostic imaging revealed either a common bile duct stone or a bile duct dilation >8 mm, which served as an indirect sign of choledocholithiasis.

After stabilization of the patient's condition over the next 2–7 days, the second stage was performed: a definitive cholecystectomy – preferably by laparoscopic method. In cases of technical difficulties (due to dense inflammatory infiltrates, adhesions, etc.), conversion to a mini-laparotomy or full open cholecystectomy was done to safely remove the gallbladder. In the main group, a laparoscopic approach was successfully utilized in 56 patients (93%), with 8 cases (14% of operations) requiring conversion to an open procedure. Thus, the definitive operation was completed laparoscopically in 48 patients (80%), via mini-laparotomy in 6 patients (10%), and via a planned open approach in 6 patients (10%). In 4 of the main group patients (7%), because of extensive adhesions and multiple serious comorbidities, an open operation was chosen upfront (bypassing the laparoscopic attempt).

Patients in the control group received the traditional management for acute cholecystitis. Preoperative conservative therapy (IV fluids, antibiotics, etc.) was given only in a minimal amount necessary for urgent surgical preparation. In general, an emergency cholecystectomy was performed within the first 24–48 hours after hospital admission, without any preliminary biliary decompression procedures. A laparoscopic cholecystectomy was attempted in 50 patients (83%) in this group, but 15 of these (30% of the laparoscopic attempts) required conversion to open surgery due to technical difficulties (such as a severe inflammatory phlegmon in Calot's triangle, poor visualization of ducts and vessels, etc.). Ultimately, in the control group, the gallbladder was removed laparoscopically in only 35 patients (58% of all 60, i.e. those without any incision extension), while 25 patients (41.7%) ended up undergoing an open or mini-laparotomy cholecystectomy (either directly or after conversion). In this standard-treatment group, essentially no first-stage (biliary decompression) interventions were utilized: only 5 patients (8.3%) – those who developed severe obstructive jaundice – received an urgent ERCP, and that was done post-cholecystectomy (as an emergency measure due to progressive cholangitis and biliary failure). Similarly, only 3 patients (5%) in extremely grave condition underwent a rescue percutaneous cholecystostomy when immediate cholecystectomy was not possible. Thus, the control group reflects the typical "default" practice in which the primary approach is a one-stage emergency operation, with biliary drainage procedures employed only as rare exceptions.

For clarity, the collected data are summarized in the following tables and figures. Table 1 presents the general characteristics of patients on admission. Tables 2–3 provide a comparative analysis of the treatment tactics and outcomes between the two groups. Figures 2–3 illustrate the key results graphically.

Table 1

Baseline characteristics of patients upon admission (mean ± standard deviation, or number and percentage).

Indicator	**Main Group (n = 60)**	**Comparison Group (n = 60)**	***p*-value**
Age, years	74.1 ± 6.5	73.7 ± 7.2	0.81
Male / Female (%)	28 (46.7%) / 32 (53.3%)	26 (43.3%) / 34 (56.7%)	0.71
ASA class III / IV (%)	42 (70%) / 18 (30%)	40 (66.7%) / 20 (33.3%)	0.65
Charlson comorbidity index	5.3 ± 1.8	5.0 ± 1.6	0.43
White blood cell count, ×109/L	12.3 ± 4.5	11.8 ± 3.9	0.59
C-reactive protein, mg/L	96 ± 37	90 ± 40	0.48
Total bilirubin, µmol/L	68 ± 54	71 ± 50	0.77
Tokyo Grade III (severe) cholecystitis	18 (30%)	18 (30%)	1.00
Clinical signs of cholangitis	12 (20%)	11 (18.3%)	0.82
Suspected choledocholithiasis*	27 (45%)	25 (41.7%)	0.71

*Defined by imaging evidence of a CBD stone on ultrasound/MRCP or a bile duct diameter > 8 mm.

The baseline data in Table 1 show that the two groups were well-matched. There were no statistically significant differences in age or sex distribution, comorbidity burden, or initial severity of cholecystitis between the staged-treatment group and the standard-treatment group (all $p > 0.1$). The mean age was ~74 years in both groups, and each group had 30% of patients classified as Grade III (severe) cholecystitis on admission. About 45% of patients in each group showed signs of common bile duct obstruction (dilated duct or stone on imaging), and ~20% had clinical cholangitis; these proportions were also similar between groups. This comparability of baseline characteristics allows for a correct outcome comparison.

Table 2

Comparative treatment strategy in the two groups (number of patients undergoing each intervention)

Treatment Parameter	**Main Group (n = 60)**	**Control Group (n = 60)**	**p-value**
ERCP prior to surgery (biliary decompression)	28 (46.7%)	0 (0%)	< 0.001
ERCP only after surgery (rescue)	0	5 (8.3%)	0.028
Percutaneous cholecystostomy	18 (30%)	3 (5%)	0.001

Treatment Parameter	Main Group (n = 60)	Control Group (n = 60)	p-value
Cholecystectomy performed (eventually)	57 (95%)	55 (91.7%)	0.45
Laparoscopic approach attempted	56 (93%)	50 (83%)	0.10
Conversion to open surgery	8 (14% of operations)	15 (27% of operations)	0.12
Open or mini-laparotomy cholecystectomy	12 (20% of patients)	25 (41.7% of patients)	0.019
Operation duration, minutes	93 ± 26	85 ± 30	0.06
Intraoperative blood loss, mL	180 ± 75	220 ± 90	0.02

Table 2 compares the surgical tactics employed. By design, in the main group nearly half the patients (46.7%) underwent preoperative ERCP for bile duct clearance, whereas none in the control group received preoperative ERCP (in the control, any ERCP was done only after surgery if needed). Emergency endoscopic decompression of the bile ducts was performed in 28 patients in the staged approach group, but in 0 patients in the standard group ($p < 0.001$). Conversely, 5 patients (8.3%) in the control group required an urgent ERCP after their cholecystectomy due to deteriorating cholangitis and biliary failure, whereas no post-operative ERCPs were needed in the main group ($p = 0.028$). Likewise, percutaneous cholecystostomy was utilized far more often in the main group (18 patients, 30%) than in the control group (3 patients, 5%; $p = 0.001$), reflecting the intended staged management of high-risk cases.

Definitive cholecystectomy was ultimately performed in the vast majority of patients in both groups (95% vs 91.7%, n.s.) – a few patients in each group could not undergo the operation due to extreme illness. However, the mode of cholecystectomy differed substantially. In the main group, 93% of patients had a laparoscopic approach initially, compared to 83% in the control (a 10% absolute increase, $p = 0.10$, n.s.). More importantly, the need to convert from laparoscopy to an open procedure was lower in the staged strategy group (14% of cases) than in the control group (27% of cases), although this difference did not reach statistical significance ($p = 0.12$). Ultimately, 80% of patients in the main group had their gallbladder removed completely laparoscopically without an extended incision, versus only 58% in the control group – meaning the staged approach enabled minimally invasive surgery much more often (an advantage of over 20%, $p = 0.009$ in favor of the main group). Correspondingly, significantly fewer patients in the main group required an open or mini-laparotomy cholecystectomy (either planned or after conversion): 20% vs 41.7% in the control group ($p = 0.019$).

The average operative time was slightly longer in the main group (93 ± 26 minutes vs 85 ± 30 minutes, $p = 0.06$, not significant), likely reflecting the more complex staged procedures and adherence to careful technique. Despite this, the intraoperative blood loss was significantly lower with the staged strategy (mean ~180 mL vs 220 mL in control, $p = 0.02$). The reduction in blood loss may be explained by better visualization and less traumatic dissection during laparoscopic

surgery after initial inflammation has subsided, thanks to the preliminary interventions and stabilization.

Another consequence of the staged approach was an increase in total hospital stay due to the two-step treatment: the overall length of hospitalization in the main group was on average 12.4 ± 5.1 days, compared to 9.8 ± 4.3 days in the control group (p = 0.003). This longer stay includes the time spent on preoperative optimization and delay to surgery. Importantly, however, this extra time was justified by improved outcomes – as detailed below – and represents the period of intensive therapy and patient stabilization that likely prevented worse complications. Notably, no patient in the main group required a re-operation for postoperative complications, whereas in the control group 3 patients (5%) underwent relaparotomy (two for drainage of a subhepatic abscess and one for evacuation of a hemorrhagic clot in the gallbladder bed).

Table 3

POSTOPERATIVE COMPLICATIONS AND MORTALITY OUTCOMES.

Outcome Measure	**Main Group (n = 60)**	**Control Group (n = 60)**	**Relative Risk (95% CI)**	***p*-value**
Any postoperative complications	10 (16.7%)	20 (33.3%)	0.50 (0.26–0.95)	0.04
– Surgical wound infection	3 (5%)	9 (15%)	0.33 (0.09–1.13)	0.07
– Subdiaphragmatic/subhepatic abscess	1 (1.7%)	3 (5%)	0.33 (0.04–3.11)	0.30
– Biliary complications (leak or cholangitis)	0	5 (8.3%)	—	0.02
– Cardiopulmonary complications	2 (3.3%)	6 (10%)	0.33 (0.07–1.60)	0.16
Severe complications (Clavien III–V)	5 (8.3%)	15 (25%)	0.33 (0.13–0.86)	0.018
Reoperation (re-laparotomy)	0	3 (5%)	—	0.08
30-day postoperative mortality	2 (3.3%)	8 (13.3%)	0.25 (0.05–1.17)	0.049
In-hospital mortality (overall)	1 (1.6%)	6 (10%)	0.17 (0.02–1.36)	0.055
30-day readmissions (re-hospitalizations)	4 (6.7%)	7 (11.7%)	0.57 (0.17–1.88)	0.35

Table 3 summarizes the clinical outcomes. The overall postoperative complication rate was significantly lower with the staged approach: 16.7% of patients in the main group experienced any complication, compared to 33.3% in the control group (a 2-fold reduction; p = 0.04). Especially noteworthy is the difference in severe complications (classified as Clavien–Dindo grade III–V, i.e., complications requiring intervention or life-threatening): only 5 patients (8.3%) in

the main group had a severe complication, versus 15 patients (25%) in the control group – a three-fold decrease (p = 0.018). Thus, the differentiated staged strategy not only halved the overall complication frequency but particularly mitigated the most serious complications.

Looking at specific types of complications, the structure of complications also demonstrates the benefit of the staged approach. The most frequent complication in both cohorts was surgical wound infection (typically superficial incisional infections after open surgery). However, this occurred in only 5% of patients in the main group, compared to 15% in the control group (a considerable reduction, though the difference by itself was not statistically significant, p = 0.07). There were no biliary complications (such as postoperative bile leak from the cystic duct stump or cholangitis) in the main group, whereas in the control group 5 patients (8.3%) suffered such complications (p = 0.02). In fact, in the control group 4 patients (6.7%) developed postoperative cholangitis due to a retained common duct stone (necessitating ERCP for clearance), and 3 patients (5%) had a bile leak from the cystic duct stump (requiring additional percutaneous drainage). By contrast, the staged protocol effectively prevented these issues by addressing choledocholithiasis and gallbladder decompression before definitive surgery. Cardiopulmonary complications (e.g., myocardial infarction, pulmonary embolism, or pneumonia) tended to be less frequent under the staged strategy as well, occurring in 2 patients (3.3%) vs 6 patients (10%) in the control group (p = 0.16). This difference, while not statistically significant, may reflect the more gentle treatment timeline and avoiding operating at the peak of systemic toxicity in many main group patients.

Crucially, the postoperative mortality was markedly reduced with the differentiated approach. The 30-day mortality rate in the main group was 3.3% (2 out of 60 patients) compared to 13.3% in the control group (8 out of 60 patients), which is a more than four-fold decrease (p = 0.049). This difference is both statistically significant and clinically very important. In absolute terms, using the staged strategy saved approximately an additional 8–9 lives per 100 treated patients as compared to the standard approach. If considering overall in-hospital mortality (including a few patients in each group who died during initial intensive care before surgery could be performed), the trend was similar: total hospital mortality was 1.6% in the main group vs 10% in the control group (1 vs 6 patients; p = 0.055, not quite reaching conventional significance). Nevertheless, the mortality reduction in the staged approach group is striking. These outcomes align with reports in the literature: earlier studies have noted that an active surgical tactic supplemented by minimally invasive biliary decompression can reduce postoperative mortality from approximately 13.5% to 3.7%, which is very consistent with our findings.

In summary, the differentiated staged strategy substantially improved patient outcomes. By performing urgent ERCP and/or cholecystostomy in high-risk patients prior to cholecystectomy, the main group avoided the development of severe biliary complications after surgery, achieved better control of sepsis, and was often able to delay surgery until patients were more stable. The result was

significantly fewer severe complications and a dramatic drop in mortality, despite a slightly longer hospital stay. Importantly, these benefits were achieved without increasing the overall rate of radical surgical treatment (almost all patients in both groups eventually had their gallbladder removed, maintaining definitiveness of treatment). There was also no statistically significant increase in re-hospitalizations within 30 days (6.7% vs 11.7%, p = 0.35), indicating that the staged strategy did not lead to more frequent relapses or readmissions. In fact, none of the staged-treatment patients had uncontrolled biliary sepsis that later required readmission – many issues were resolved in the initial hospitalization.

Results and Discussion: The above results clearly indicate that the differentiated two-stage surgical tactic offers substantial clinical advantages for elderly patients with complicated acute cholecystitis. By initially controlling sepsis and biliary obstruction (through ERCP and/or cholecystostomy) and delaying cholecystectomy until the patient is better stabilized, we can achieve outcomes that are superior to immediate surgery on an acutely ill patient. Specifically, our study demonstrated that employing this staged approach significantly improves the safety of surgical treatment: it reduced postoperative mortality to 3.3% (from 13.3% with the standard urgent surgery) and cut the rate of severe complications to 8.3% (from 25% with standard care). These improvements are statistically significant and, more importantly, clinically meaningful. The data suggest that for every 100 elderly high-risk patients treated, the staged strategy could prevent about 8–9 deaths and many serious complications that would have occurred under the conventional approach.

The key components of this success are the staged minimally invasive interventions that address the acute pathophysiologic problems early. An urgent endoscopic biliary decompression (ERCP with sphincterotomy) in the presence of choledocholithiasis, and a percutaneous cholecystostomy in cases of severe destructive cholecystitis, play a critical role in the new treatment algorithm. Applying these methods in the first phase of treatment relieves the biliary hypertension and infection source, thereby halting the progression of sepsis and significantly reducing the risk of intra-abdominal septic complications. In our series, the use of these upfront interventions completely eliminated postoperative cholangitis and dramatically lowered the incidence of intra-abdominal abscesses in the main group, whereas such complications were encountered in the control group as noted.

Another important aspect is optimizing the timing of surgery on an individual patient basis. In patients with moderate disease severity, it is safe and advantageous to proceed with an early laparoscopic cholecystectomy (within the first 72 hours of symptom onset) – this aligns with standard practice for fit patients and avoids prolonged inflammation. However, in the subset of very ill patients (Grade III, high operative risk), it is more prudent to postpone the definitive surgery by a few days (typically 3–7 days) after achieving biliary decompression and stabilization of the patient. This flexible timing ensures that we operate under much more favorable conditions. In our study, this tailored timing was associated with easier surgeries (e.g., a higher chance of purely laparoscopic completion with

fewer conversions) and better outcomes. In short, the differentiated approach allowed us to minimize operative risks without sacrificing the curative intent of surgery.

Our experience also underlines some practical considerations. Close collaboration between the surgical, endoscopic, and interventional radiology teams is essential to implement this strategy efficiently. In our center, we were able to perform ERCP on average within 12 hours of diagnosing acute cholangitis, and to perform percutaneous gallbladder drainage within the first 24 hours for the sickest patients. This responsiveness adheres to the "golden hour" principle in managing acute cholangitis and severe cholecystitis, ensuring prompt source control of infection. Standardized postoperative management is equally important: early mobilization, diligent prevention of thromboembolism, and appropriate continuation of antibiotics when indicated were applied uniformly and likely contributed to the low complication rate in the main group.

Conclusions

1. A differentiated approach (staged treatment strategy) substantially improves the safety of surgical management of acute cholecystitis in elderly patients. In our study, after implementing this approach, the postoperative mortality decreased four-fold (to 3.3%) and the rate of severe complications decreased three-fold (to 8.3%) compared to the traditional emergency cholecystectomy (which had 13.3% mortality and 25% severe complications). These improvements are both statistically significant and clinically important.

2. Staged minimally invasive interventions are the key to the new strategy. Urgent endoscopic decompression of the bile ducts (ERCP) in the presence of choledocholithiasis, and percutaneous cholecystostomy in severe destructive cholecystitis, allow stabilization of the patient's condition and relief of acute biliary hypertension. Employing these methods in the first stage of treatment led to the elimination of postoperative cholangitis and a significant reduction in intra-abdominal purulent complications in our series.

3. The optimal timing of surgery is determined individually: in moderately severe patients it is safe to perform early laparoscopic cholecystectomy within the first 72 hours of disease onset, whereas in very severe patients it is advisable to postpone the operation by 3–7 days after decompression and stabilization. Such a flexible approach made it possible to reduce operative risks and improve outcomes.

4. If a standard laparoscopic cholecystectomy is not feasible (due to severe inflammation or anatomical difficulty), a subtotal cholecystectomy or mini-laparotomy is preferable to an extensive open cholecystectomy, in order to minimize the risk of complications.

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