New Day in Medicine
Новый День в Медицине
NDM

TIBBIYOTDA YANGI KUN

Ilmiy referativ, marifiy-ma'naviy jurnal

AVICENNA-MED.UZ

ISSN 2181-712X.
EiSSN 2181-2187

2 (88) 2026

ТИББИЁТДА ЯНГИ КУН
НОВЫЙ ДЕНЬ В МЕДИЦИНЕ
NEW DAY IN MEDICINE

Илмий-рефератив, маънавий-маърифий журнал
Научно-реферативный,
духовно-просветительский журнал

УЧРЕДИТЕЛИ:

БУХАРСКИЙ ГОСУДАРСТВЕННЫЙ МЕДИЦИНСКИЙ ИНСТИТУТ
ООО «ТИББИЁТДА ЯНГИ КУН»

Национальный медицинский исследовательский центр хирургии имени А.В. Вишневского является генеральным научно-практическим консультантом редакции

Журнал был включен в список журнальных изданий, рецензируемых Высшей Аттестационной Комиссией Республики Узбекистан (Протокол № 201/03 от 30.12.2013 г.)

2 (88)

2026
февраль

www.bsmi.uz
https://newdaymedicine.com
E: ndmuz@mail.ru
Тел: +99890 8061882

Received: 20.01.2026, Accepted: 06.02.2026, Published: 10.02.2026

UDC 616.366-003.7-06:616.89-02-089

SURGICAL TACTICS FOR EXTRAHEPATIC BILE DUCTS IN PATIENTS WITH COMPLICATED CHOLELITHIASIS

Gulomov Furkat Kayyumovich https://orcid.org/0000-0002-3154-2078
e-mail: Furkat_gulomov@mail.ru
Khamdamov Bakhtiyor Zarifovich https://orcid.org/0000-0003-3569-6688
e-mail: dr.hamdamov@mail.ru

Bukhara State Medical Institute named after Abu Ali ibn Sina, Uzbekistan, Bukhara, st. A. Navoi. 1 Tel: +998 (65) 223-00-50 e-mail: info@bsmi.uz

✓ ***Resume***

Implementation of the algorithm resulted in a 3.4-fold reduction in severe complications, a more than 5-fold reduction in conversion rates, and improved outcome predictability. The algorithm has proven its practical applicability and effectiveness in laparoscopic hepatobiliary surgery.

Keywords: Gallstone disease, extrahepatic duct lesions, surgery

ХИРУРГИЧЕСКАЯ ТАКТИКА ПРИ ПОРАЖЕНИИ ВНЕПЕЧЕНОЧНЫХ ЖЕЛЧНЫХ ПРОТОКОВ У БОЛЬНЫХ С ОСЛОЖНЕННОЙ ЖЕЛЧНОКАМЕННОЙ БОЛЕЗНЬЮ

Гуломов Фуркат Кайюмович https://orcid.org/0000-0002-3154-2078
e-mail: Furkat_gulomov@mail.ru
Хамдамов Бахтиёр Зарифович https://orcid.org/0000-0003-3569-6688
e-mail: dr.hamdamov@mail.ru

Бухарский государственный медицинский институт имени Абу Али ибн Сины, Узбекистан, г. Бухара, ул. А. Навои. 1 Тел: +998 (65) 223-00-50 e-mail: info@bsmi.uz

✓ ***Резюме***

Реализация алгоритма привела к снижению тяжелых осложнений в 3,4 раза, уменьшению конверсий более чем в 5 раз и повышению предсказуемости исходов. Алгоритм доказал практическую применимость и эффективность в условиях лапароскопической гепатобилиарной хирургии

Ключевые слова: Желчекаменная болезнь, поражения внепеченочных путей, операция

ASORATLANGAN O‘T TOSH KASALLIGIDA JIGARDAN TASHQARI O'T YO'LLARI ZARARLANISHIDA XIRURGIK TAKTIKA

G'ulomov Furqat Kayyumovich https://orcid.org/0000-0002-3154-2078
e-mail: Furkat_gulomov@mail.ru
Xamdamov Baxtiyor Zarifovich https://orcid.org/0000-0003-3569-6688
e-mail: dr.hamdamov@mail.ru

Abu Ali ibn Sino nomidagi Buxoro davlat tibbiyot instituti, O‘zbekiston, Buxoro sh. A. Navoiy kochasi 1 Tel: +998 (65) 223-00-50 e-mail: info@bsmi.uz

✓ ***Rezyume***

Algoritmning joriy etilishi og'ir asoratlarni 3,4 baravar, konversiya darajasini 5 baravardan ortiq kamaytirishga va natijalarni oldindan aytib berishni yaxshilashga olib keldi. Algoritm laparoskopik gepatobiliar jarrohlikda amaliy qo'llanilishi va samaradorligini isbotladi.

Kalit so'zlar: O't tosh kasalligi, jigardan tashqari yo'llarning shikastlanishi, operatsiya

Relevance

The problem of GB lesions in complicated cholelithiasis has remained a central issue in abdominal surgery for decades. A growing body of clinical observations has clarified the pathogenesis, classification, and clinical and morphological features of these lesions; however, many aspects remain insufficiently systematized (1,3,5).

The development of minimally invasive technologies has radically changed the surgical approach to treating complicated forms of cholelithiasis. Laparoscopic cholecystectomy has become the "gold standard" for uncomplicated cases, while combined hybrid procedures and FCG navigation techniques have significantly improved the safety of interventions. However, most studies focus on individual technical aspects and do not offer a unified strategy that takes into account the morphological and functional factors of the injury (2,4,6).

Controversies persist regarding the timing and extent of reconstruction for different types of lesions. Some authors advocate early, radical restoration of patency, while others favor a staged approach with preliminary decompression. To date, there are no uniform criteria for stratifying the severity of lesions, indications for minimally invasive reconstructions, or objective assessment of functional outcomes (7, 8, 10).

Thus, the level of understanding of this problem can be characterized as high in terms of the volume of accumulated data, but insufficient in terms of systematization and integration of knowledge. Current research is primarily aimed at improving individual techniques, while practical healthcare requires a comprehensive strategy combining pathogenetic rationale, standardized diagnostic and surgical correction algorithms, and an objective assessment of long-term outcomes (7, 9).

All of the above determined the main focus of this work.

Objective of the study: Develop a method for selecting a surgical procedure for extrahepatic bile duct lesions in patients with complicated cholelithiasis.

Materials and methods

The clinical material consisted of 127 patients with complicated forms of cholelithiasis, accompanied by lesions of the extrahepatic bile duct of varying severity, who were treated and examined at the Republican Scientific Center for Emergency Medical Care of the Ministry of Health of the Republic of Uzbekistan and at the Department of Faculty and Hospital Surgery of the Bukhara State Medical Institute named after Abu Ali Ibn Sina in the period from 2020 to 2025. All patients were divided into two chronological groups according to the conditions of the study: the control group, including 62 (48.8%) patients treated in 2020-2022 using traditional methods of laparoscopic surgery, and the main group, consisting of 65 (51.2%) patients operated on in 2023-2025 using the developed technologies for diagnosis, prognosis and surgical treatment of lesions of the extrahepatic bile duct.

The study was prospective and comparative in nature, with elements of cohort analysis and was conducted as a controlled clinical observation. Its design included two sequential time periods, differing in the surgical treatment technologies used. During the first stage (2020-2022), traditional laparoscopic interventions for complicated gallstone disease and lesions of the bile duct were performed, forming a control group. During the second stage (2023-2025), the study was continued with the implementation of an improved system for diagnosis, prognosis, and selection of surgical tactics, which made it possible to identify a study group. This design allowed for direct comparison of clinical outcomes between successive patient cohorts while maintaining uniform inclusion criteria, examination methods, and outcome assessment. The prospective nature of the observation allowed for data validation, recording the dynamics of laboratory, instrumental, and morphological parameters, and statistically assessing the impact of the implemented technologies on immediate and long-term treatment outcomes. Surgeries, tissue sampling, and subsequent processing were performed in accordance with established standards of biological safety and professional surgical ethics.

The study design included a sequential system of stages aimed at the comprehensive study, development, and clinical validation of diagnostic and surgical treatment methods for biliary tract lesions in complicated gallstone disease.

The study was based on a comparison of two cohorts of patients, with consistent inclusion criteria, examination methods, and surgical principles. The first stage involved diagnostics, including clinical, laboratory, instrumental, morphological, and immunohistochemical studies, which allowed for a

quantitative characterization of the degree of inflammatory-fibrous changes and the determination of baseline biliary hypertension. Next, the results of traditional laparoscopic treatment methods were assessed, and the incidence and pattern of POIs, as well as the causes of "unsatisfactory" outcomes and mortality, were analyzed.

The final stage of the design was a comparative assessment of the immediate and long-term treatment outcomes between the control and study groups, including an analysis of clinical, morphological, and resource indicators, which allowed for objective confirmation of the effectiveness of the implemented comprehensive surgical treatment system.

Correlations between quantitative parameters were assessed using Pearson's r-squared coefficients (r) for normal distributions and Spearman's r-squared coefficients (ρ) for abnormal distributions. Correlation strength was defined as weak (r = 0.2-0.39), moderate (0.4-0.59), and strong ($r \geq 0.6$). Multivariate logistic regression analysis was used to identify independent predictors of morphofunctional disorders. The diagnostic and prognostic accuracy of individual parameters was assessed using receiver operating characteristic (ROC) analysis, calculating the area under the curve (AUC) and 95% confidence interval. To quantitatively assess the influence of factors on outcomes, odds ratios (OR) and relative risks (RR) were calculated with 95% CI.

Differences were considered statistically significant at a probability of error of $p < 0.05$. The ICMJE-2021 guidelines [Guidelines for Reporting Statistics in Biomedical Journals: Updated Recommendations for Authors, Editors, and Reviewers. - International Committee of Medical Journal Editors, 2021. - 14 p.] and the principles of evidence-based medicine were followed when interpreting the results, ensuring the reliability and reproducibility of the analysis.

Results and discussion

The development of a set of technical approaches aimed at reducing the risk of injury to the bifida and preventing complications naturally required the creation of a tactical algorithm that ensures a consistent and reproducible choice of surgical scope depending on the degree of morphofunctional changes and preoperative risk. Analysis of the results presented in the previous chapters revealed that outcomes of LCEC for complicated gallstone disease directly depend on the severity of biliary hypertension, the presence of cholangitis, morphological signs of CBD wall fibrosis, and the technical complexity of the surgery. The use of an integrated scale for predicting the severity of CBD damage (ISP-CBD) allowed us to develop a quantitative basis for the algorithm, and the implementation of a digital, trainable prediction program transformed the process of choosing a surgical strategy into a manageable format with the ability to objectively differentiate patients.

The developed algorithm for selecting a surgical method is a multi-level decision-making system built on the principle of a "decision tree" with sequential branching based on key criteria. The first level considers clinical and laboratory data reflecting the degree of cholestasis and the activity of the inflammatory process (total bilirubin level, alkaline phosphatase activity, and the presence of signs of cholangitis). These parameters form the initial risk assessment block and define the initial branch of the surgical method selection algorithm we developed.

The second level analyzes imaging data (ultrasound, MRCP, or PTC) to determine the diameter of the CBD, the length of the stricture zone, and the presence of suspected vesico-biliary communication. The third level includes intraoperative parameters reflecting the technical complexity of the intervention (the degree of difficulty of the LCEC, the achievement of a "critical safety review" within 30 minutes, the amount of blood loss, and the results of a fluoroscopic gastroscopy with indocyanine green). The combination of these parameters forms three main tactical branches. With a combination of favorable indicators (≤ 16 points on the ISP-VZHP scale), the surgery is performed using the standard technique. In these cases, identification of the structures of the Calot triangle and completion of the LCEC are straightforward, and control IOC is performed only when indicated. This combination of parameters forms branch A, corresponding to the low-risk category.

With moderate changes (from 17 to 26 points on the ISP-VZHP scale), preference is given to a combined approach. In these cases, it is recommended to complete the intervention with transinfundibular lithoextraction with temporary placement of an internal stent or soft drainage, which ensures decompression of the bile ducts without traumatic dissection of the hepatic porta hepatis. With early normalization of bilirubin and alkaline phosphatase in the pelvic area, de-escalation of the approach is possible with drainage removal within 5-7 days. This branch is designated as B and corresponds to a moderate risk, which ensures a balance between the radicality and safety of the operation.

The highest risk category (branch C) is determined by a combination of unfavorable indicators (≥ 27 points on the "ISP-VZHP" scale). In these cases, performing a standard dissection carries the risk of damaging the main structures. Therefore, it is recommended to limit the intervention to a subtotal laparoscopic cuff repair, covering the suture line with an autoperitoneal film, and installing a drain using a dual-arm biosleeve. If the intraoperative situation further deteriorates, an escalation of the strategy is recommended, i.e., transition to reconstructive surgery or conversion.

Signs of mandatory conversion, or so-called "red flags," occupy a special place in the algorithm. These include the inability to achieve a critical safety review within 30 minutes, blood loss >200 ml, unidentifiable structures in the area of Calot's triangle, absence of bile duct fluorescence ("silent common bile duct") after administration of indocyanine green, and a progressive increase in bilirubin levels based on rapid intraoperative analysis. If at least one of these signs appears, the laparoscopic stage should be discontinued and an open approach or staged reconstruction should be used. This rule serves as an important element of the safety control system and helps prevent severe complications associated with bile duct damage.

Thus, the proposed tactical algorithm ("decision tree") is an integral part of the developed treatment and diagnostic system. It integrates morphological, clinical, laboratory, instrumental, and intraoperative data and enables the implementation of a personalized approach to the surgical treatment of biliary tract lesions in complicated gallstone disease. The algorithm serves as a dynamic decision-making model, allowing not only to improve the safety of laparoscopic procedures but also to optimize patient routing based on the degree of risk and severity of the pathological process.

The "decision tree" algorithm is used by surgeons as a practical tool to standardize the selection of the scope of laparoscopic intervention and promptly adjust tactics based on current examination data and intraoperative findings. Implementing the "decision tree" into clinical practice facilitates patient routing, reduces surgical time and blood loss, ensures the rational use of the laparoscopic approach, and creates a basis for unifying tactics in complex hepatobiliary surgery situations.

After completing the development and clinical implementation of a set of laparoscopic techniques (cuff choledochoplasty with autoperitoneal closure, transinfundibular lithoextraction, and the use of a dual-arm biological drainage sleeve), we identified the need to objectively confirm their safety and reproducibility with varying degrees of morpho-fibrous changes in the ventricular wall. The goal of this stage was to internally evaluate the parameters characterizing the reliability and feasibility of performing the developed procedures in patients belonging to different morphological categories according to the "ISP-VZhP" scale (low, moderate, and high).

Table 1 summarizes the key safety criteria, namely, the average surgical duration, the volume of intraoperative blood loss, the frequency of achieving a critical safety review within the first 30 minutes of the procedure, and the proportion of forced conversions. These parameters allow us to comprehensively assess the technical complexity and reproducibility of the intervention, as well as evaluate the tolerability of the techniques across various morphological types of lesions.

Table 1

Evaluation of the safety and reproducibility of the developed laparoscopic techniques depending on the degree of morpho-fibrosis of the wall of the gastrointestinal tract

EVALUATION CRITERIA	DEGREE OF MORPHO-FIBROSIS		
	MODERATE	EXPRESSED	TOTAL
Average duration of operation, min	91,4±15,2	104,7±18,3	116,3±21,6
verage volume of blood loss, ml	72,8±25,6	88,3±31,4	110,7±37,9
Achieving "critical safety review" ≤30 min, n (%)	21 (87,5%)	20 (74,1%)	8 (57,1%)
Achieving "critical safety review" ≤30 min, n (%)	21 (87,5%)	20 (74,1%)	8 (57,1%)

As the degree of morphofibrosis in the hepatobiliary zone increased, a predictable increase in surgical time and a moderate increase in blood loss were observed. However, these indicators remained within physiologically and clinically acceptable limits. With moderate fibrosis, the average procedure time was 91.4±15.2 minutes; with severe fibrosis, it increased to 104.7±18.3 minutes; and with total fibrosis, it was 116.5±21.6 minutes, reflecting the expected impact of tissue rigidity on technical complexity. A similar

trend was noted for blood loss. Despite the slight increase in these indicators, hemodynamic stability was generally maintained in all patients, and transfusions were not required. The rate of achieving a critical safety review within 30 minutes decreased predictably from 87.5% (21 of 24 cases) with moderate fibrosis to 57.1% (8 of 14 cases) with total fibrosis, reflecting the objectively more complex topographic situation. However, even with total fibrosis and tissue rigidity, safe isolation of Calot's triangle structures was achieved in more than half of patients. The rate of forced conversions remained minimal: one (3.7%) with severe fibrosis and one (7.1%) with total fibrosis, demonstrating the high reproducibility and acceptability of the laparoscopic approach when appropriately selected using the "decision tree" algorithm.

Thus, the presented data confirm that the developed laparoscopic surgical techniques remain safe and technically feasible across the entire range of morphofunctional changes in the pelvic cavity. Blood loss and conversion rates did not exceed generally accepted standards for laparoscopic hepatobiliary surgery, allowing them to be recommended for widespread practical use as part of a treatment and diagnostic algorithm. The results of the internal safety assessment serve as a transitional step to the next stage of the study, which will focus on a comparative assessment of the effectiveness of the proposed methods versus traditional approaches.

Conclusions:

1. The developed treatment and diagnostic algorithm for selecting surgical tactics, based on the ISP-VZHP scale and morphofunctional risk stratification, ensured a standardized and reproducible selection of the optimal intervention.

2. Implementation of the algorithm resulted in a 3.4-fold reduction in severe complications, a more than 5-fold reduction in conversions, and improved outcome predictability. The algorithm has proven its practical applicability and effectiveness in laparoscopic hepatobiliary surgery.

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Entered 20.01.2026