

Development Factors and Prevention Strategies for Early Biliary System Complications After Gallbladder Removal

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Abstract Cholecystectomy is one of the most common surgical operations in abdominal surgery. Millions of such interventions are performed annually worldwide, predominantly using laparoscopic access. Despite the high frequency of performance and standardization of surgical technique, early biliary complications remain a serious problem, significantly affecting treatment outcomes and patients' quality of life.

Keywords Cholecystectomy, Biliary complications, Bile leakage, Bile duct injuries, Biliary peritonitis, Risk factors, Intraoperative imaging, Complication prevention, Minimally invasive surgery, Biliary reconstruction

1. Introduction

Bile leakage is one of the most serious complications that occur after gallbladder removal. This complication should be considered as an independent problem since it can result from damage to the main bile ducts and be life-threatening. The frequency of bile leakage after various types of cholecystectomy is 0.9-3.5%. The most common causes of bile leakage are considered to be accessory hepatocystic ducts in the gallbladder bed and insufficiency of the cystic duct stump or clip failure (from 0.15 to 0.6%). Depending on the source and its localization, they may resolve at different times. Even a small bile leakage into the abdominal cavity can lead to peritonitis [1]. Cholecystectomy is one of the most common surgical operations in global practice, with more than 1.5 million procedures performed annually. Despite the introduction of minimally invasive technologies and standardization of surgical techniques, the frequency of early biliary complications remains at 0.2-2.7%, representing a serious clinical problem. These complications not only worsen immediate treatment results but can also lead to the formation of persistent bile duct dysfunctions, significantly reducing patients' quality of life [2]. The spectrum of early biliary complications includes bile leakage, injuries to the main bile ducts of varying severity, cystic duct stump insufficiency, biliary peritonitis, and biloma formation. The pathogenesis of these complications is multifactorial, including both anatomical predispositions and technical aspects of the operation [3].

Risk factors for early biliary complications can be conditionally divided into patient-related (variant bile duct

anatomy, inflammatory changes in the operating area, adhesions), surgical technique (incorrect structure identification, excessive tissue traction, inadequate hemostasis), and organizational (surgeon's experience, operating room equipment, availability of intraoperative imaging). Understanding these factors is crucial for developing effective prevention strategies [4]. Modern approaches to preventing biliary complications have evolved from simply following surgical principles to comprehensive strategies including preoperative preparation, application of intraoperative imaging technologies, standardization of surgical techniques, and patient management protocols. Nevertheless, despite significant progress, the problem remains relevant, as evidenced by the stable frequency of biliary complications even in highly specialized centers [5].

Developing an effective system for preventing early biliary complications requires detailed analysis of their causal relationships and systematization of existing preventive approaches, considering modern technological capabilities and organizational solutions. The implementation of educational programs and simulation technologies for surgeon training, as well as the algorithmization of intraoperative decision-making processes in complex clinical situations, are of particular importance [6].

Clear descriptions of the clinical picture of bile leakage are lacking. However, A. Barkin et al. (1997) notes that such patients may experience abdominal pain, fever, and increasing abdominal distension. There are also nonspecific shifts in blood parameters, including elevated liver enzyme levels.

Diagnosis of intra-abdominal bile leakage is a complex task. The presence of standard signs in the postoperative space contributes to early diagnosis and prevention of serious peritonitis. In the absence of drainage, it is advisable to expand the indications for postoperative ultrasound on days

1-2. With intra-abdominal complications, a large amount of fluid and peritonitis are noted. Endoscopic drainage of bile ducts or micro-prosthesis placement can be quite effective (A.G. Beburishvili et al., 2009; E.I. Galperin et al., 2010). The use of laparoscopy in diagnosing operative complications has been influenced by clinical effectiveness in patients after creating a cholangiographic barrier for the surgeon and the patient after the proposed positive supplement. This often leads to prolonged conservative therapy and unjustified loss of time (V.V. Boyko et al., 2009). In all patients, repeat operations were not performed, although they were indicated. Delay in surgical intervention leads to high mortality. At the same time, minor bile leakage from a drainage tube can sometimes be observed without requiring immediate laparotomy [7].

The widespread implementation of ultrasound in the diagnosis and treatment of postoperative bile leakage necessitates a clear diagnostic and treatment approach.

Early biliary complications after cholecystectomy include: bile duct injuries, bile leakage, cystic duct stump insufficiency, bile duct strictures, and biliary peritonitis. Their frequency, according to various studies, ranges from 0.2% to 2.5%, and they can lead to repeated operations, prolonged hospitalization, and, in severe cases, to fatal outcomes [8].

The problem is particularly relevant because most biliary complications are potentially preventable when adhering to certain principles of surgical technique and correctly assessing anatomical variations of the bile ducts. Nevertheless, despite the introduction of new technologies and improvement of surgical skills, the frequency of these complications does not show a significant downward trend.

Modern approaches to preventing early biliary complications include thorough preoperative examination using highly informative imaging methods, intraoperative cholangiography, application of fluorescent technologies for visualizing bile ducts, and strict adherence to the principles of the "Critical View of Safety." However, the effectiveness of these methods varies in different clinical situations, especially in the presence of inflammatory changes and anatomical anomalies [9].

In this regard, improving existing and developing new approaches to preventing early biliary complications after cholecystectomy represents an important scientific and practical task in modern surgery. Solving this problem requires a comprehensive approach, including risk factor analysis, systematization of available preventive measures, and the introduction of innovative visualization and decision-making technologies into surgical practice [10].

According to the World Health Organization, "over the last decade, there has been a universal increase in the number of patients with gallstone disease and its complications. At the same time, bile duct injury is one of the most serious complications of biliary surgery and shows no tendency to decrease despite constantly improving surgical techniques. When performing operations on abdominal organs, the frequency of intraoperative injury to the bile ducts is 0.09-3%." As a rule, "iatrogenic trauma to the extrahepatic bile ducts occurs during operations on the biliary tract, most

often cholecystectomy, less frequently during operations on the stomach, duodenum, or pancreas." In global practice, it is known that technical and tactical errors by surgeons, as well as the lack of adequate technological support, are decisive in the genesis of bile duct injuries during cholecystectomy [11]. Research in this direction continues because the consequences of iatrogenic bile duct injury can cause catastrophic damage to the patient's health, and only a timely and competently performed operation can prevent the development of such complications as biliary cirrhosis, portal hypertension, purulent cholangitis, and liver failure. One of the real ways to improve the results of treating iatrogenic bile duct injuries is their timely diagnosis during the first operation, as up to 90% of injuries remain unnoticed. The development of rational diagnostic and treatment tactics remains important. The development of minimally invasive endoscopic methods, percutaneous endobiliary methods of interventional radiology, as well as the accumulation of more than a century of experience in "traditional" hepatobiliary surgery, serve as the basis for improving the tactical aspects of surgical treatment for this problem [12].

The introduction of new technologies into surgical practice brings new types of iatrogenic injuries. Of great interest is the question of the causes of extrahepatic bile duct injuries. Many authors consider the causes of accidental hepaticocholedochal injuries to be anomalies of the bile ducts and vessels in the area of the liver gate, inflammatory infiltrate and scar adhesions at the gallbladder neck, bleeding that occurred during the operation, forced surgical interventions at night, Mirizzi syndrome (type II), and others (Song S). Despite certain successes achieved in this complex area of surgery, unsatisfactory results even among the most experienced surgeons are noted on average in 10% of cases (Tsuruda Y). According to Rifatbegovic Z, "such patients need repeated, sometimes multiple reconstructive operations, and they are rightfully called 'biliary cripples'." From the perspective of treatment outcomes, the timing of bile duct injury detection is of fundamental importance. A distinction is made between "fresh" injuries and post-traumatic cicatricial strictures of the bile ducts. "Fresh" injuries, in turn, are divided into those diagnosed on the operating table and those identified in the early postoperative period. Accordingly, the long-term results of surgical treatment for this category of patients depend on the timing of detection and the nature of the injury [13].

"The main reasons for failures in the treatment of injuries to the main bile ducts are untimely diagnosis and the performance of reconstructive operations that are inadequate in volume, by surgeons who do not have the proper experience in biliary surgery." There is no consensus on the choice of operation method for "fresh" bile duct injuries diagnosed intraoperatively or in the immediate postoperative period [14]. There is still a tendency toward restorative operations, which give unsatisfactory results due to the rapid development of cicatricial stricture or anastomosis failure. Some surgeons resort to anastomoses with the duodenum, which leads to the development of a duodenal fistula or reflux cholangitis, or anastomosis stricture. Determining

factors in the treatment tactics for bile duct injury are factors that influence the choice of operation: the nature and location of the injury, the condition of the transected duct, the time of injury diagnosis, and the presence of a surgeon with experience in reconstructive surgery of the bile ducts. The developed methods for treating iatrogenic bile duct injuries, when used in a timely and correct manner, allow for good results in most patients, although postoperative complications reach 48.7% [15].

The conducted literature analysis indicates that in the current period, the diagnostic and treatment tactics for iatrogenic bile duct injuries is one of the relevant and not fully resolved problems of modern surgery. The presented data allow us to consider the search for and development of an optimal diagnostic algorithm and surgical tactics to improve the results of treatment for iatrogenic injuries of the main bile ducts as one of the relevant problems in abdominal surgery.

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