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Total laparoscopic radical resection of hilar cholangiocarcinoma: preliminary experience of a single center

Yusheng Du[1], Ji Wang[1], Li Liu[1], Hongqin Ma[1], Wenxing Zhao[1*] and Ying Li[1*]

Abstract

Background The aim of this study was to describe our preliminary experience in the procedure of laparoscopic radical resection of hilar cholangiocarcinoma and to evaluate its feasibility, safety, and clinical efficacy.

Methods A retrospective analysis was conducted on 44 patients with hilar cholangiocarcinoma who underwent laparoscopic surgery at our hospital from August 2019 to September 2023. Clinical data were collected from these patients, including 13 cases of Bismuth type I, 17 cases of Bismuth type II, 5 cases of Bismuth type IIIa, and 9 cases of Bismuth type IIIb.

Results Laparoscopic radical resection of hilar cholangiocarcinoma was successfully performed in 38 patients (86.3%). Among the remaining patients, 3 required vascular reconstruction to complete radical surgery and were converted to laparotomies, while 3 others underwent T-tube drainage only due to unresectable metastases. The median operation time was 285 min (range, 190–450), and the median estimated blood loss was 360 mL (range, 260–1200). The postoperative hospital stay duration was 14.3 ± 3.6 days. No perioperative mortality was observed. Postoperative pathological examination revealed negative microscopic margins (R0) in 39 cases and positive microscopic margins (R1) in 2 cases. Postoperative complications occurred in 8 patients (18.1%), with 4 cases (9.0%) of Grade I, 3 cases (6.8%) of Grade II, 1 case (2.2%) of Grade IIIa, and no Grade IIIb or IV complications. The median overall survival for patients who underwent radical R0 resection was 30.4 months (range, 5.3–43.6). The Disease-free survival rates were 73.6% at 1 year, 61.2% at 2 years, and 40.1% at 3 years.

Conclusion Total laparoscopic radical resection of hilar cholangiocarcinoma can be performed safely, feasibly, and effectively by experienced surgeons after an accurate preoperative evaluation.

Keywords Hilar cholangiocarcinoma, Laparoscopy, Hepaticojejunostomy

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Introduction

Hilar cholangiocarcinoma, a malignant biliary epithelial tumor originating from the common hepatic duct, left and right hepatic ducts, and their junctions, accounts for approximately 40–60% of all cholangiocarcinomas [1]. This tumor is characterized by a low early diagnosis rate and a poor prognosis. Radical resection remains the only effective treatment for hilar cholangiocarcinoma, with a 5-year survival rate ranging from 20 to 40% following radical surgery [2–4]. However, traditional open surgery is highly invasive and poses greater risks for elderly patients with comorbid underlying diseases and poor cardiopulmonary function, resulting in many patients being deemed unsuitable for surgery. Therefore, it is imperative to explore a less invasive radical surgical approach that has a reduced impact on cardiopulmonary function in clinical practice to improve this situation. This paper aims to analyze a case series and summarize the surgical experience of total laparoscopic radical resection for hilar cholangiocarcinoma, with the goal of providing surgeons with a better understanding of this novel technique.

Materials and methods

Patients

A retrospective study was conducted, approved and adopted by the Ethics Committee of the Affiliated Hospital of Xuzhou Medical University (Ethics No.XYFY2019-KL051-01). Informed consent was obtained from all patients. Clinical data were collected from 44 patients who underwent laparoscopic surgery for hilar cholangiocarcinoma at the Department of General Surgery, Affiliated Hospital of Xuzhou Medical University, from August 2019 to September 2023. The study population consisted of 29 males and 15 females, with a mean age of 69.3±7.8 years and a mean BMI of 24.5±2.8 kg/m^2. Among the patients4 had diabetes, 3 had coronary artery disease, 6 had hypertension, and one had previously undergone laparoscopic cholecystectomy. The median preoperative total bilirubin level was 189.7 μmol/L (range: 91.9-347.9 μmol/L), and the median preoperative direct bilirubin level was 164.3 μmol/L (range: 75.8-208.5 μmol/L). All patients were diagnosed with hilar cholangiocarcinoma combined with obstructive jaundice by color Doppler ultrasound, computed tomography (CT), and magnetic resonance cholangiopancreatography (MRCP) before surgery. For patients considered preoperatively for possible combined extensive hepatectomy, 3D image reconstruction imaging was performed, and the residual liver volume was assessed. Endoscopic nasobiliary drainage (ENBD) was performed in one patient to attenuate jaundice due to severe jaundice (347.9 μmol/L) and cholangitis. Two patients with severe jaundice required a period of preoperative nutritional support due to poor nutrition and underwent percutaneous transhepatic cholangial drainage (PTCD). The American Society of Anesthesiologists (ASA) classification was as follows: 15 cases were Grade I, 27 cases were Grade II, and 2 cases were Grade III. According to the Bismuth classification, there were 13 cases of Bismuth type I, 17 cases of Bismuth type II, 5 cases of Bismuth type IIIa, and 9 cases of Bismuth type IIIb. No obvious operative contraindications or distant metastases were found on preoperative examination (details in Table 1).

Table 1 Patients' preoperative characteristics

Parameter	Value (*n*=44)
Sex	
Male	29 (65.9)
Age (y)	69.3±7.8
BMI (kg/m^2)	24.5±2.8
Comorbidity	
Hypertension	6(13.6)
Coronary artery disease	3(6.8)
Diabetes	4(9.0)
Biliary drainage	
PTCD	2(4.5)
ENBD	1(2.2)
Laboratory Tests	
TBil (μmol/L)	189.7(91.9,347.9)
DBil (μmol/L)	164.3(75.8,208.5)
HGB (g/L)	127.7±14.8
ALB (g/L)	37.8±5.6
CA199(U/ml)	188.2 (92.7,563.3)
CEA (ng/ml)	2.6(1.9,4.9)
Bismuth type	
I: II: IIIa: IIIb: IV	13:17:5:9: 0
ASA class	
I: II: III	15:27:2:

Parametric data are presented as n (%) or mean (SD)

Nonparametric data are presented as median (interquartile range)

Surgical procedures

Surgical position and exploration

The patient was placed in the supine and Trendelenburg positions. A 5-port laparoscopic approach was employed, with the primary operator positioned on the patient's left side. An observation port was established using a 10-mm trocar placed under the umbilicus, while a 12-mm trocar, serving as the main operation port, was inserted under the left anterior axillary costal margin. Two 5-mm trocars were placed in the midclavicular line of the middle abdomen and the symmetrical position of the right abdomen as auxiliary operation ports, and an additional 12-mm trocar was positioned in the right abdomen. Upon entering the abdominal cavity, a thorough exploration was conducted to confirm the absence of implantation metastasis. Subsequently, the hilar plate was exposed and meticulously dissected to assess the tumor's location, size, texture, and the presence of enlarged surrounding lymph nodes, facilitating an initial evaluation of the feasibility of radical surgery.

Resection of cholangiocarcinoma

The gastrocolic ligament was opened to clear the Group 8 lymph nodes of the common hepatic artery (CHA) along the upper edge of the pancreas. The anterior wall fascia of the hepatoduodenal ligament was incised to strip the proper hepatic artery (PHA) and remove the Group 12 lymph nodes on the left portal vein (PV). The right gastric artery was then resected by dissociating towards the porta hepatis and the stripped PHA, followed by the stripping of the left hepatic artery (LHA) and right hepatic artery (RHA). By lifting the PHA and dissecting the right wall of the PV, the posterior wall of the PV was stripped. The lymphatic adipose tissue on the left side of the hepatoduodenal ligament was pulled from behind the PV to the right side, ensuring complete removal of the lymphatic adipose tissue along with the tumor. The common bile duct was resected along the upper edge of the duodenum and pancreas until the pancreatic segment, and the lymph nodes behind the pancreatic head (Group 13) were cleared using a Kocher incision. An anastomosis stapler was used to resect the common bile duct along the upper edge of the pancreas, and the margin was subjected to fast-frozen pathology. The gallbladder was retrogradely stripped from the gallbladder bed and resected towards the hilar region along the bile duct. The left and right hepatic gallbladder and caudate bile duct were separated at least 1 cm above the tumor, with the margin undergoing fast-frozen pathology. Additionally, the liver tissue surrounding the bile duct was removed to achieve radical resection of hilar cholangiocarcinoma (Fig. 1A). In cases with multiple bile duct openings at the upper cutting edge of the bile duct stump, rapid freezing pathology was mandatory. Following confirmation of negative pathological reports, the anastomosis operation was performed.

Hepatectomy

In instances where intraoperative exploration or rapid pathology suggested tumor invasion of one side of the intrahepatic bile duct, a combined hepatectomy was necessary to achieve radical surgery. The specific method, using combined left hepatectomy as an example, involved dissecting the portal blood vessels and branches, followed by the disconnection of the LHA (Fig. 2A) and the left branch of the PV (Fig. 2B).

The perihepatic ligament of the left liver was dissected, exposing the hepatic vein at the second hepatic hilar. The peritoneum was dissected anterior to the inferior hepatic vena cava, and the short hepatic veins were gradually dissected from the bottom up, clipped, and dissected, separating the liver from the posterior hepatic vena cava. The liver parenchyma was transected using an ultrasonic knife combined with an electric hook along the left hepatic ischemic zone, and the intrahepatic vessels were sequentially ligated. The left hepatic vein was dissected using an anastomosis stapler (Fig. 2C), completing the left hepatectomy and caudate lobectomy. Throughout the procedure, meticulous hemostasis was ensured, and the remaining liver section was carefully examined, with any missing vessel or bile duct sections being sutured.

Gastrointestinal reconstruction

Roux-en-Y hepaticojejunostomy was performed for gastrointestinal reconstruction. Approximately 15–20 cm away from the Treitz ligament, the jejunum was dissected using an anastomosis stapler. Following closure of the distal jejunum, the hepatic duct-jejunum anastomosis was carried out after lifting the jejunum to the hilar region over the back of the colon. In cases where the tumor location was high, multiple lumens would be

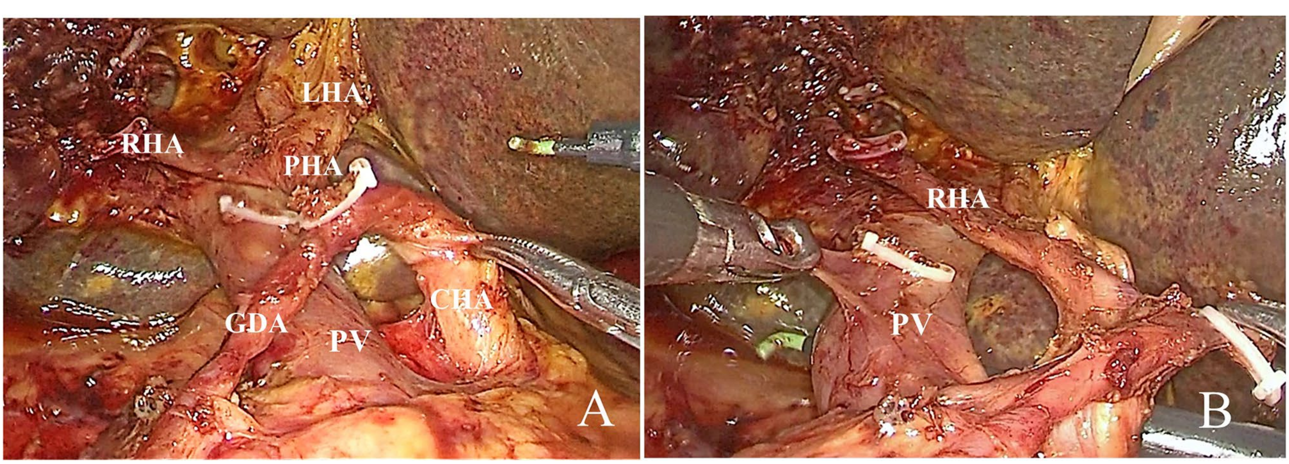

Fig. 1 Surgical field of view after hilar cholangiocarcinoma (Bismuth type I) **A** Hepatoduodenal ligament after lymph node dissection. **B** Portal vein naked 360°

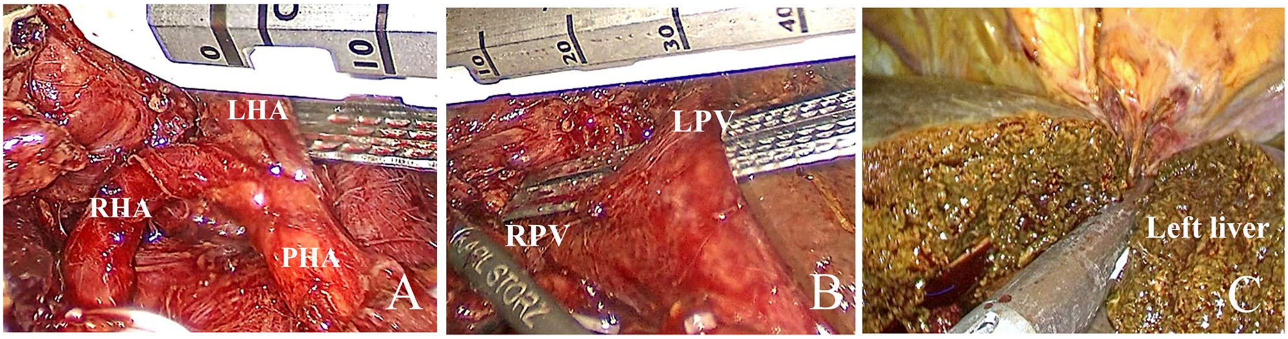

Fig. 2 Surgical field of view during radical operation of hilar cholangiocarcinoma combined with left hepatectomy (Bismuth type IIIb) **A** The left hepatic artery is being cutting and closing. **B** The Left portal vein is being cutting and closing. **C** The left liver is being cutting and closing

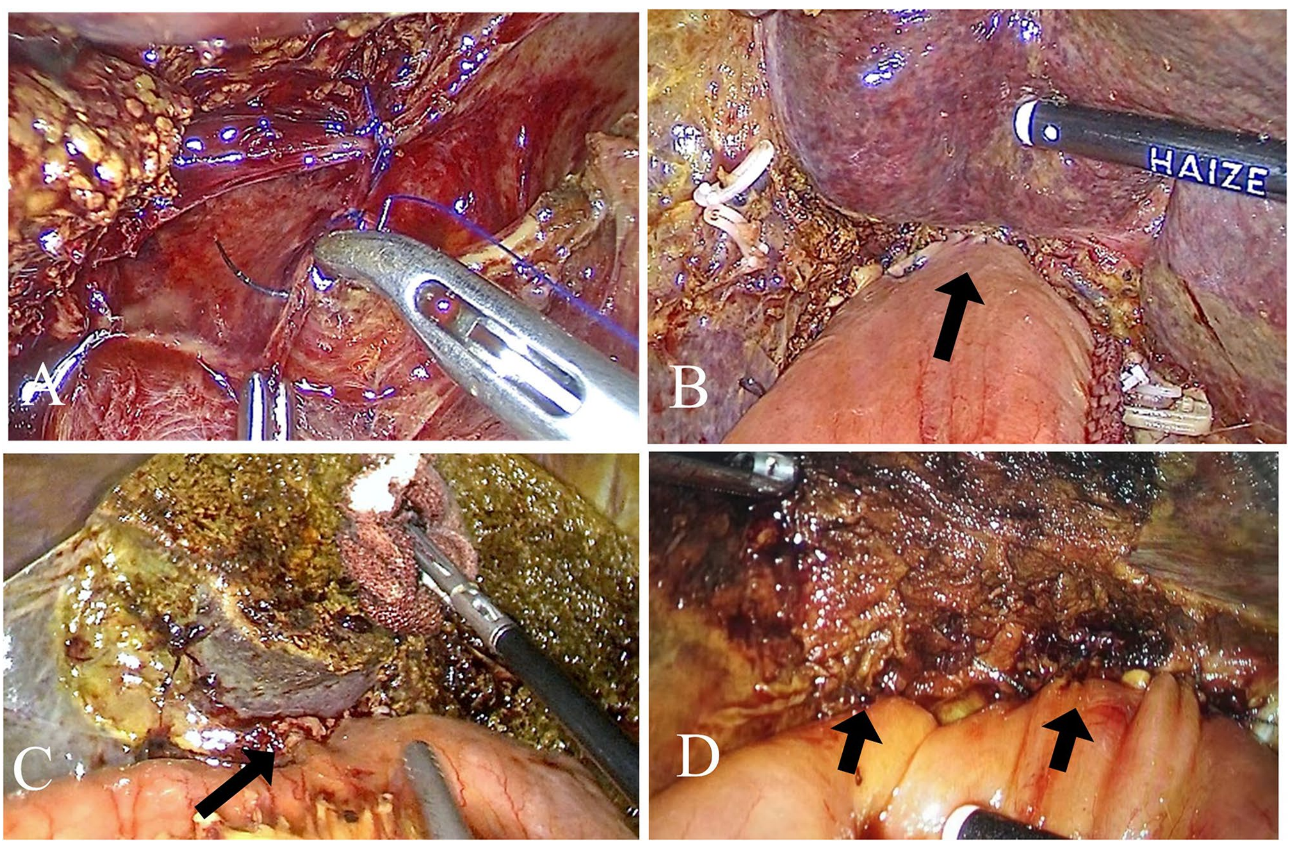

Fig. 3 Roux-en-Y anastomosis of hepatic duct and jejunum **A** Left and right hepatic duct reshaping. **B** Hepatic jejunostomy after perihepatic resection. **C** Hepatic jejunostomy after combined left hepatectomy. **D** Two hepatic duct jejunostomy

present in the broken end of the hepatic duct after cutting off the left and right hepatic ducts. In such instances, hilar cholangioplasty was performed prior to bilioenteric anastomosis (Fig. 3A). The size of the anastomosis was determined by the cross-sectional diameter of the bile duct after shaping. An incision was made in the distal jejunum, matching the size of the mesangial limbus. Using 4−0 VOL-C, a continuous full-thickness suture of the hepatic duct and jejunum was performed in the order from left to right, starting with the first wall and then the front wall (Fig. 3B-C). In cases where the opening of the hepatic duct was too far apart, multiple hepatic duct jejunostomies were required (Fig. 3D).

Postoperative management

Postoperative management was conducted in accordance with the principles of Enhanced Recovery After Surgery (ERAS) [5]. Briefly, the patients were encouraged to engage in off-bed activities on the first postoperative day and were allowed to consume an appropriate amount of water. The liquid diet was reintroduced as soon as possible, guided by the individualized target-oriented fluid infusion principle. Additionally, conventional anti-infection measures, somatostatin, acid suppression, and nutritional support therapy were implemented. Albumin and plasma were supplemented as necessary. Abdominal CT scans were performed 3 to 5 days following surgery, and drainage tubes were removed in patients with no significant surgical area effusion or bile leakage. For patients with distinct peritoneal effusions, ultrasound-guided puncture drainage was employed.

Data collection and statistical analysis

The following data were collected and analyzed: average operation time, intraoperative blood loss, intraoperative transfusion requirement, time to first postoperative bowel movement, average postoperative hospitalization duration, postoperative pathological grading and staging, number of dissected lymph nodes, negative margin rate (including the radial margin, hepatic and duodenal margin of the resected bile duct, and cut surface of the liver), and postoperative complications (assessed using the Clavien–Dindo classification [6].

Follow-up was not preplanned but was generally conducted at intervals of 3–6 months. It included comprehensive physical examinations, laboratory testing, and computed tomography when necessary. If patient survival status was unknown at the time of data collection, it was verified through telephone communication.

Statistical analysis was performed using SPSS 23.0 software. Measurement data with a normal distribution are presented as mean±standard deviation (x±s), while measurement data with a skewed distribution are presented as median (range). Count data are expressed as absolute numbers.

Table 2 Patients' intraoperative parameters and pathological results

Parameters	Value (*n*=44)
Time(min)	285(190–450)
Estimated blood loss(ml)	360(260–1200)
Transfusion requirement	
Red cell(U)	0 (0, 6)
Plasma(ml)	0 (0, 1600)
Type of Hepatectomy	
Left/extended left hepatectomy	11(25.0)
Right/extended right hepatectomy	6 (13.6)
Hepatectomy with caudate lobe	11(25.0)
Perihilar resection	13(29.5)
T-tube drainage only	3 (6.8)
R0 resection	39(88.6)
Number of lymph nodes dissection	8 (6,17)
Pathology	
Cholangiocarcinoma	44(100)
AJCC stage system	
I: II: III: IV	14:17:10:3

Parametric data are presented as n (%) or mean (SD)

Nonparametric data are presented as median (interquartile range)

Results

Laparoscopic radical resection of hilar cholangiocarcinoma was ultimately performed in 38 (86.3%) patients. The remaining patients included 3 who required vascular reconstruction to complete radical surgery and thus converted to laparotomy, and 3 who underwent T-tube drainage only due to unresectable metastases. Among the patients who underwent laparoscopic radical resection, 13 underwent perihilar resection, 11 underwent perihilar resection combined with caudate lobectomy, 11 underwent left hemi hepatectomy combined with caudate lobectomy, and 6 underwent right hemi hepatectomy combined with caudate lobectomy. Among the 17 patients who underwent combined hemihepatectomy, the transected ends of the right or left hepatic ducts were reshaped and subsequently anastomosed with the jejunum. Similarly, for the 22 patients who underwent perihilar hepatectomy or perihilar hepatectomy combined with caudate lobe resection, the bile ducts at the hepatic hilum required reshaping prior to the anastomosis with the jejunum.The median operation time was 285 min (range, 190–450), and the median estimated blood loss was 360 mL (range, 260–1200). Postoperative pathological examination revealed negative microscopic margins (R0) in 39 cases and positive microscopic margins (R1) in 2 cases. The number of lymph nodes harvested ranged from 6 to 17 per case, with a median of 8. According to the American Joint Committee on Cancer (AJCC) eighth edition staging system for hilar cholangiocarcinoma, 14 cases were classified as stage I, 17 as stage II, 10 as stage III, and 3 as stage IV (Table 2). The mean time to the first postoperative flatus was 2.7±0.3 days, and the average postoperative hospital stay was 14.3±3.6 days. Postoperative complications occurred in 8 patients (18.1%), with 4 cases (9.0%) classified as Grade I, 3 cases (6.8%) as Grade II, and 1 case (2.2%) as Grade IIIa according to the Clavien–Dindo complication grading system. No Grade IIIb or IV complications were observed. The main complications included pulmonary infection (1 case), postoperative abdominal infections (3 cases), postoperative hepatic insufficiency (1 case), and Grade A biliary fistulas (3 cases). The patient with a Grade IIIa complication had preoperative diabetes mellitus and hypoalbuminemia and developed persistent hyperthermia on the sixth postoperative day. Abdominal culture showed multidrug-resistant bacterial infection with a positive fungal culture. The patient was discharged on the 23rd postoperative day with a normal white blood cell count and no significant effusion on repeat CT. All other patients with complications were cured after symptomatic treatment and discharged from the hospital. No perioperative deaths or severe postoperative complications, such as bleeding, liver failure, or cardiovascular or cerebrovascular events, were observed (Table 3).

As of December 10, 2023, 35 of 44 patients (79.5%) were followed up.The median overall survival for patients who underwent radical R0 resection was 30.4 months (range, 5.3–43.6). The Disease-free survival rates were 73.6% at 1 year, 61.2% at 2 years, and 40.1% at 3 years.

Discussion

Laparoscopic hepatectomy (LH) has gradually expanded in hepatobiliary surgery since Reich's first successful LH in 1991 [7]. However, laparoscopy is more often used for exploratory assessment of surgical feasibility in managing hilar cholangiocarcinoma, avoiding unnecessary open surgery [8]. The porta hepatis's special location and the region's complex structures make tumor resection difficult and complex, requiring extensive experience in open surgery and laparoscopic techniques. Consequently, only a few larger hepatobiliary and pancreatic centers in China and abroad have performed experimental procedures for this purpose [9–11]. It is worth investigating the availability of minimally invasive surgery for patients with hilar cholangiocarcinoma. Our institute has explored laparoscopic radical resection of hilar cholangiocarcinoma based on numerous laparoscopic resections of the digestive tract and pancreatic tumors, with satisfactory clinical efficacy [12, 13].

Feasibility of laparoscopic radical resection of hilar cholangiocarcinoma

The surgeon and team's laparoscopic experience play a crucial role

Laparoscopic surgery differs from open surgery due to the lack of longitudinal depth and tactile sensation. Simultaneously, the difficult and complex anatomical relationships of the surgery itself for hilar cholangiocarcinoma make this procedure highly demanding for the surgeon and team. Our team can now routinely perform laparoscopic radical gastric cancer surgery, laparoscopic pancreaticoduodenectomy, and laparoscopic hemihepatectomy. Through these procedures, we have mastered the critical techniques required in radical laparoscopic surgery for hilar cholangiocarcinomas, such as "naked vascularization of the hilum," "laparoscopic biliary-enteric anastomosis," and laparoscopic hemihepatectomy, which has significantly accelerated our learning curve for this procedure. The surgeon's extensive laparoscopic experience plays a vital role in managing intraoperative bleeding and accidental injury, reducing the rate of conversion from laparoscopy to open surgery, and ensuring the operation's safety.

We believe that for a highly challenging operation such as laparoscopic hilar cholangiocarcinoma, a smooth and safe learning curve requires the above-mentioned laparoscopic technical reserve, as well as the close cooperation of anesthesiologists and nursing teams. It is recommended to select suitable type 1 or partial type 2 cases in the initial stage, because these patients are relatively less difficult to operate. Because if serious complications occur early in the development of a new technology, it is a fatal blow to the confidence of the surgeon.

Table 3 Patients' postoperative characteristics and complications

Parameters	Value (n=44)
Overall hospital stay (d)	14.3±3.6
Exhaust time after surgery(d)	2.7±0.3
Complication	
Pulmonary infection	1(2.2)
Abdominal infections	3(6.8)
Bile leakage A class	3(6.8)
Hepatic insufficiency	1(2.2)
Clavien–Dindo grading system	
I: II: IIIa: IIIb: IV: V	4:3:1:0:0:0
Reoperation	0
Mortality (30 days)	0

Parametric data are presented as n (%) or mean (SD)

Evaluation of the assistance of preoperative imaging

Advanced imaging techniques can accurately determine tumor staging, classification, and resectability preoperatively, which is crucial for surgical success. MRCP displays the complete hepatic hilum mass, intrahepatic bile duct distribution, and invasion extent of the left and right hepatic ducts [14]. Three-dimensional CT reconstruction is essential for assessing vascular variation and the relationship between tumors and blood vessels. For patients potentially undergoing extensive hepatectomy, the residual liver volume should be evaluated before surgery. These factors guide surgical planning. All patients underwent enhanced CT and MRCP, followed by careful assessment to determine the preset upper edge. Additionally, the feasibility of safely performing R0 resection laparoscopically was judged, ensuring a safe and thorough operation while saving time.

Understanding and development of the scope of surgery

Radical R0 resection of hilar cholangiocarcinoma requires complete mass resection, negative margins, and clearance of potentially invaded surrounding tissues [15]. The previously prevalent theory of enlarged hepatectomy positively impacts tumor radical resection. However, it increases the risk of liver failure due to insufficient postoperative residual liver function, failing to improve prognosis and increasing risk [16]. Recently, many scholars have proposed 'perihepatic resection' under the guidance of precision hepatic surgery, which retains functional liver tissue while radically resecting tumor lesions [17]. This view aligns with our goal of radical laparoscopic surgery. We routinely handle the hepatoduodenal ligament during surgery to expose the hepatic artery, portal vein, and extrahepatic bile ducts, accurately localizing the tumor and its relationship with arterial and portal vein branches. Intraoperative fast frozen pathological examination confirms resection margins, including secondary bile ducts, caudate lobe bile ducts, and liver tissues.

For Bismuth type I and some type II cases, R0 resection is achievable after the above procedure. However, if preoperative examination or intraoperative exploration detects tumor invasion of the left (right) hepatic duct or caudate lobe hepatic duct, combined or extended hepatectomy is performed strictly according to standardized consensus [1].

Safety and clinical effect of this surgery

In this study, 39 out of 44 patients (88.6%) successfully underwent radical R0 resection, with most procedures (37/39) performed laparoscopically. The operation time and intraoperative blood loss were comparable to, or slightly better than, data from open surgery in most local and international centers in recent years [7–11]. Regarding postoperative complications, no cases of postoperative bleeding, perioperative death, or severe cardiopulmonary complications were observed. According to the Clavien–Dindo postoperative complication grading system, only one patient had a grade of 3 or higher, and this patient was successfully discharged after aggressive nutritional support, anti-infection, and other nonsurgical treatments.

The median age of the 44 patients in this study was 69.3 years, with the oldest patient being 80 years old, which is higher than previously reported in China [8, 9]. All patients recovered well after surgery, suggesting that the upper age limit for inclusion in this procedure can be relaxed. The minimally invasive nature of laparoscopic surgery may provide an opportunity for patients of advanced age and poor cardiopulmonary function to experience better postoperative recovery and a reduced incidence of postoperative cardiopulmonary-related complications.

Experiences and problems

Preoperative biliary drainage (PBD) strategy

Undoubtedly, PBD can significantly reduce the risk of liver resection in patients with hyperbilirubinemia. However, there remains ongoing debate about the benefits and drawbacks of PBD for perioperative and long-term survival in patients with hilar cholangiocarcinoma (HCCA) [18]. Guidelines from Europe and the United States recommend PBD before HCCA surgery, but there are no clear recommendations on the specific drainage route or protocol [19]. Our approach is to advocate for PBD in patients with cholangitis, prolonged biliary obstruction, poor nutritional status, serum total bilirubin > 200 μmol/L, and when extensive liver resection is needed with a residual liver volume of less than 40%. Currently, there is no uniform standard for the duration of preoperative biliary drainage. It is generally believed that the duration of drainage should be preferably more than 3 weeks, with a serum total bilirubin level below 50 μmol/L, and the liver function should be basically restored to normal.

Lymph node clearance

As shown by data, lymph node metastasis is a significant indicator of poor prognosis in hilar cholangiocarcinoma. The eighth edition of AJCC recommends routine dissection of lymph nodes located in the hilar, cystic duct, common bile duct, hepatic artery, pancreaticoduodenum, and near the portal vein [20]. Lymph node dissection in the hepatoduodenal ligament is a challenging and critical aspect of radical resection due to the presence of important blood vessels and the risk of uncontrollable bleeding during the dissection process.

Incomplete clearance of the site can lead to the remaining cancer cells in the hepatoduodenal ligament tissue becoming a high-risk factor for the recurrence of cholangiocarcinoma after resection19 [21]. Laparoscopy offers advantages in this regard, as it can be performed perpendicular to the visceral surface of the liver. The 30-degree lens provides a wide and deep field of vision, allowing for flexible rotation in the hilar region. The ultrasonic knife can be operated in close proximity to the blood vessel wall under close-sight operation. Additionally, laparoscopy facilitates the identification and clipping of small blood vessels supplying the tumor during lymph node dissection in the hilar area, minimizing unnecessary bleeding and ensuring a clear operation field and smooth progress of the operation. These advantages enable a more detailed and secure'skeletonization' operation of the hepatoduodenal ligament, which is associated with a high risk of haemorrhage. Although lymph node dissection behind the pancreatic head was previously considered to pose a risk of postoperative pancreatic leakage, our experience in laparoscopic pancreaticoduodenectomy suggests that a 'Kocher incision' can be utilized to expose the posterior segment of the common bile duct, allowing for the clearance of posterior pancreatic lymph nodes [13]. If the tumor is closely related to the blood vessels and the preoperative assessment indicates possible resection, a complete dissection and subsequent nondestructive blocking clip are recommended before proceeding with other relevant interventions.

Hepaticojejunostomy anastomosis

Hepaticojejunostomy anastomosis is another critical step in this operation, as the quality of the anastomosis is generally associated with the risk of postoperative biliary fistula. The fundamental principle of hepatic duct reconstruction is the mucosa-to-mucosa anastomosis of the hepatic duct to the jejunum [11, 22]. The main challenge arises from the deep location of the high bile duct and its proximity to the main branches of the portal vein, necessitating extra caution during the procedure. The magnification provided by laparoscopic surgery enables the operator to better control suture spacing, avoiding issues such as missed stitches and inadvertent injury to surrounding vessels, ultimately enhancing the quality of the anastomosis. It is recommended that the residual bile duct should not be excessively stripped, with 3–5 mm being an appropriate length. For patients undergoing PTCD before surgery, the catheter is generally visible after biliary duct incision, and the drainage tube is slightly retracted visually to avoid suture of the catheter during anastomosis, and then pulled out about 4 weeks after surgery. Dilated bile duct can be an advantage when constructing the anastomosis, in cases of significantly dilated and flexible bile ducts, a single layer of continuous epithelialization using a 4−0 or 5−0 barbed suture can be employed. However, if the bile duct is edematous and fragile, a 5−0 PDS II suture is preferable to prevent tissue tearing. When addressing bile duct severed ends, type III bile duct confluence is low, and adjacent bile ducts can be assembled and shaped into a single duct, reducing both the complexity of the anastomosis and the likelihood of biliary fistula formation. If the opening distance remains too excessive after rectification, separate anastomoses may be necessary. In situations where the bile duct openings are large and difficult to reshape, where excessive tension is present after reshaping, or where the bile duct wall is weak and prone to tearing during suturing, a pelvic anastomosis utilizing the Glisson sheath or the tough tissue of the porta hepatis is recommended.

Determination of negative hepatic duct margins

The "skeletonization" of the hepatoduodenal ligament, high-quality bile-intestinal anastomosis, and even combined hemihepatectomy no longer pose insurmountable technical barriers for surgeons with extensive laparoscopic experience. However, ensuring negative hepatic duct margins remains a challenge. Negative hepatic duct margins are of paramount importance for achieving R0 resection [23].

In open surgery, the texture of the bile duct and surrounding tissues can be visualized to provide a comprehensive view of the incisional margin. Even so, accurate determination by palpation can be difficult, relying on preoperative imaging and intraoperative frozen section pathology. Laparoscopic surgery, on the other hand, relies more heavily on intraoperative frozen section pathology to determine margins, requiring a higher level of pathology expertise in the hospital and greater demands on the surgeon to remove the bile duct stump during surgery. Ensuring the integrity of the anterior and posterior walls of the bile ducts and marking the upper and lower ends before sending the specimen for pathological examination, with a margin of at least 3 mm, is crucial. The magnification provided by the laparoscope can help distinguish small bile ducts and the specific location of tumor invasion, offering certain advantages. Future technological advances (e.g., 3D printing) may better address this issue [24].

Limitations of this study

This study is a single-center retrospective analysis with a small sample size, so the conclusions drawn are one-sided to a certain extent. Therefore, prospective studies with large sample size and long follow-up time are still needed in the later stage to further verify the findings. Additionally, the role of neoadjuvant chemotherapy, targeted therapy, and immunotherapy for patients with resectable hilar cholangiocarcinoma was not addressed. Despite these shortcomings, this minimally invasive surgery is friendly for elderly patients with liver insufficiency, and laparoscopic surgery also has advantages in amplification for lymph node dissection and high bilioenteric anastomosis. The most important thing is that none of the patients in this study had serious complications or died after surgery, and the safety of this operation can be preliminarily confirmed.

Conclusion

Laparoscopic hilar cholangiocarcinoma is a challenging procedure, and our limited experience suggests that it can be performed safely by selecting the appropriate cases for surgeons with extensive laparoscopic experience, which warrants further exploration to confirm its clinical efficacy.

Abbreviations

ENBD	Endoscopic nasobiliary drainage
PTCD	Ercutaneous transhepatic cholangial drainage
CT	Computed tomography
MRCP	Magnetic resonance cholangiopancreatography
ASA	The American Society of Anaesthesiologists classification
CHA	Common hepatic artery
PHA	Proper hepatic artery
HA	Hepatic artery
AJCC	American Joint Committee on Cancer
LH	Laparoscopic hepatectomy
ALB	Albumin
TBil	Total bilirubin
DBil	Direct bilirubin
HGB	Hemoglobin
BMI	Body mass index
IQR	Interquartile range

Author contributions
W.X.Z and Y.L proposed the study. Y.S.D designed and wrote the article. All authors contributed to literature searching, data collecting and interpretation of the study. Y.L and W.X.Z supervised the study and revised the article. All authors have reviewed and approved the final article.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Human ethics and consent to participate
This study was approved and adopted by the Ethics Committee of the Affiliated Hospital of Xuzhou Medical University (Ethics No.XYFY2019-KL051-01). All patients provided informed consent.

Competing interests
The authors declare no competing interests.

Disclosures
Yusheng Du, Ji Wang, Li Liu, Hongqin Ma, Wenxing Zhao, Ying Li have no conflicts of interest or financial ties to disclose.

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