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Clinical Study of Priority Exposure of Common Bile Duct in Laparoscopic Cholecystectomy to Prevent Biliary Tract Injury

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Abstract: The purpose of this study was to investigate the safety and feasibility of preferentially exposing the common bile duct in the prevention of iatrogenic biliary tract injury during laparoscopic cholecystectomy. The methods were retrospectively analyzed, and a total of 572 cases of LC were selected as the study group from March 2019 to December 2024. From March 2011 to December 2018, a total of 506 LC cases were used as control groups. The research group actively dissected the hepatoboduodenal ligament to reveal the common bile duct, clarified the location of the gallbladder duct into the common hepatic duct and then ligated and cut off the gallbladder duct, and the control group directly found and exposed the cystic duct and then ligated and cut off the gallbladder duct. The results showed that there was no intraoperative transmission of abdomen and biliary tract injury in the study group, no bile duct stenosis and 1 case of residual gallbladder after 6-36 months of follow-up. In the control group, there was 1 case of intraoperative laparotomy, 6 cases of biliary tract injury, 8 cases of bile duct stricture and 8 cases of residual gallbladder after 6-36 months of follow-up, and the difference was statistically significant (P<0.05). There were no significant differences in the type of gallbladder disease, preoperative comorbidities, operative time, intraoperative bleeding, and postoperative hospital stay between the study group and the control group. The conclusion is that LC has more advantages in preventing iatrogenic biliary tract injury, reducing surgery-related complications, and improving clinical prognosis.

Keywords: Common Duct; Iatrogenic Biliary Tract Injury; Laparoscopic Cholecystectomy; Bile Duct Stenosis

1 INTRODUCTION

Cholecystectomy is recognized as the preferred procedure for treating benign diseases of the gallbladder. Since laparoscopic cholecystectomy (LC) was first reported in 1987, with the update of medical concepts and the continuous development of laparoscopic technology, LC has gradually replaced open cholecystectomy, and has become the mainstream procedure and has become the gold standard for the treatment of benign gallbladder diseases. Gallbladder stones are the main cause of clinical LC. As the concept of laparoscopic minimally invasive has gradually taken root in the hearts of the people, LC, as its typical representative, has simplified the treatment of gallbladder stones, but at the same time, it has also relaxed the indications for gallbladder stone resection to a certain extent. Between 1989 and 1993, the number of cholecystectomy worldwide increased by 18.7%, including a significant increase of 25% among people aged 45-64 years [1-3]. Therefore, it is very important to be cautious about the indications for cholecystectomy surgery. At present, LC is the best choice for the treatment of benign diseases of the gallbladder, with the continuous popularization of laparoscopic technology and equipment, the learning curve time of LC is shortened, more and more grassroots hospitals have laparoscopy and have the ability to carry out LC independently, but due to the difference in the development of technology and equipment, according to relevant statistics, there is still 0.3-0.5% iatrogenic biliary duct injury (BDI), which is 2-3 times that of open cholecystectomy. LC has become the most common cause of iatrogenic biliary tract injury [4-6], causing great trauma to patients' physical, mental, and economic conditions, losing the inherent advantages of minimally invasive surgery, increasing surgical complications, and reducing long-term prognosis and survival. For patients with a long course of disease, recurrent acute cholecystitis, gallbladder atrophy, suspected gallbladder

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triangular fibrosis, Mirizzi syndrome, or anatomical variations before surgery, it is recommended to complete ultrasound, enhanced CT, and MRCP before surgery, and carefully evaluate the degree of gallbladder inflammation, gallbladder triangle, and perihepatic hilum anatomy before selecting the surgical method [7]. Avoiding intraoperative biliary tract injury in LC is the goal that hepatobiliary surgeons always pursue. Most iatrogenic biliary tract injuries are caused by doctors misidentifying the common hepatic duct or common bile duct as a cystic duct and then arbitrarily clamping and separating it, resulting in bile duct injury, or improper ligation of the cystic duct leading to postoperative bile duct stenosis or residual gallbladder. Many doctors believe that the comprehensive evaluation of the patient's imaging before surgery and the accurate dissection of the Calot triangle during the operation are the most critical, and most of them are passively exposed the common bile duct, lest the free common bile duct cause damage to blood vessels and single canals and are unwilling to actively reveal it. Our team investigated the safety and feasibility of the technique of preferential bile duct exposure during LC by comparing the operation time, intraoperative blood loss, postoperative hospital stay, bile duct injury, postoperative liver stenosis, and the incidence of residual gallbladder between LC and traditional LC.

2 Data and Methods

2.1 General Information

A retrospective analysis showed that from March 2019 to December 2024, a total of 572 cases of LC were selected as the study group. From March 2011 to December 2018, a total of 506 LC cases were used as control groups. Case selection criteria: Preoperative CT and B-ultrasound clearly diagnosed, benign lesions that meet the indications for cholecystectomy, and can tolerate endotracheal intubation general anesthesia and pneumoperitoneum. Exclusion criteria: LC was performed with laparoscopic liver resection and/or common cholangiotomy for intrahepatic cholangiostones, gallbladder stones with endoleakage and Mirizziz syndrome.

There were 273 males and 299 females in the study group. Age 23-91 years, median age 64 years. Body mass index (BMI) 16.5-41.1, average 23.3. There were 448 cases of gallbladder stones and chronic cholecystitis, of which 17 were preceded by percutaneous puncture and drainage of liver and gall bladder PTGD and LC 2 months after surgery; 63 cases of gallbladder stones and acute cholecystitis, 7 cases of gangrene, and 3 cases of perforation; 32 cases of gallbladder polyps (diameter $\geqslant$1cm); 19 cases of gallbladder adenomyosis. There were 51 cases of abdominal pain in 1-3 days with gallbladder stones and acute cholecystitis, 17 cases with abdominal pain in 4-5 days, and 5 cases in 6-7 days. There were 23 cases with a history of abdominal surgery, 53 cases with hypertension, and 27 cases with diabetes.

There were 506 cases in the control group, 241 males and 265 females. Age 20-83 years, median age 61 years. BMI 16.8-41.3. There were 402 cases of gallbladder stones and chronic cholecystitis, 51 cases of gallbladder stones and acute cholecystitis, 4 cases of gangrene, and 2 cases of perforation. 35 cases of gallbladder polyps (diameter $\geqslant$1cm); There were 12 cases of gallbladder adenomyosis. There were 48 cases of gallbladder stones and acute cholecystitis with abdominal pain in 1-3 days, abdominal pain in 3 cases in 4-5 days, and 0 cases in 6-7 days. There were 18 cases with a history of abdominal surgery, 50 cases with hypertension, and 23 cases with diabetes.

There were no significant differences in the basic conditions such as gender, age, BMI index, proportion of acute cholecystitis, and comorbidities between the two groups.

2.2 Surgical Methods

Endotracheal intubation is under general anesthesia, and after the lying position, it is changed to a high head and low position. A 10mm incision below the umbilical cord was taken, a pneumoperitoneum was established, the abdominal pressure was maintained at 12-14mmHg, a 30-degree laparoscope was placed, and a 10mm main operation hole and a 5mm auxiliary operation hole (three-hole method) were established to the right side of the xiphoid process and under the costal margin of the right midclavicle, respectively. If the gallbladder is large or the tension is high and it is not easy to pull or seriously affect the surgical operation, a small hole can be cut at the bottom of the gallbladder and immediately decompressed the gallbladder with an aspirator before surgery.

Research group: After revealing the Calot triangle, first make a longitudinal incision in front of the peritoneum of the hepatoduodenal ligament at the place where the cystic duct may merge into the common bile duct, expose the common bile duct 0.5-1cm downwards, and expose the common hepatic duct 0.5-1cm upwards, bluntly peel off the adipose tissue in front of the common bile duct and common hepatic duct (pay attention to avoid damaging the bile duct trophic vessels), at this time, the cystic duct and the gallbladder artery are also easy to dissect and reveal, and the relationship between the three bile ducts of the cystic duct, common hepatic duct, and common bile duct is clearly distinguishable. Separate and reveal the gallbladder duct and gallbladder artery, ligate and break the gallbladder artery, ligate and break the gallbladder duct about 5mm away from the common bile duct, remove the gallbladder from the gallbladder bed with an ultrasound knife or electric hook, and remove the gallbladder from the operating hole under the xiphoid process with a retrieval bag. The gallbladder bed completely stopped the bleeding, checked the stump of the cystic duct and the gallbladder bed for no bleeding or bile leakage, reconfirmed the relationship between the three bile ducts, and decided whether to place a Winslow hole drainage tube according to the intraoperative situation, close each incision, and completed the operation.

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FIG. 1 ANTEROGRADE LC PREFERENTIALLY EXPOSES THE COMMON BILE DUCT

FIG. 2 RETROGRADE LC PREFERENTIALLY EXPOSES THE COMMON BILE DUCT

FIG.3 THE GALLBLADDER DUCT IS SEPARATED AFTER IDENTIFYING THE THREE-TUBE RELATIONSHIP

After revealing the Calot triangle, first dissect the free cystic duct, after showing the gallbladder duct, carefully separate the gallbladder artery and then reveal the gallbladder duct, common hepatic duct, and common bile duct area, after completely free the gallbladder triangle, ligate and break the gallbladder duct about 5mm away from the common bile duct, separate the gallbladder duct from the gallbladder bed with an ultrasonic knife or electric hook, completely stop the bleeding, check the gallbladder bed and the stump of the cystic duct for no bleeding and bile leakage, and check the anatomical relationship of the three bile ducts again. According to the intraoperative situation, decide whether to place the Winslow hole drainage tube, close each incision, and complete the operation.

2.3 OBSERVATION INDICATORS

The operation time, intraoperative blood loss, postoperative hospital stay, and postoperative complication rate of the two groups were observed.

2.4 METHODS

The data were processed using SPSS 17.0 statistical software, and the measurement data were expressed as ($\bar{x} \pm s$) and the t-test was used. The calculation data is expressed as a percentage and the X2 test is performed. The test level is $\alpha=0.05$.

3 RESULTS

All 572 patients in the study group completed LC according to the preoperative plan, without transit laparotomy and iatrogenic biliary injury, and the operation time was 30~160 minutes, with an average of 42.32±14.68 minutes. intraoperative blood loss was 5~300ml, with an average of 18.64 ± 8.62ml; The postoperative hospital stay was 2~10 days, with an average of 3.78 ± 1.68 days. Postoperative pathology: 448 cases of gallbladder stones and chronic cholecystitis, 63 cases of gallbladder stones and acute cholecystitis, 7 cases of gangrene, and 3 cases of perforation; 32 cases of gallbladder polyps; 19 cases of gallbladder adenomyosis. There was no postoperative extrahepatic bile duct stricture after 6-36 months of follow-up, and 1 residual gallbladder disease occurred, which improved after active treatment.

503 patients in the control group completed LC as planned, with an operation time of 35~150 minutes, an average time of 41.56 ± 19.82 minutes, intraoperative bleeding of 10~250ml, an average blood loss of 18.35 ± 9.25ml, and a postoperative hospital stay of 3~9 days, with an average hospital stay of 3.56 ±2.65 days. Postoperative pathology: 402 cases of gallbladder stones and chronic cholecystitis, 51 cases of gallbladder stones and acute cholecystitis, 4 cases of gangrene, and 2 cases of perforation; 35 cases of gallbladder polyps; There were 12 cases of gallbladder adenomyosis. Three cases had iatrogenic biliary tract injury, including 1 case of biliary tract injury (Strasberg type D) underwent laparoscopic bile duct repair + T-tube drainage, 3 cases of biliary tract injury (Strasberg type E1) were transferred to open abdomen for biliary Roux-en-Y anastomosis, and 3 cases had biliary leakage on the second day after surgery, and MPCP confirmed biliary tract injury (Strasberg). E2 type), and the second surgery was performed to perform gallblioenteral Roux-en-Y anastomosis. The 6 patients had no biliary stricture after 36 months of follow-up. 8 cases of extrahepatic bile duct stenosis and 8 cases of residual gallbladder disease. The iatrogenic biliary tract injury in the study group was significantly reduced, and the surgical difficulty in the study group was increased. See Table 1 and Table 2.

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TABLE 1 DATA OF THE TWO GROUPS 1. COMPARISON OF INTRAOPERATIVE AND POSTOPERATIVE CONDITIONS

Constituencies	n	Operation time(min)	Intraoperative bleeding (ml)	Postoperative length of hospital stay(d)
Study group	572	42.32 ± 14.68	18.64 ± 8.62	3.78 ± 1.68
Control group	506	41.56 ± 19.82	18.35 ± 9.25	3.56 ± 2.65
t		0.71	0.53	1.64
P-value		>0.05		

TABLE 2 COMPARISON OF POSTOPERATIVE COMPLICATIONS BETWEEN THE TWO GROUPS

Constituencies	n	Biliary tract injury	Extrahepatic bile duct stenosis	Residual cystic duct disease
Study group	572	0	0	1
Control group	506	6	8	8
X2		4.84	7.09	4.82
P-value		<0.05		

4 DISCUSSION

At the beginning of 1991, Dr. Zhong Shangzhi and Dr. Gou Zuwu performed and independently performed the first LC surgery in Chinese mainland [8,9], marking that our country's abdominal minimally invasive surgical technology has entered the track of rapid development, and LC is currently the first choice for the treatment of benign diseases of the gallbladder, after more than 30 years of minimally invasive biliary surgery, iatrogenic biliary tract injury is still the key area of LC prevention, and is one of the most serious complications of LC. BDI can lead to serious complications such as bile leakage, biliary peritonitis, bleeding, cholangitis, bile duct stricture, intrahepatic bile duct stones, liver atrophy, biliary cirrhosis, portal hypertension and even liver failure. 20% of BDI patients require multiple surgeries, and about 0.8% of BDI patients even end up with liver transplantation. The case fatality rate associated with BDI can reach 0.95% [10], which not only seriously affects the life safety and quality of life of patients, but also is an important hidden danger leading to medical disputes. It must be noted that elderly patients are slow to respond to pain, do not seek medical attention quickly, and are often accompanied by complications when discovered; At the same time, it is often accompanied by complications such as underlying diseases, which increases the risk of treatment and the difficulty of surgery. In addition, problems such as slow postoperative recovery, poor wound healing, and weakened immunity all make clinical treatment challenging. Surgery should be actively considered for patients who are suitable for surgery, and studies [11-12] have shown that surgery is more effective than delaying surgery as early as possible (in the first three days). However, it should be noted that the perioperative incidence of cholecystectomy in the elderly was 24% and the mortality rate was 3.5% [13]. At the same time, the proportion of biliary tract injury in elderly patients undergoing gallbladder surgery is higher, about 0.10% in people under 50 years old, 0.13% in people aged 60~79 years, and 0.14% in people over 80 years old [14]

The causes of LC-associated biliary tract injury (BDI) mainly cover both subjective and objective levels. Objective factors include: (1) Anatomical factors. There are accessory bile ducts, segments IV.b or V that run superficially in the gallbladder bed, and subvesical bile ducts between the intrahepatic biliary tract and the gallbladder [15-17]or abnormal gallbladder duct such as absence, confluence, and abnormal movement; the common hepatic duct or common bile duct is slender and difficult to identify, etc. (2) Pathological factors. Tissue edema, easy bleeding, dense adhesions or severe fibrosis in the triangular region of the gallbladder, tissue contracture, loss of anatomical layers of the gallbladder wall, etc. Subjective factors include: (1) Insufficient preoperative evaluation. Inadequate history and imaging reading lead to inadequate understanding of the inflammatory status and anatomical variations in the gallbladder region. (2) Improper surgical operation. Improper layout of the puncture hole, poor exposure or excessive traction of the gallbladder triangle leading to angular deformation of the common bile duct, rough operation techniques, wrong anatomical path and hierarchy, misidentification of vasculature structure in the perihepatic hilar area, improper use of surgical instruments, especially energy instruments, leading to bile duct thermal injury.

Many BDIs occur in cases where inflammation is not severe and the gallbladder triangle is easy to dissect. Surgeons relax their vigilance, blindly speed up the operation, ignore anatomical variations, and increase the arbitrariness of operations are the main reasons. Maintaining the correct anatomical level, carefully identifying the exposed vasculature, achieving a critical view of safety (CVS) as much as possible, and not easily breaking any duct structure before confirming the confluence of the cystic duct-common hepatic duct-common bile duct are important steps to prevent injury.

Through relevant clinical studies, it was found that giving priority to actively exposing the common bile duct during LC surgery, and then dissecting the common hepatic duct and cystic

duct will greatly reduce the possibility of misjudgment of the cystic duct. Second, the dissection of the common bile duct will not prolong the operation time and increase bleeding, and the operation time and bleeding of the study group and the control group are basically the same, because the technical method is simple, the opening structure level is shallow, and the risk is controllable: slightly open the peritoneum in front of the hepatoduodenal ligament, and then use separation forceps to bluntly separate the common bile duct 0.5~1cm, and then cut the hepatoduodenal ligament longitudinally to dissect the common hepatic duct 0.5~1cm, at this time, the gallbladder duct and gallbladder artery are also easy to dissect and reveal, the cystic duct, common hepatic duct, The relationship between the three tubes of the common bile duct is clearly identifiable (Figure 1). The results of the control between the two groups showed that there was no increase in operation time and intraoperative bleeding.

Some scholars believe that excessive dissection of the common bile duct-common hepatic duct will lead to blood circulation disorders and increase the occurrence of complications such as leakage of cystic duct stump or extrahepatic bile duct stenosis after surgery. The blood circulation of the common bile duct comes from multiple arteries, and there is a high chance of anastomosis arteries appearing on the left and right edges [18], and the author's priority to reveal the common bile duct technique does not require excessive free arteries, but only 0.5~1.0cm in front of it, which will not seriously damage the bile duct trophic vessels, does not affect the blood circulation of the bile ducts, and can clearly distinguish the relationship between the "three bile ducts". In fact, when laparoscopic common bile duct incision and lithotomy stage I suturing or radical gastric cancer dissection of twelve groups of lymph nodes, the range of common bile duct free is larger, and sometimes it is inevitable to break the bile duct nutritional blood vessels. Some doctors have suggested that LC surgery with the Rouviere groove as a marker and boundary can prevent iatrogenic biliary tract injury, and confirm the location of the Rouvière groove and the boundary between the hepatic hilar plate and the basal segment of segment IV (S4) [19]. The virtual connection formed by these two points is the range of the "liver bed" on the head side. The incision of the subserosal layer of the gallbladder should be above the ventral and cephalic levels of this line, and should be avoided on the dorsal and foot sides to prevent damage to the right posterior Glisson's pedicle, common hepatic (bile) duct, or mistakenly entering the common bile duct, but this anatomical landmark will be missing in some patients, and the authors reported that only 705 of the 750 patients had Rouviere, with a deletion rate of 6% [20]. Moreover, some patients are prone to postoperative residual gallbladder disease due to the clamping and severing of the cystic duct due to the distance from the common bile duct.

With the development of laparoscopic technology, surgeons are becoming more and more skilled, and acute cholecystitis is no longer a contraindication to laparoscopic surgery [21], giving priority to the common bile duct technique is more important to prevent biliary tract injury. Through research and summarizing experience, it is found that in the case of very difficult LC surgery, a 0.5cm assistant operation hole can be added, and the gallbladder with large tension or volume can be sucked out of the bottom of the gallbladder to decompress before surgery. At this time, intraoperative cholangiography, flexible cholangioscopy, ICG intrahepatic biliary fluorescence imaging technology, laparoscopic intraoperative ultrasound (LIOUS), etc. can be used to help reveal the surgical field. The most effective and commonly used technique for identifying biliary tract travel during surgery is biliary construction [22].

Hashimoto et al. [23] reported in a retrospective multicenter study that the recognition rate of LIOUS at the confluence of the tritube at the beginning of dissection of the gallbladder triangle was as high as 84%, and the recognition rate after the triangle was revealed was further increased to 98%. The use of LIOUS at the end of surgery also confirms the integrity of the common bile duct. These are priority exposure common bile duct techniques assisted by special equipment.

In summary, it is safe and feasible to apply priority exposure common bile duct technology to prevent iatrogenic biliary tract injury in LC, and the technology is simple and worthy of promotion.

5 Conclusion

It was found that the biliary injury rate was significantly lower in the study group compared with the control group (0‰ in the study group vs 12‰ in the control group; Second, the dissection of the common bile duct did not prolong the operation time (42.3 vs. 41.5 min in the control group) and increase bleeding (18.6 vs. 18.3 ml in the control group), and the operation time and bleeding in the study group and the control group were basically the same. In addition, studies suggest that active exposure of the common bile duct can effectively reduce the incidence of residual cystic duct disease in the study group 2‰ vs 16‰ in the control group, improve the long-term quality of life of patients, and reduce medical expenses.

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