MRCP and microincision of the cystic duct can prevent residual gallstones: A single-center experience

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Research Article

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Abstract

Background: Residual gallstones are an infrequent but troublesome complication after laparoscopic cholecystectomy (LC). This study aimed to explore the feasibility of routine preoperative magnetic resonance cholangiopancreatography (MRCP) examination and intraoperative microincision of the cystic duct in preventing residual gallstones after LC surgery.

Methods: This report presents a summary and analysis of 1217 cases of gallbladder stones treated by LC in the People's Hospital of Nyingchi from January 2016 to August 2021. According to the different measures taken to prevent residual gallstones, it is divided into 3 phases. In phase 1, there is no preoperative MRC examination P and intraoperative microincision. In phase 2, preoperative MRCP examination was performed without intraoperative microincision. In phase 3, both preoperative MRCP examination and intraoperative microincision were performed. Then the differences in residual gallstones at different phases were analyzed. And further analysis of preoperative MRCP and intraoperative microincision case data was performed to assess feasibility in phase 3, including the extra cost posed by the MRCP examination, operation time, volume of blood loss, and presence of residual gallstones after surgery.

Results: In phase 1, 0.63% (3/473) of patients had residual gallstones after LC surgery; in phase 2, 0.24% (1/418) of patients had residual gallstones; in phase 3, no patients residual gallstones were present (0/326). Feasibility analysis for Phase 3 showed that 7.98% of cases of silent choledocholithiasis that were not detected by abdominal ultrasound were detected by MRCP, and MRCP examination only accounted for 9.45% of the total hospitalization expenses, which could effectively reduce the missed diagnosis of cholecystolithiasis combined with choledocholithiasis. The average time of microincision and squeezing of the cystic duct during the operation was 3 to 5 minutes, and the bleeding volume was 1 to 3 ml, indicating that microincision of the cystic duct was safe and easy to perform. Sedimentary stones or flocs could be squeezed out by this technique in 21% of LC cases, which could effectively reduce the risk of secondary choledocholithiasis stones after surgery.

Conclusion: These data show that routine preoperative MRCP examination and intraoperative microincision of the cystic duct can effectively prevent residual gallstones after LC.

Introduction

Gallstone disease is one of the most common disorders in the world, the prevalence in the Western countries is approximately 7.9–16%, of which, approximately 80% are without symptoms [1]. A report showing a gallstone disease frequency of 8.1% among 2,068,523 participants screened in a study conducted in Shanghai, China [2]. The prevalence of gallstones is even higher in the Tibetan Plateau, and this may be related to the hypoxic environment of the plateau and the Tibetans' long-term preference for high-calorie and high-fat foods, such as butter tea [3, 4]. Among elective abdominal surgeries per year, cholecystectomy is the most common [1]. Usually, cholecystectomy can be divided into open

cholecystectomy and laparoscopic cholecystectomy. In 1987, Mouret performed the first laparoscopic cholecystectomy (LC) for gallstone disease. Since then, LC technology has developed rapidly, and this surgical procedure has become the gold standard for clinical cholecystectomy [5]. However, LC is an indirect operation and lacks the direct touch of the surgeon's hand, compared with traditional open surgery, some serious complications, such as residual gallstones, bile duct damage and biliary leakage are more likely to occur [6]. This is especially problematic for common bile duct stones that do not cause clinical symptoms [7].

Residual gallstones are a very difficult complication after LC surgery. Once it occurs, endoscopic retrograde cholangiopancreatography (ERCP) plus endoscopic sphincterotomy (EST) or repeat abdominal surgery is required, and ERCP/EST may not be performed in less developed areas due to limited technical skills. Repeat abdominal surgery is traumatic and expensive for patients, which is difficult for patients and their families to accept. How to prevent the residual gallstones after LC surgery seems more worthwhile. We tried to discuss the measures to prevent residual gallstones from two aspects before and during operation.

At present, imaging methods commonly used for the preoperative diagnosis of biliary tract diseases include ultrasound, CT, ERCP, percutaneous transhepatic cholangiopancreatography (PTC) and magnetic resonance cholangiopancreatography (MRCP) [8]. Abdominal ultrasound has the advantages of simplicity, economy, avoiding the use of radiation, and being painless, and has always been the first choice for cholelithiasis. However, due to limitations associated with equipment performance, operator expertise, and gas accumulation in the right upper quadrant, the accuracy of ultrasound in judging cystic duct and common bile duct lesions is only 60% [9]. Similarly, CT imaging has its own limitations, as it is affected by factors such as the thickness of the scanning slices, lack of continuity in the bile duct, its tendency to miss small lesions, and its unsuitability to the diagnosis of equal-density or sedimentary stones. Since PTC and ERCP are invasive examination, they are generally not preferred [10]. MRCP is a noninvasive cholangiopancreatic hydrography technique that can clearly display the anatomical variation of the bile duct system, intrahepatic and extrahepatic bile duct stones, space-occupying lesions, obstruction and dilation. Relative to abdominal ultrasound and CT, MRCP does not suffer from blind spots and improves the detection rate of stones in the middle and lower segments of the common bile duct [11]. Cystic duct microincision was developed in recent years as a supplement for laparoscopic cholelithiasis surgery [12]. Most studies on this technique describe its use for common bile duct stones, but this approach has rarely been used in simple LC surgery [12–14].

In this study, we aimed to explore the feasibility of routine preoperative MRCP examination and intraoperative microincision of the cystic duct in preventing residual gallstones after LC surgery. To do this, we performed a retrospective analysis of the clinical experience at People's Hospital of Nyingchi. The study outcomes used to assess feasibility were extra costs, operation time, blood loss and residual gallstones.

Materials And Methods

Study design

We collected clinical data of 1,217 patients who underwent LC surgery in People's Hospital of Nyingchi from January 2016 to August 2021. All patients enrolled in the study provided informed consent information. The study protocol conformed to the ethical guidelines of the Declaration of Helsinki, and was approved by the Ethical Committees and Institutional Review Board of People's Hospital of Nyingchi, Tibet. We divided the surgical cases into 3 phases according to different periods. From January 2016 to December 2017 as the first phase, a total of 473 patients with LC surgery were included, with no MRCP examination before surgery and no microincision or extrusion of the cystic duct during the surgery. From January 2018 to December 2019 as the second phase, 418 patients with simple LC due to gallbladder stones underwent routine MRCP examination before the operation, with no microincision or extrusion of the cystic duct during the operation. From January 2020 to August 2021 as the Third phase, 326 patients with simple LC due to cholecystolithiasis underwent routine MRCP examination before the operation and microincision and extrusion of the cystic duct during the operation. For further study, the Clinical practice protocol of the third phase is shown in Fig. 1.

Patients

A total of 1,217 patients who underwent LC surgery in three phases were included in this study. The inclusion criteria were as follows: (1) abdominal ultrasound-confirmed cholecystolithiasis before admission, with or without cholecystitis; (2) age greater than 18 years but less than 80 years; (3) no history of upper abdominal surgery; (4) no pneumoperitoneum or general anesthesia contraindications; and (5) no moderate or severe anemia.

The exclusion criteria were as follows: (1) the presence of common bile duct stones or intrahepatic bile duct stones found by outpatient abdominal ultrasound before admission; (2) gallstones combined with jaundice; (3) alanine aminotransferase (ALT) or aspartate aminotransferase (AST) levels greater than 3 times the normal value; (4) creatinine or urea nitrogen levels greater than 1.5 times the normal value; (5) gallstones combined with pancreatitis; (6) severe cardiopulmonary disease or inability to tolerate surgery; or (7) pregnancy.

Assessment of clinical indicators

We further analyzed the clinical data of 326 patients with LC surgery in phase 3. Among the 26 cases of common bile duct stones found on preoperative MRCP examination, all of them had multiple stones with diameters ≤ 5 mm. The outpatient B- ultrasound results of these patients were negative, with no common bile duct dilatation and no jaundice. MRCP was performed using a 1.5 T system (Optima MR 360, GE) before surgery.

The surgical data of 300 patients who underwent LC surgery alone were collected. There were 83 cases of single gallbladder stones and 217 cases of multiple gallbladder stones. Sedimentary stones were defined as multiple small stones with a maximum diameter of < 1.5 mm. All the selected cases underwent

intraoperative cystic duct microincision and extrusion, and the total operation time and cystic duct microincision and extrusion time were recorded. Blood loss during the entire operation, including cystic duct microincision, was recorded by suction bottle measurement per the operator's judgment and experience.

Evaluation indicators

The study outcomes in Phase 3 patients were evaluated by the following indicators. They were (1) Total hospitalization costs and MRCP examination costs; (2) operation time and time of cystic duct microincision/extrusion; (3) intraoperative blood loss and cystic duct microincision blood loss; and (4) residual gallstones. Cases of residual gallstones were identified by abdominal ultrasonography, routine blood and biochemical indexes of all patients six months after surgery. If the patient's B-ultrasound examination results are normal, but the patient has abdominal pain, fever, or jaundice, or the laboratory test indicators are abnormal, outpatient MRCP examination is required to further exclude the presence of residual gallstones.

Results

Patients' characteristics

General characteristics of the included patients are shown in Table 1. There was no statistical difference between the three phases in sex, age, BMI, History of gallstones, symptoms and signs. For the phase 3, women were the high-risk group of gallstones, accounting for 66.26% (216/326) of the total cases; the mean age was 48.79 years old; the mean BMI was 25.37 kg/m^2, and the medical history ranged from 2 days to 20 years. The patients who underwent surgery for asymptomatic gallstones accounted for 42.64% (139/326).

Table 1
General characteristics of the included patients

Characteristics	Phase 1 (n = 473)	Phase 2 (n = 418)	Phase 3 (n = 326)	*P* value
Sex(male/female)	154/319	148/270	110/216	0.668
Age (years)	47.46 ± 10.45	46.79 ± 15.63	48.79 ± 13.27	0.117
BMI (kg/m^2)	24.87 ± 3.87	25.06 ± 3.42	25.37 ± 3.65	0.166
History of gallstones	1 days ~ 18 years	1 days ~ 25 years	2 days ~ 20 years	
Abdominal pain or fever before surgery	247	225	187	0.353
Murphy sign	86	82	75	0.239

Surgical procedure

LC was performed on all cases as a conventional four-hole operation, with general anesthesia with tracheal intubation, and in the head-high-foot-low-left tilt position. The CO2 pneumoperitoneum pressure was set at 12–14 mmHg. The assistant clamped the gallbladder body-bottom and pushed it toward the abdominal wall, exposing the gallbladder triangle. The surgeon used an electric hook to separate the adhesions around the gallbladder and dissected the anterior and posterior triangles of the gallbladder. If the gallbladder tension greatly affected the operation, the gallbladder was decompressed first. If gallbladder triangle adhesion was serious, the assistant used gauze to hold the liver to expose the adhesion and the gallbladder was removed in a retrograde manner. After dissecting the gallbladder triangle, the cystic artery was clamped and cut off to visualize the connection between the cystic duct, the common hepatic duct and the common bile duct clearly. Separation forceps were used to squeeze the cystic duct from the common bile duct to the gallbladder neck, and the potential small cystic duct stones were squeezed into the gallbladder. Then, titanium clips were used to close the cystic duct near the gallbladder neck. A piece of clean gauze was placed under the gallbladder triangle, then a "cystic duct microincision" was performed at a distance of 0.2 cm below the titanium clip. The cystic duct was cut horizontally to ½ its diameter, and the common bile duct and cystic duct were squeezed from the common bile duct to the gallbladder neck, extruding possible sedimentary stones or flocs through the microincision (Figs. 2A-C). If the diameter of the cystic duct was too small for extrusion, the duct was enlarged with separation forceps. Extruded bile that was clear and yellow indicated that the cystic duct and common bile duct were unobstructed and that no stones remained. Then, the cystic duct was clipped with a Hemolock at a distance of 0.5 cm from the confluence and then cut off, and the gallbladder specimens were separated and removed. In cases where choledocholithiasis was found by preoperative MRCP (Fig. 3), choledocholithotomy was performed after removal of the gallbladder.

Outcomes of residual gallstones

The outcomes of residual gallstones in different phases are shown in Table 2. In phase 1, 473 patients underwent LC surgery, with no MRCP examination before surgery and no microincision or extrusion of the cystic duct during the surgery, resulting in residual gallstones in 3 patients. In phase 2, 418 patients received LC surgery underwent routine MRCP examination before the operation, with no microincision or extrusion of the cystic duct during the surgery, resulting in residual gallstones in 3 patients. These patients with residual gallstones underwent reoperation or treatment by means of the endoscopic stone extraction technique (EST) treatment for these patients after simple LC. In the phase 3, 326 patients received LC surgery underwent routine MRCP examination before the operation and microincision and extrusion of the cystic duct during the operation, no residual gallstones were found at 6-month follow-up after surgery.

Table 2
Residual gallstones in different phases

Preventive measures	Phase 1 (N = 473)	Phase 2 (N = 418)	Phase 3 (N = 326)
Preoperative MRCP	No	Yes	Yes
Intraoperative microincision	No	No	Yes
Residual gallstones (%)	3 (0.63%)	1 (0.24%)	0 (0%)

Extra expenses

In the phase 3, the 326 patients who underwent LC in this study recovered successfully and were discharged from the hospital after surgery. The total cost of hospitalization was 11,786.40 yuan to 28,432.25 yuan, and the median cost was 14,437.47 yuan. The inspection fee for MRCP was 1,365.00 yuan, accounting for approximately 9.45% of the total cost (1365/14,437.47). Preoperative routine MRCP examination identified 26 cases of common bile duct stones missed by abdominal ultrasonography, and these cases accounted for 7.98% (26/326) of all gallbladder stone cases (Fig. 1). MRCP examination accounted for 9.45% of the extra cost, and 7.98% of silent choledocholithiasis were detected, which was a very worthwhile thing.

Surgical feasibility

In the phase 3, 300 patients underwent simple LC surgery and microincision and extrusion of the cystic duct, without choledocholithotomy. The operation time ranged from 30 to 135 minutes, with the median time being 63 minutes. Generally, cystic duct microincision and squeezing plus wiping and cleaning took 3 to 5 minutes, accounting for approximately 5% of the operation time. Sedimentary stones or flocs were extruded in 63 cases, accounting for 21% of the total cases. The blood loss volume from simple LC surgery ranged from 5-100 ml, the median blood loss was 10 ml, and that from the cystic duct microincision was only 1–3 ml. Therefore, in terms of operation time and blood loss, cystic duct microincision was safe and had little impact on the entire operation, the effect is remarkable and worth promoting.

Discussion

LC is the accepted “gold standard” operation for gallstone disease, owing to its minimal morbidity and rapid recovery resulting in a high acceptability of this treatment option. Nowadays, approximately 95% of patients with gallbladder stones are treated with laparoscopic cholecystectomy [15]. The increased risk of conversion to open cholecystectomy is associated with obesity, a history of previous abdominal surgery, gallbladder wall thickening, acute cholecystitis, leukocytosis, or jaundice as well as suspicion of common bile duct stones [16]. Whether laparoscopic or open cholecystectomy is performed, the incidence of residual gallstones after cholecystectomy is very low. The reported incidence of residual gallstones following cholecystectomy is less than 2.5% [17]. According to the review by Chowbey [18], the typical sites of residual gallstones after cholecystectomy are the residual gallbladder (56.6%), cystic duct

(40.7%) and common bile duct (2.7%). With the extensive development and technical proficiency of LC surgery, residual gallbladder or cystic duct stones have rarely occurred. In this study, we had 3 cases of residual gallstones in Phase 1 and 1 case of residual gallstones in Phase 2, all of which were located in the common bile duct, which were silent common bile duct stones before surgery. Due to the lack of ERCP/EST technology in this area, these patients with residual choledocholithiasis developed acute cholangitis after LC surgery and were forced to undergo emergency reoperation, which brought great trouble to the clinic and patients.

Cholelithiasis is a common digestive tract disease with an incidence of 5%-15%, of which 5%-30% are combined with Choledocholithiasis [19]. As we all know, abdominal ultrasonography has its limitations in the judgment of common bile duct disease, and usually requires a combination of laboratory tests and clinical manifestations for diagnosis. In 1991, Wallner et al. introduced MRCP as an alternative imaging method into the examination of hepatobiliary and pancreatic diseases, and it has been gradually accepted and widely used in clinical practice [11]. Yan Qiu et al. showed that concurrent gallbladder stones and choledocholithiasis accounting for 26.39% of all gallstone cases, of which 44.95% of cases were not detected by ultrasound examination but were confirmed by MRCP instead [20]. Nibiker CA et al. and Bahram M et al. revealed that MRCP screening prior to LC surgery, clinically silent CBD stones were found in 4% [21, 22].

In Phase 3 of this study, 26 cases of common bile duct stones were found by preoperative MRCP and were misdiagnosed as simple gallstones by abdominal ultrasonography, accounting for 7.98% of all gallstone cases. In these cases, single-stage LC combined with choledochal incision for exploration and stone extraction was conducted to avoid the risk of residual gallstones or medical disputes in these patients after simple LC. Due to economic improvements and increases in the medical insurance reimbursement ratio over time, most patients can afford the additional cost of the MRCP examination cost, which makes up less than 10% of the cost of the entire procedure. Furthermore, MRCP examination can reduce the missed diagnosis rate by 7.98%, making the examination quite valuable in terms of cost and long-term efficacy. Consistent with our data, the study by Rao et al showed that among 106 patients with newly diagnosed gallstones, 16% of had choledocholithiasis, and in 6% of the total, the choledocholithiasis could not be detected by ultrasonography and but was detected by MRCP [23]. Anwar et al reported that for common bile duct stones, the sensitivity of abdominal ultrasound was only 78.2%, while the sensitivity of MRCP was as high as 92%, with mostly sedimentary stones in false-negative cases [24]. The results of the above studies suggest that MRCP is a noninvasive and very low-risk test with high diagnostic sensitivity and specificity for cholelithiasis and can be carried out as a routine preoperative test.

Microincision of cystic duct is mainly used for laparoscopic transcystic common bile duct exploration in patients with common bile duct stones, this improved procedure takes advantage of the natural tube of the cystic duct and avoids traditional common bile duct incision, and it is a safe, effective and minimally invasive management for common bile duct [14]. There are very few reports on the application of microincision of cystic duct in laparoscopic cholecystectomy. In fact, it is easy to perform and safe. In

Phase 3 of this study, cystic duct microincision was performed in 300 patients who underwent LC surgery alone, without choledocholithotomy. With this new procedure, we were able to extrude sedimentary stones or flocs in 21% of the total cases, with an average microincision time of 3–5 min and blood loss volume of only 1–3 ml. Although most common bile duct sedimentary stones or flocs pass spontaneously, a few may settle to form secondary common bile duct stones. To briefly summarize, microincision of the cystic duct during LC surgery, fully squeezing the common bile duct, squeezing out the clear bile, and clipping the cystic duct close to the confluence can largely prevent the recurrence of gallstones in the short term after surgery. In this study, no residual gallstones were found in any of the cases at the six-month follow-up after the operation. On the other hand, the performance of the microincision of the cyst duct has certain limitations. First, the anatomy of the gallbladder triangle should be clear and there should be no obvious abdominal adhesions around it. Second, the length of the cystic duct should exceed 1 cm to be easy to operate. Otherwise, the risk and difficulty of the operation will increase. Then it's not worth going to perform microincision.

In general, residual or secondary common bile duct stones could be treated with ERCP/EST techniques, however, this endoscopic technique is not available in many underdeveloped areas in China. Moreover, ERCP and EST will bring corresponding procedural complications, such as bleeding, perforation and pancreatitis. Therefore, efforts should be made to prevent residual gallstones after LC surgery. With our use of both preoperative routine MRCP examination and intraoperative cystic duct microincision for the prevention of residual gallstones, we were able to achieve an outcome in which no residual stones were found at follow- up. This is a remarkable outcome that makes this approach worthy of clinical application. In addition, the current study has certain limitations. Firstly, this is a retrospective analysis with a single-center experience, with an emphasis on assessing the feasibility, expense, safety, and effectiveness based on our preliminary experience of the prevention of residual gallstones, and robust RCT will be the next goal. Secondly, the diagnosis-related groups (DRGs) payment on hospital healthcare limits the total cost of LC surgery, which is not conducive to routine preoperative MRCP examinations [25]. Finally, in economically developed areas, ERCP/EST technology is proficient and easy to carry out, and the performance of microincision of cystic duct is controversial and is not easily accepted by surgeons. In any case, prevention of postoperative complications is more meaningful than management, and this should be the direction of our efforts.

Conclusions

In this study, we found that the addition of preoperative MRCP examination to the surgical routine led to our being able to effectively avoid missing common bile duct stones that would otherwise be missed by abdominal ultrasound. In addition, the addition of intraoperative cystic duct microincision allowed us to squeeze out sediment stones or flocs, thereby greatly reducing the likelihood that secondary common bile duct stones would form after LC surgery. Our findings provide a new idea for the prevention of residual gallstones after LC surgery, which needs to be further confirmed by prospective studies with large samples.

Abbreviations

MRCP
Magnetic resonance cholangiopancreatography
CT
Computed tomography
ERCP
Endoscopic retrograde cholangiopancreatography
EST
Endoscopic sphincterotomy
PTC
Percutaneous transhepatic cholangiopancreatography
LC
laparoscopic cholecystectomy
ALT
Alanine aminotransferase
AST
Aspartate aminotransferase
BMI
Body mass index.

Declarations

Ethics approval and consent to participate

The study protocol conformed to the ethical guidelines of the Declaration of Helsinki, and was approved by the Ethical Committees and Institutional Review Board of People's Hospital of Nyingchi, Tibet. All methods were performed in accordance with the relevant guidelines and regulations. We obtained the informed consent from all patients.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing of interest.

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Author contributions

Yonghong Huang collected data, analyzed relevant information, and drafted the manuscript; Fei Peng collected data and performed the data analysis; Binxian Zhou and A Duo clinically managed the patient. All authors read and approved the final manuscript.

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References

1. Sun H, Tang H, Jiang S, et al. Gender and metabolic differences of gallstone diseases. World J gastroenterology: WJG. 2009;15(15):1886.
2. Wang J, Shen S, Wang B, et al. Serum lipid levels are the risk factors of gallbladder stones: a population-based study in China. LIPIDS HEALTH DIS. 2020;19:1–6.
3. Giordani MT, Giaretta R, Scolarin C, et al. Ultrasound and infections on the Tibetan Plateau. J Ultrasound. 2012;15:83–92.

4. Asai Y, Yamada T, Tsukita S, et al. Activation of the hypoxia inducible factor 1α subunit pathway in steatotic liver contributes to formation of cholesterol gallstones. Gastroenterology. 2017;152:1521–35.
5. Pucher PH, Brunt LM, Davies N, et al. Outcome trends and safety measures after 30 years of laparoscopic cholecystectomy: a systematic review and pooled data analysis. Surg Endosc. 2018;32:2175–83.
6. Grbas H, Kunisek L, Zelić M, et al. Outcome evaluation of 10,317 laparoscopic cholecystectomies: a 17-year experience at a single center. Hepatogastroenterology. 2013;60(128):1873–6.
7. Farda W, Tani MK, Manning RG, et al. Laparoscopic cholecystectomy: review of 1430 cases in Cure International Hospital, Kabul, Afghanistan. BMC Surg. 2021;21:1–8.
8. Portincasa P, Molina-Molina E, Garruti G, et al. Critical care aspects of gallstone disease. J Crit Care Med. 2019;5:6–18.
9. Palanivelu C, Rangarajan M, Jategaonkar PA, et al. Laparoscopic management of remnant cystic duct calculi: a retrospective study. Ann R Coll Surg Engl. 2009;91:25–9.
10. Alkarboly TAM, Fatih SM, Hussein HA, et al. The accuracy of transabdominal ultrasound in detection of the common bile duct stone as compared to endoscopic retrograde cholangiopancreatography (with literature review). Open J Gastroenterol. 2016;6(10):275–99.
11. Dillman JR, Patel RM, Lin TK, et al. Diagnostic performance of magnetic resonance cholangiopancreatography (MRCP) versus endoscopic retrograde cholangiopancreatography (ERCP) in the pediatric population: a clinical effectiveness study. Abdom Radiol. 2019;44:2377–83.
12. Chen XM, Zhang Y, Cai HH, et al. Transcystic approach with micro-incision of the cystic duct and its confluence part in laparoscopic common bile duct exploration. J Laparoendosc Adv Surg Tech A. 2013;23:977–81.
13. Niu X, Song J, He X, et al. Micro-incision of the cystic duct confluence in laparoscopic common bile duct exploration for elderly patients with choledocholithiasis. Indian J Surg. 2018;80:227–32.
14. Yang XB, Xu AS, Li JG, et al. Dilation of the cystic duct confluence in laparoscopic common bile duct exploration and stone extraction in patients with secondary choledocholithiasis. BMC Surg. 2020;20:1–7.
15. Williams E, Beckingham I, El Sayed G, et al. Updated guideline on the management of common bile duct stones (CBDS). Gut. 2017;66(5):765–82.
16. Sobstyl J, Sojka M, Kuczyńska M, et al. Percutaneous extraction of residual post-cholecystectomy gallstones through the T-tube tract. Pol J Radiol. 2018;83:183–8.
17. Chowbey P, Soni V, Sharma A, et al. Residual gallstone disease—Laparoscopic management. Indian J Surg. 2010;72(3):220–5.
18. Chowbey P, Sharma A, Goswami A, et al. Residual gallbladder stones after cholecystectomy: a literature review. J Minim Access Surg. 2015;11:223–30.

19. Wu Y, Xu CJ, Xu SF. Advances in risk factors for recurrence of common bile duct stones. Int J Med Sci. 2021;18(4):1067–74.
20. Qiu Y, Yang Z, Li Z, et al. Is preoperative MRCP necessary for patients with gallstones? An analysis of the factors related to missed diagnosis of choledocholithiasis by preoperative ultrasound. BMC Gastroenterol. 2015;15(1):1–8.
21. Nebiker CA, Baierlein SA, Beck S, et al. Is routine MR cholangiopancreatography (MRCP) justified prior to cholecystectomy? Langenbeck's archives of surgery. 2009;394(6):1005–10.
22. Bahram M, Gaballa G. The value of pre-operative magnetic resonance cholangiopancreatography (MRCP) in management of patients with gall stones. Int J Surg. 2010;8(5):342–5.
23. Rao GB, Nayak SR, Teja SB, R, et al. Pre-operative MRCP: is it necessary before routine laparoscopic cholecystectomy to exclude CBD stone-prospective study in tertiary care hospital. INT J SURG. 2017;4:3633–7.
24. Anwar J, Waheed S, Raja W. COMPARATIVE EFFICACY OF ULTRASONOGRAPHY (USG) VERSUS MAGNETIC RESONANCE CHOLANGIOPANCREATOGRAPHY (MRCP) FOR THE DIAGNOSIS OF CHOLEDOCHOLITHIASIS. PAFMJ. 2020;70:1003–6.
25. Zou K, Li HY, Zhou D, et al. The effects of diagnosis-related groups payment on hospital healthcare in China: a systematic review. BMC Health Serv Res. 2020;20(1):1–11.

Figures

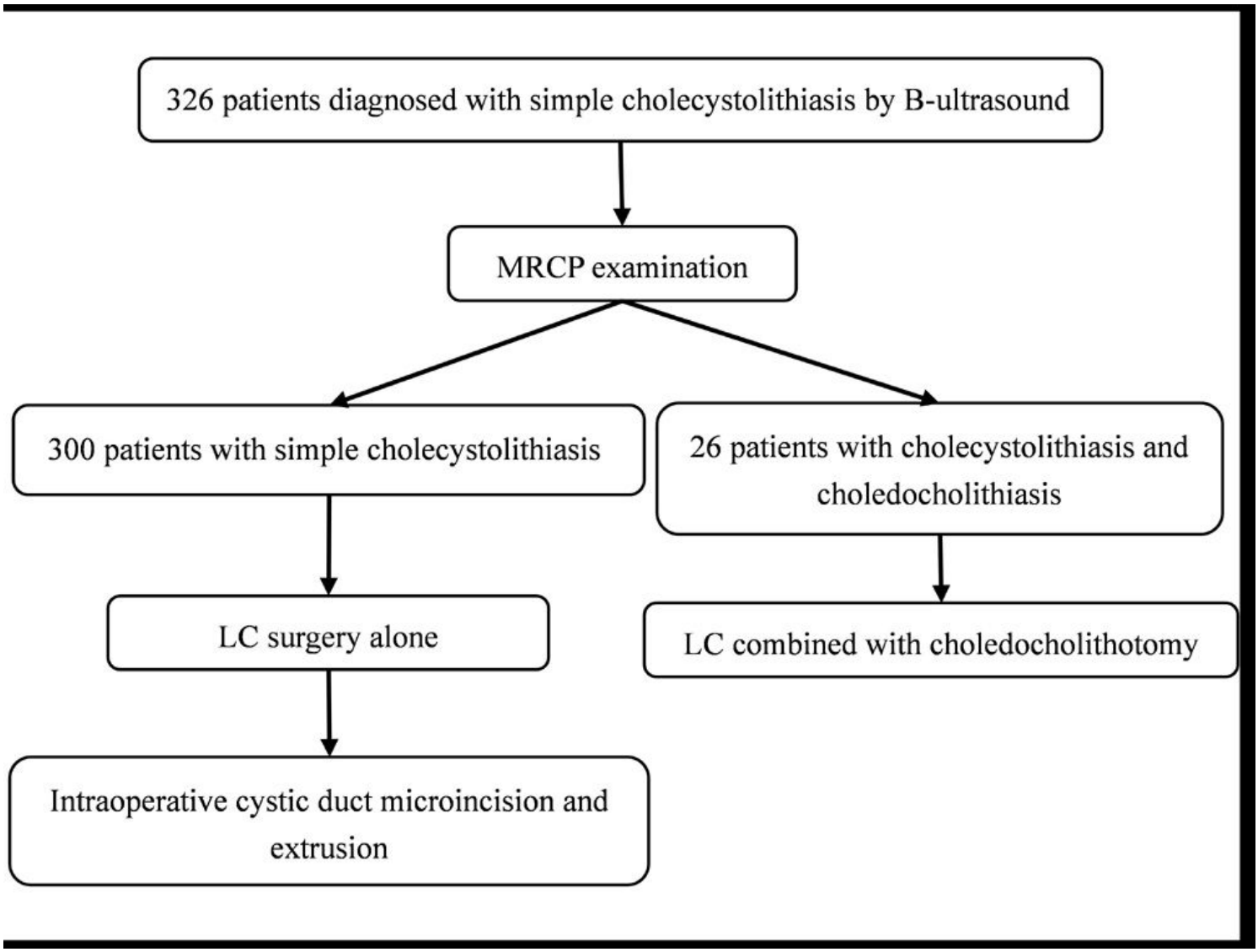

Figure 1

Clinical practice protocol of Phase 3

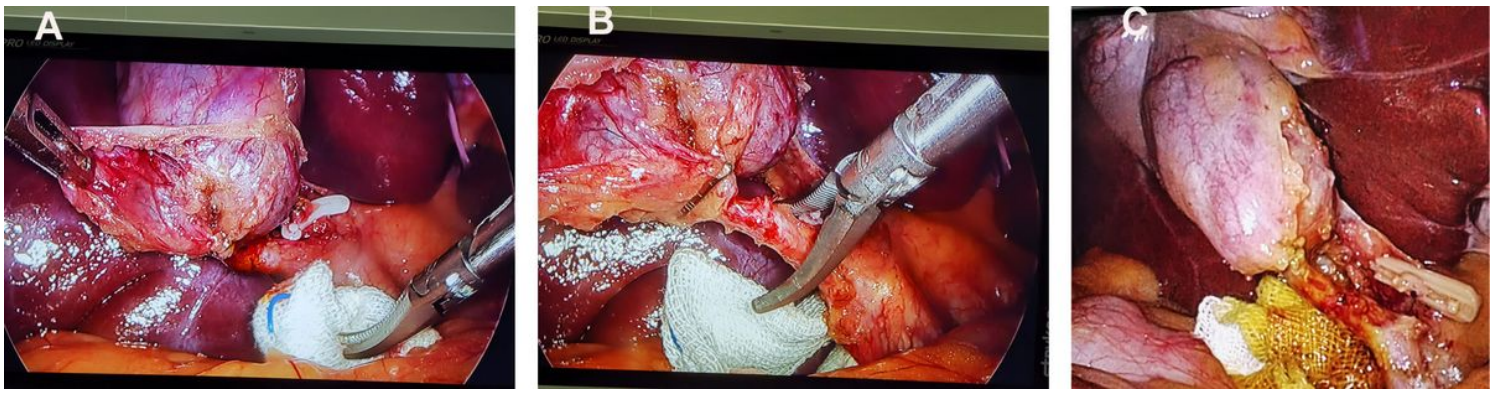

Figure 2

Microincision of the cystic duct in LC surgery. Fig. 2A Squeeze the common bile duct, Fig. 2B Squeeze the cystic duct, Fig. 2C A small amount of floc was squeezed out on the gauze.

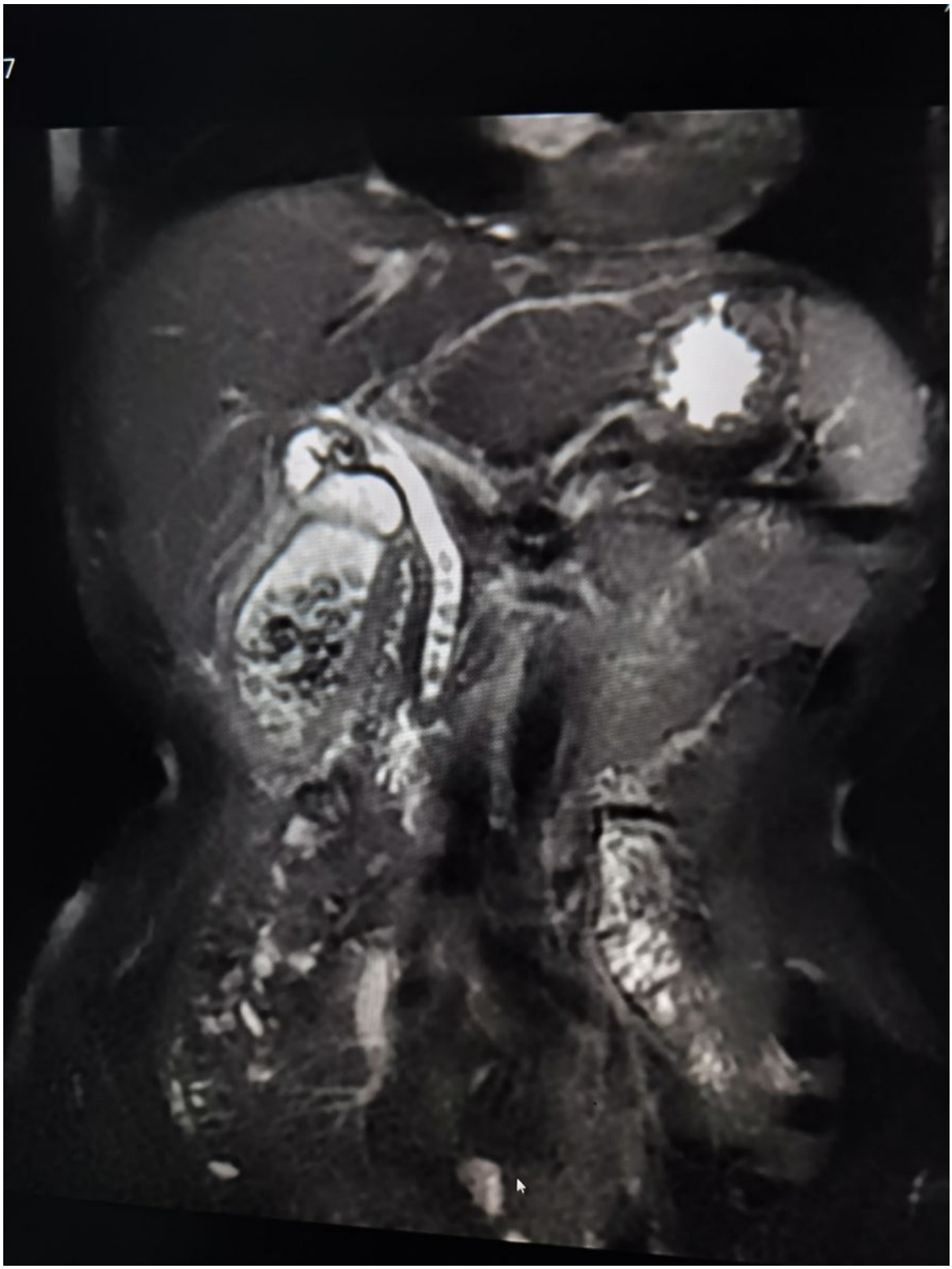

Figure 3

MRCP showed cholecystolithiasis complicated with multiple small stones in the common bile duct. These common bile duct stones are too small and have no bile duct dilatation to be detected by

ultrasound.