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Case Control Study

Classification of Anatomical Morphology of Cystic Duct and Its Association with Gallstone

classification of the morphology of the cystic Duct

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Abstract

BACKGROUND

Gallstones are a common disease that tends to require surgical intervention. Laparoscopic cholecystectomy (LC) is the treatment of choice for symptomatic gallstones. Preoperatively, we need to accurately recognize the anatomical morphology of the cystic duct (CD), especially in the presence of anatomical variations of the CD, which are otherwise prone to bile duct injury (BDI). However, at present, there is no optimal classification of the morphology of CD applicable to clinical practice, and the relationship between anatomical variation of the CD and gallstone remains to be explored.

AIM

To create a more comprehensive clinically applicable classification of the morphology of the CD and to explore the correlations between anatomic variants of the CD and gallstone.

METHODS

A total of 300 patients were retrospectively enrolled from October 2021 to January 2022. They were divided into two groups: the gallstone group and the non-gallstone group. Relevant clinical data as well as anatomical data of the cystic duct based on magnetic resonance cholangiopancreatography (MRCP) were collected and analyzed to propose morphological classification of the cystic duct and to explore its relationship with gallstones. And multivariate analysis was performed using the Logistic Regression Analyses to identify the independent risk factors using variables significant in the univariate analysis.

RESULTS

Of the 300 patients enrolled in this study, 200 (66.7%) of them had gallstones. The mean age was 48.10±13.30 years, of which 142 (47.3%) were male and 158 (52.7%) were female. 55.7% of the patients had a body mass index (BMI) ≥ 24 kg/m^2. Based on the MRCP, the cystic duct anatomical typology is divided into four types: type I: Linear, type II: n-shaped, type III: S-shaped, and type IV: W-shaped. Univariate analysis showed differences between the gallstone and non-gallstone groups in relation to sex, BMI, cholesterol, triglyceride, morphology of CD, site of the CD insertion into the extrahepatic bile duct, length of CD, the angle between the common hepatic duct and CD (∠CHD). In the multivariate analysis, female, BMI (≥24 kg/m^2), and morphology of CD (n-shaped: OR=10.97, 95%CI 5.22-23.07, p＜0.001; S-shaped: OR=4.43, 95%CI 1.64-11.95, p=0.003; W-shaped: OR=7.74, 95%CI 1.88-31.78, p=0.005) were significantly associated with gallstone.

CONCLUSION

This present study details the morphological variation of the cystic duct and confirms that cystic duct tortuosity is an independent risk factor for gallstones.

Key Words: Cystic duct; Gallstone; Classification; Anatomy; Magnetic resonance cholangiopancreatography; Risk factor

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Core Tip: We proposed a novel classification of the morphology of CD based on MRCP to guide clinical practice. We also found that the cystic duct tortuosity is an independent risk factor for gallstone, which provides some theoretical basis for the construction of predictive models and prevention in high-risk groups.

INTRODUCTION

Gallstone disease is the most common inpatient digestive diagnosis and carries substantial costs for health care services[1, 2]. There are three types of gallstone depending on the major constituents: pure cholesterol, pure pigment, and mixed, of which cholesterol gallstone account for 80–90%[3]. The formation of gallstone is a complex process under the interaction of environment and genes. Major risk factors include age, gender, race, parity, obesity, and family history of gallstone[4, 5]. Some scholars believe that the formation of gallstone is related to the anatomical variation of the **cystic duct (CD)**[6, 7]. The angle between the CD and common bile duct (CBD) junction (sistocholedochal angle: SCA) affects the gallstone formation, and as the SCA increases, the incidence of gallstone formation increases[6]. The number of gallstones, the angle between the long axis of the gallbladder and the cystic duct, and the diameter of the cystic duct are significantly related to gallstone-related biliary events[7]. Few scholars pay attention to the relationship between the morphological variation of the CD and gallstone. The relationship between the two needs to be further explored and refined.

Currently, **laparoscopic cholecystectomy (LC)** has become gold standard operation for symptomatic gallbladder stones[8, 9]. According to relevant studies, during LC, the incidence of **bile duct injury (BDI)** was 0.86% from 1995 to 2002[10], 0.46% from 2000 to 2011[11], and 0.19% from 2012 to 2016[12]. With the improvement of preoperative examination and the refinement of intraoperative techniques, the incidence of BDI has decreased, but it always exists. BDI is a constant topic, and how to reduce the occurrence of bile duct injury is something we should work on. This relies on our accurate identification anatomy of the cystic duct before LC, especially when there are anatomical variations in the cystic duct. And we believe that the morphology of the cystic duct deserves our attention. Because during LC, the tortuous gallbladder duct is more likely to cause misjudgment, which can lead to BDI.

The cystic duct connects the gallbladder to the extrahepatic bile duct (EHBD). The CD usually measures 2–4 cm in length and enters the extrahepatic bile duct from the right lateral aspect in 49.9% of cases[13]. Anatomic variants of the CD are common and many researchers have proposed their own anatomical classification according to the CD insertion site to the EHBD[14-16]. A new classification for EHBD as per the percentile distribution of the ratio length between cystic duct insertion and the duodenal papilla (CDDP) /EHBD was designed, and the following categories were obtained: type 1 (below the 25th percentile) for CDDP/ EHBD ratio ≤ 50%; type 2 (25th to 75th percentile) for CDDP/EHBD ratio 51–75% and type 3 (above the 75th percentiles) for CDDP/EHBD ratio > 75%[14]. According to the angle and morphology of the convergence of the CD into the extrahepatic bile duct, cystic duct patterns were divided into 3 patterns: Type I (85.4%), located on the right and angled up; Type II (3.1%), located on the right and angled down; and Type III (11.5%), located on the left and angled up[15]. Some researchers have also broadly classified the configuration of the cystic duct into four types: Angular (44%), Linear (40%), Spiral (11%) and Complex (5%)[16]. However, not all cystic ducts implant to EHBD, some cystic ducts implant to the left hepatic duct (LHD) or right hepatic duct (RHD)[17]. We should not focus only on the implantation of the cystic duct to classify its anatomical variants. Perhaps we can start from the morphology of the CD and propose new classification criteria.

Magnetic resonance cholangiopancreatography (MRCP) is a well-established and non-invasive diagnostic technique for visualizing the pancreatic and biliary duct system without the adverse effects of injecting a contrast agent[18, 19]. MRCP has excellent overall sensitivity and specificity for demonstrating the level and presence of biliary obstruction[20]. MRCP can clearly show the anatomy of the intrahepatic and extrahepatic bile ducts. We can learn the alignment and morphology of the CD from MRCP. At present, MRCP has become a routine examination before LC.

Therefore, the primary aim of this study is to propose a new classification of the morphology of the CD for better clinical application. The secondary aim was to explore the relationship between anatomic variants of the CD and gallstone.

MATERIALS AND METHODS

Study Population

We retrospectively collected data on patients underwent MRCP for the need of disease diagnosis and treatment from October 2021 to January 2022 in our hospital. The observation group (gallstone group) met the following criteria for inclusion:(1) preoperative MRCP and abdominal ultrasonography confirmed gallstone or postoperative pathology suggested gallstone; (2) the anatomy of the CD can be completely and clearly visualized in MRCP. Patients meeting the following criteria were excluded: (1) combined with other gallbladder diseases such as gallbladder polyps, gallbladder adenomyosis, gallbladder cancer, *etc.* (2) CBD stones, stricture or obstruction; (3) gallbladder removed; (4) incomplete clinical information. The control group (non-gallstone group) met the following criteria for inclusion:(1) MRCP or pathology suggesting hepatic hemangioma, hepatocellular carcinoma, or pancreatic tumor;(2) MRCP can clearly show the structure and morphology of the intrahepatic and extrahepatic bile ducts. Patients meeting the following criteria were excluded:(1) Patients with gallbladder diseases such as gallstone, gallbladder polyps, gallbladder adenomyosis, and gallbladder cancer, etc; (2) The rest of the exclusion criteria are detailed in (2) to (4) of the exclusion criteria for the gallstone group. The following data were collected for each patient: age, sex, BMI, cholesterol, and triglyceride. This study was approved by the ethics committee of our hospital and was conducted in accordance with the Declaration of Helsinki.

Imaging Technique and Analysis

All MRI examinations were performed on a 1.5 T MRI superconductive scanner (Siemens Sonata) by using abdominal coil. The imaging parameters for T2W-TSE slices: TR 4500ms, TE 985ms, 150 flip angle, 256x512 matrix, 28x28cm field of view (FOV), 265Hz bandwidth, slice thickness 60 mm. The collection of evaluation indicators for the CD was performed by 2 researchers who were proficient in MRCP. When disagreements arose, a third researcher participated in the discussion and finally reached a consensus conclusion. The following data were collected for each MRCP examination: the morphology of CD, site of the CD insertion into the EHBD, length of

CD, and the angle between the common hepatic duct and the cystic duct (∠CHD) (Figure 1). In addition, the anatomy of intrahepatic bile ducts is also observed and documented in the present study.

Statistical analysis

The statistical analyses were performed using SPSS version 25.0 (Chicago, IL, USA). Continuous variables were expressed as the mean ± standard deviation (SD) or median and inter-quartile ranges (IQRs). Categorical variables were expressed as counts and percentages. Mann-Whitney U test was performed to compare Continuous variables. Categorical variables were compared using chi-squared or Fisher's exact tests. Multivariate analysis was performed using the Logistic Regression Analyses to identify the independent risk factors using variables significant in the univariate analysis. p <0.05 was considered statistically significant.

RESULTS

There were 200 patients (66.7%) in the gallstone group and 100 patients (33.3%) in the non-gallstone group among the 300 patients enrolled in this study. And the mean age was 48.1±13.3 years, of which 142 (47.3%) were male and 158 (52.7%) were female. 55.7% of the patients had a BMI over 24 kg/m^2. In addition, in the study population, cholesterol and triglyceride were 4.8 mmol/L (IQR 4.1-5.4 mmol/L) and 1.6 mmol/L (IQR 1.1-2.2 mmol/L), respectively. These results are detailed in Table 1.

We found that the anatomical variations of intrahepatic bile ducts were mainly in the right posterior duct (RPD). Based on the different locations of the RPD converging into the intrahepatic and extrahepatic bile ducts, we classified them into 4 types (Figure 2): Type A: the right posterior duct converges into the right hepatic duct (Figure 2A); Type B: the right posterior duct converges into the junction of the right and left hepatic ducts, and the three show a three-fork type (Figure 2B); Type C: the right posterior duct converges into the left hepatic duct (Figure 2C); Type D: the right posterior duct converges into the extrahepatic bile duct (Figure 2D). Typical anatomy of intrahepatic bile ducts (type A) can be observed in 270 cases (66.7%), atypical (type B, type C, and type D) can be in 30 cases (33.3%) (Table 1).

Classification of the Morphology of CD

A novel classification of the CD based on the anatomical morphology of the CD was proposed. It is classified into four types (Figure 3):

1. Type I: Linear, the cystic duct straight into extrahepatic bile duct with no tortuosity (Figure 3A, 3E);
2. Type II: n-shaped, the cystic duct has a bend in the shape of an n (Figure 3B, 3F);
3. Type III: S-shaped, the cystic duct converges in an S-shape into the extrahepatic bile duct (Figure 3C, 3G);
4. Type IV: W-shaped, the cystic duct converges into the extrahepatic bile duct in a W-shape (Figure 3D, 3H).

Association Between the Anatomic Variants of the CD and Gallstone

In 300 patients, the CD length was 23.4 mm (IQR 17.3-29.8 mm), 88.3% of the CD converged to the right of EHBD, the∠CHD was 31.6 degrees (IQR 21.8-45.7 degrees), and only 117(39%)of CD converged to the EHBD in a straight line (Table 1). The univariate analysis reveals the correlation between gallstone formation and anatomical variation of the CD (Table 2). Among all anatomical factors, there were significant differences in the morphology of CD in the gallstone group compared to the non-gallstone group (Linear: 43(21.5%) vs.74(74%); n-shaped: 108(54%) vs. 15(15%); S-shaped: 28(14 %) vs. 8(8%); W-shaped: 21(10.5%) vs. 3(3%), $P<0.001$). And the gallstone group showed a significantly longer CD length (24.5 (19.6-32.4) mm vs. 18.9 (13.5-27.1) mm, $P<0.001$). There was also a statistical difference in the site of the CD insertion into the EHBD between the two groups (gallstone vs. non-gallstone: right: 177(88.5%) vs. 99(99%); left: 16(8%) vs. 1(1%); front: 2(1%) vs. 0(0%); back: 5(2.5%) vs. 0(0%), $P=0.011$). There was no difference in the ∠CHD between the gallstone and non-gallstone groups(31.0(21.9-44.9) degrees vs. 33.4 (21.2-50.8) degrees, *P* =0.576). There is also no difference in intrahepatic biliary anatomy in the gallstone and the non-gallstone groups (Typical: 178 (89.0%) vs.22 (11.0%), *P* =0.414). In addition, there were statistically differences in gender distribution, BMI, cholesterol, and triglyceride between the two groups. The gallstone group had more women than non-gallstone ($P<0.001$), larger BMI (*P* =0.002), higher cholesterol(4.9(4.4-5.4)mmol/L vs. 4.5 (3.8-5.3) mmol/L, *P* =0.01), higher triglyceride(1.7(1.2-2.3)mmol/L vs. 1.5 (1.0-2.0) mmol/L, *P* =0.025) (Table 2).

In the multivariate analysis, female (OR=3.32, 95%CI 1.77-6.21, $p<0.001$), BMI (≥24 kg/m^2) (OR = 2.51, 95%CI 1.35-4.66, *p*=0.004), and the morphology of CD were the independent risk factors for gallstone formation. The odds ratio for n-shaped, S-shaped, and W-shaped were 10.97 (95%CI: 5.22-23.07, $P<0.001$), 4.43 (95%CI: 1.64-11.95, *P*=0.003), 7.74 (95%CI: 1.88-31.78, *P*=0.005), respectively (Table 2).

DISCUSSION

Gallstones are a frequent health problem. The overall prevalence of gallstones ranges from 10% to 15% in adults in Europe and the USA[3], and from 4.2% to 12.1% in the Chinese population[21]. The incidence rate of gallstone in the general population was found to be 0.60% per year[2]. Gallstone can cause various complications, such as secondary choledocholithiasis, cholangitis, acute biliary pancreatitis, gallstone ileus, and even life-threatening complications including severe acute pancreatitis, gallbladder cancer, and recurrent pyogenic cholangitis, leading to increased healthcare burden[22, 23]. Currently, LC is the first choice of treatment for symptomatic gallstone. Preoperatively, we need to accurately predict the morphology of the CD based on MRCP, especially those with anatomical variants, which are otherwise prone to BDI. However, the anatomical morphology of the CD has not been adequately studied to date. Therefore, we have formulated a classification of the morphology of CD for better clinical application.

Anatomic variations in the biliary system are highly prevalent and might be seen in more than 30% of cases[24]. Operative findings of LC revealed variations in 61

(20.33%) patients mainly involving cystic artery (10.67%), cystic duct (4.33%), right hepatic artery (2.67%) and gallbladder (2%)[25]. Turner M A *et al* indicated that variations in CD Insertion are common, occurring in 18%–23% of cases[13]. Sureka B *et al* have tried to simplify the classification of CD anatomy and finally classified it into 8 types [26]. Al-Muhanna A F *et al*[24] found only four variants: Type (A), Type (B), Type (C), and Type (D) based on the classification system by Sureka B *et al*[26]. Renzulli M *et al* [14]have proposed anatomical classification of the CD based on the ratio of the length of the CDB to the length of the EHBD. According to the cystic duct take-off, Cao J *et al*[15], have divided 226 cystic duct patterns into 3 patterns, of which type I is divided into three subtypes: Line type, S type, and α type. Garg S *et al*[16]have broadly classified into four types: Angular, Linear, Spiral and Complex, which are subsequently divided into numerous subtypes. On the one hand, these anatomical typologies are too complex for clinical application, on the other hand part of the CD confluence flows into the intrahepatic bile duct (Figure 3), while our new classification focuses on the morphology of the CD.

We believe that the residual cystic duct length should be ≤ 0.5 cm when LC is performed. The long cystic ducts may develop secondary or residual stones after laparoscopic cholecystectomy, further leading to postcholecystectomy syndrome (PCS)[27, 28]. This group of patients often requires reoperation to remove the overlong cystic duct. The incidence of residual gallstones following cholecystectomy is <2.5%[29, 30]. However, the pursuit of shorter CD is usually accompanied by an increased risk of BDI. **Moreover, the length of the residual CD is not always less than 0.5 cm each time LC is undertaken, especially when there are anatomical variants of the CD such as convergence to the left side of the extrahepatic bile duct, convergence to the intrahepatic bile duct, and the classification of the morphology of CD as type II, III, or IV.** The length of the residual cystic duct should be further investigated and explored. The near-infrared imaging with indocyanine green (ICG) may be the answer to this contradiction. The use of the near-infrared imaging with ICG technique provides good overall visualization rates of the CD, CBD, CHD and CD junction prior to and following dissection of Calot's triangle[31, 32]. **Therefore, the use of the near-infrared imaging with ICG technique for cholecystectomy should be taken into consideration, especially in patients with anatomical variants of the CD**.

Based on a study of MRCP in 300 patients, we classified the anatomy of the intrahepatic bile ducts into 4 types: type A, type B, type C, and type D. Type D was defined when the right posterior duct converges into the extrahepatic bile duct. For Type D, we observed that the RPD converges into the common hepatic duct in our study (Figure 2D). **Sarawagi R *et al* [33] found that in 4% of subjects, RPD was draining into the common hepatic duct and in 0.8% of subjects into the cystic duct in their MRCP-based study.** Choi J W *et al*[34] intraoperative cholangiography of 300 Liver transplant donors revealed that the anatomy of the intrahepatic bile ducts was typical in 63% of cases (*n* = 188), anomalous drainage of the RPD into the common hepatic duct in 6% (*n* = 19), anomalous drainage of the RPD into the cystic duct in 2% (*n* = 6). In this study, we did not observe the convergence of the RPD into the CD, but this anatomical variation of the intrahepatic bile duct is not uncommon. Gupta A *et al*[35] found it in 4.4 % of MRCPs; Chaib E *et al* [36] showed it in 6.1 % of study population based on endoscopic retrograde cholangiography and intraoperative cholangiography study. In present study, 22% of the patients with gallstones had anatomical variations of intrahepatic bile ducts. When the anatomical classification of intrahepatic bile ducts is Type D, especially when the RPD into the cystic duct, we tend to misidentify the RPD as the CD, resulting in BDI. Accurate assessment of the anatomical variations of the intrahepatic bile ducts prior to LC is also essential to ensure the safety of the surgery. And in our clinical practice, we sometimes find a phenomenon: the cystic duct converges into the intrahepatic bile duct (Figure 4 A-C). Before LC, we need to attend to both the anatomical morphology of the CD and anatomical variations of the intrahepatic bile ducts.

Several studies have shown that advancing age, female gender, race, obesity, rapid weight loss, diet and a family history of gallstone disease are the risk factors for the development of gallstone[3-5, 37, 38]. The univariate analysis showed that sex, BMI, triglyceride and cholesterol were associated with the formation of gallstone. Multivariable logistics analysis suggested that sex and BMI are independent risk factors for gallstone. A population-based study in China found that the risk of gallstone increases markedly with age[39]. Our study did not show that age is a risk factor for gallstone. With the awakening of health awareness, people undergo regular medical checkups, which can lead to an earlier age of diagnosis of gallstone. BMI (≥24 kg/m^2) is an independent risk factor for gallstone. A recent study found that there have been steady increases in the mean BMI among all age groups in China[40]. Rapid increases of BMI may accelerate the formation of gallbladder stones and thus weaken the correlation between gallbladder stones and age.

In addition, our study found that the anatomical morphology of the CD is an independent risk factor for gallstone formation, which means that tortuous CD is an important cause of gallstone formation. When the gallbladder is not functioning properly, the components of the bile are supersaturated leading to the formation of solid crystals, called gallstone[41]. Gallbladders with tortuous cystic ducts are prone to gallstone formation for the following reasons :

1. Bile stasis.

Bile stasis may cause cholesterol super-saturation and allow the formation of cholesterol stones[41]. The studies suggest that flow resistance is affected by the cystic duct morphology, which plays the dominant role[42, 43]. Tortuous cystic ducts can lead to increased flow resistance, resulting in bile stasis, which can promote the development of gallstone. From the aspect of conservation of energy, the gallbladder can be considered to be a pump, pumping the bile flow through the cystic duct into the common bile duct. The pump function of the gallbladder provides the bile with a kinetic energy that enables the bile to flow. The tortuous cystic duct increases the flow resistance, which robs some of the kinetic energy. With this reduction in kinetic energy, the bile cannot be completely drained, resulting in bile stasis, which contributes to the formation of gallstone.

2. Increased bile viscosity.

Increased viscosity of gallbladder bile plays an important role in the pathogenesis of gallstone[41]. The tortuous cystic duct increases the flow resistance, which leads to reduced bile flux. According to Poiseuille's law bile flux through the cystic duct is inversely correlated to bile viscosity[43]. The decrease in bile flux increases the bile viscosity, which leads to the development of gallstone.

3. Mucous membrane repair.

The bile flowing through the tortuous cystic duct is constantly impinging on the tortuous points of the duct, which may cause damage to the mucosa of the CD. On the one hand, under the stimulation of inflammation and mucosal repair, gallstone may form by damaging the mucosa as an eruption point. **On the other hand, repair of the mucosa may cause narrowing of the CD, which may result in bile stasis[41, 43].**

Univariant analysis showed the length of the cystic duct ($p < .001$) and non-right lateral confluence into the extrahepatic bile duct ($p = 0.011$) to be risk factors for gallstone formation. The group with gallstones had a longer or narrower cystic duct than those without calculi[44, 45]. The longer the CD is, the more likely it is to become tortuous in a relative space. When the CD converges into the anterior, posterior or bypasses the anterior or posterior EHBD to the left side, it increases the length of the CD on the one hand, and the filling EHBD may squeeze the CD on the other hand, causing relative narrowing and leading to bile stasis.

There are certain limitations of our study. First, this study is retrospective and may need further validation by prospective studies; second, we excluded patients who were unable to undergo MRCP, which could have led us to miss certain rare the morphology of CD; third, we only performed an imaging study, and we can use the near-infrared imaging with ICG technique for further in-depth study and validation in LC.

CONCLUSION

In conclusion, our study provides a comprehensive knowledge of the spatial anatomical morphology of the CD and suggests a better clinically applicable classification of the morphology of CD. It also confirmed that cystic duct tortuosity is an independent risk factor for gallstone. In the future, we will construct predictive models based on the risk factors for gallstone identified in our study to provide individualized follow-up strategies for high-risk groups.

ARTICLE HIGHLIGHTS

Research background

At present, there is no optimal classification of the morphology of the cystic duct applicable to clinical practice, and the relationship between anatomical variation of the cystic duct and gallstone remains to be explored.

Research motivation

Classification of anatomical morphology of cystic duct can be applied to clinical practice to reduce the occurrence of bile duct injury , and we also found that cystic duct tortuosity is an independent risk factor for gallstone. In the future, we will construct predictive models based on the risk factors for gallstone identified in our study to provide individualized follow-up strategies for high-risk groups.

Research objectives

To create a more comprehensive clinically applicable classification of the morphology of the cystic duct and to explore the correlations between anatomic variants of the cystic duct and gallstone.

Research methods

This was a case-control study. we retrospectively collected data on patients underwent magnetic resonance cholangiopancreatography with (without) gallstones at the Second Affiliated Hospital of Kunming Medical University, Yunnan, China.300 patients with (without) gallstones identified by abdominal ultrasound and magnetic resonance cholangiopancreatography were enrolled from October 2021 to January 2022. They were divided into two groups: the gallstone group and the non-gallstone group. Data such as sex, age and body mass index were collected.

Research results

Of the 300 patients enrolled in this study, 200 (66.7%) of them had gallstones. The mean age was 48.10±13.30 years, of which 142 (47.3%) were male and 158 (52.7%) were female. 55.7% of the patients had a BMI $\geq$ 24 kg/m^2. Based on the MRCP, the cystic duct anatomical typology is divided into four types: type I: Linear, type II: n-shaped, type III: S-shaped, and type IV: W-shaped. Univariate analysis showed differences between the gallstone and non-gallstone groups in relation to sex, body mass index (BMI), cholesterol, triglyceride, morphology of CD, site of the CD insertion into the extrahepatic bile duct, length of CD, the angle between the common hepatic duct and CD (∠CHD). In the multivariate analysis, female, BMI (≥24 kg/m^2), and morphology of CD (n-shaped: OR=10.97, 95%CI 5.22-23.07, p＜.001; S-shaped: OR=4.43, 95%CI 1.64-11.95, p=.003; W-shaped: OR=7.74, 95%CI 1.88-31.78, p=.005) were significantly associated with gallstone.

Research conclusions

This present study details the morphological variation of the cystic duct and confirms that cystic duct tortuosity is an independent risk factor for gallstones.

Research perspectives

Basic and clinical research of diseases in Hepatopancreatobiliary Surgery.

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