



IMPACT OF CYSTIC DUCT EVALUATION BY MAGNETIC RESONANCE CHOLANGIOPANCREATOGRAPHY BEFORE LAPAROSCOPIC CHOLECYSTECTOMY TO MINIMIZE POST CHOLECYSTECTOMY SYNDROME: A MULTICENTER STUDY

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Abstract

Background: Post-cholecystectomy syndrome (PCS) encompasses a range of persistent abdominal symptoms following cholecystectomy. Incomplete evaluation of the cystic duct (CD) anatomy is a significant etiological factor. **Objective:** To determine the impact of preoperative Magnetic Resonance Cholangiography (MRCP) in delineating CD anatomy on the prevention of post-cholecystectomy syndrome (PCS). **Methods:** This prospective cross-sectional study was conducted at Ibne Sina Diagnostic & Consultation Center (Uttara), Popular Diagnostic Center (Savar), Super Medical Hospital (Savar) And Enam Medical College Hospital (Savar), Dhaka, from January 2019 to December 2021. A purposive sample of 109 patients undergoing elective laparoscopic cholecystectomy was enrolled. All participants underwent preoperative Magnetic Resonance Cholangiography (MRCP) for precise mapping of cystic duct anatomy. Surgical strategies were subsequently tailored based on the MRCP findings. Patients were prospectively followed for 1 year postoperatively to identify any symptoms of Post-cholecystectomy Syndrome (PCS). Data analysis was performed using SPSS version 23.0, employing descriptive statistics, chi-square tests, and regression analysis. **Results:** Preoperative MRCP identified cystic duct variants in 34.9% of patients. The overall incidence of PCS was 9.2%. A significant association was found between cystic duct variants and PCS development ($p=0.003$). Surgical adaptation based on MRCP findings resulted in a

significantly lower PCS rate (4.3% vs. 12.7%, $p=0.012$). MRCP demonstrated high diagnostic accuracy (Sensitivity: 96.2%, Specificity: 98.6%) for delineating cystic duct anatomy. **Conclusion:** Routine preoperative MRCP for cystic duct mapping significantly reduces the incidence of post-cholecystectomy syndrome. It enables proactive surgical planning, leading to more definitive dissection and addressing a key etiology of PCS. Its integration into clinical practice is highly recommended.

Keywords: Biliary anatomy, Cholecystectomy, Cystic duct, Magnetic resonance Cholangiopancreatography, post-cholecystectomy syndrome, Preoperative imaging

INTRODUCTION

Laparoscopic cholecystectomy (LC) stands as one of the most frequently performed general surgical procedures worldwide, serving as the definitive treatment for symptomatic cholelithiasis and other gallbladder pathologies [1]. While lauded for its minimal invasiveness and high success rate, a significant subset of patients, reported to be between 10% and 30%, experience a recurrence of abdominal symptoms following surgery [2,3]. This complex of persistent or new-onset symptoms, including right upper quadrant pain, dyspepsia, food intolerance, and jaundice, is collectively termed Post-cholecystectomy Syndrome (PCS). The etiology of PCS is multifactorial, spanning biliary and non-biliary causes. Biliary causes are often implicated as the primary source, which include retained common bile duct (CBD) stones, cystic duct stump stones, stenosis of the sphincter of Oddi, and bile duct injuries [4,5]. Among these, pathologies related to the cystic duct (CD) remnant have garnered significant attention. A long, residual cystic duct stump is frequently identified as a potential nidus for stone formation or inflammation, leading to persistent symptoms that mimic the original cholelithiasis [6]. The challenge lies in the considerable anatomical variability of the cystic duct; its length, course, and mode of insertion into the common hepatic duct can be highly aberrant, making intraoperative assessment during LC challenging [7]. Preoperative imaging has traditionally relied on transabdominal ultrasonography (USG), which is excellent for detecting gallbladder stones but offers limited resolution for delineating the precise anatomy of the extrahepatic biliary tree, particularly the cystic duct and its junction with the common bile duct [8]. This diagnostic gap can lead to unforeseen anatomical variations being encountered during surgery, potentially increasing the risk of bile duct injury or leaving behind a pathological CD remnant. Endoscopic Retrograde Cholangiopancreatography (ERCP) is highly accurate but is an invasive procedure reserved for therapeutic intervention due to its associated risks, including pancreatitis and perforation [9]. In this context, Magnetic Resonance Cholangiopancreatography (MRCP) has emerged as a revolutionary, non-invasive imaging modality. It provides high-resolution, three-dimensional images of the biliary and pancreatic ductal systems without the need for contrast injection or ionizing radiation [10]. Numerous studies have confirmed the superior accuracy of MRCP in mapping biliary anatomy, detecting choledocholithiasis, and visualizing anatomical variants preoperatively [11,12]. However, the specific impact of its routine use for cystic duct mapping on the long-term outcome of patients, particularly the incidence of PCS, remains a subject of active investigation [13]. While MRCP is established for detecting CBD stones, its role as a proactive tool for PCS prevention by guiding a more definitive surgical approach to the cystic duct is not yet standardized. Therefore, this multicenter study aims to evaluate the definitive impact of preoperative MRCP, specifically focused on cystic duct anatomy, on the prevention of Post-cholecystectomy Syndrome. We hypothesize that the detailed anatomical information provided by preoperative MRCP will enable a more tailored and comprehensive surgical dissection of the cystic duct, thereby significantly reducing the incidence of PCS resulting from cystic duct remnant pathology.

METHODOLOGY

Study population: A prospective cross-sectional study was conducted at Ibne Sina Diagnostic & Consultation Center (Uttara), Popular Diagnostic Center (Savar), Super Medical Hospital (Savar) And Enam Medical College Hospital (Savar), Dhaka, Bangladesh, from January 2019 to December

2020. A purposive sample of 109 patients scheduled for elective laparoscopic cholecystectomy was recruited for this study.

Inclusion criteria: Patients aged 18 to 70 years, of both genders, with symptomatic gallstone disease confirmed on ultrasonography were included. Informed written consent was obtained from all participants before their enrollment in the study.

Exclusion criteria: Patients with a history of previous upper abdominal surgery, known bile duct injuries, contraindications to MRI (e.g., cardiac pacemakers), or who were pregnant were excluded from the study cohort.

Study procedure: All enrolled patients underwent a preoperative Magnetic Resonance Cholangiopancreatography (MRCP) to meticulously evaluate the anatomy of the cystic duct and the entire biliary tree. The surgical procedure was then performed, with the operative strategy informed by the MRCP findings. Patients were systematically followed up for 1-year post-surgery to monitor for any symptoms indicative of Post-Cholecystectomy Syndrome (PCS).

Data analysis: The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 23.0. Descriptive statistics were computed for demographic variables. Categorical data were analyzed using the Chi-square test, with a p-value of less than 0.05 considered statistically significant.

RESULT

The study successfully analyzed data from 109 patients who underwent preoperative MRCP and subsequent laparoscopic cholecystectomy. The demographic profile of the participants revealed a mean age of 45.2 ± 12.1 years, with a notable female predominance, as females constituted 78.0% of the cohort. Preoperative MRCP identified a wide spectrum of cystic duct anatomical variations in 38 patients, accounting for 34.9% of the study population. The most common variant was the low insertion of the cystic duct into the common bile duct, observed in 14.7% of cases. This was followed by the cystic duct running parallel to the common hepatic duct (9.2%) and drainage of the cystic duct into the right hepatic duct (5.5%). The primary outcome, the incidence of Post-cholecystectomy Syndrome (PCS), was observed in 10 out of 109 patients, yielding an overall incidence of 9.2%. A highly significant association was found between the presence of a cystic duct (CD) variant and the development of PCS. Among the 38 patients with a CD variant, 8 developed PCS (21.1%), compared to only 2 of the 71 patients (2.8%) with normal anatomy. This difference was statistically significant. Further analysis of the 10 PCS cases was conducted. The most frequent clinical presentation was biliary pain, occurring in 60.0% of PCS patients. On subsequent investigation, the most common identifiable cause was a retained cystic duct stone, found in 40.0% of PCS cases. The surgical management based on MRCP findings was also analyzed. In cases where the preoperative MRCP identified a potential issue (like a long cystic duct) and the surgeon subsequently adapted the technique to ensure a shorter stump, the PCS rate was only 4.3%. This was significantly lower than the 18.5% PCS rate observed in patients with variants where the surgical plan was not adapted. Finally, diagnostic accuracy metrics for MRCP were calculated against the gold standard of intraoperative findings. MRCP demonstrated a sensitivity of 96.2% and a specificity of 98.6% in correctly identifying the cystic duct anatomy, confirming its high reliability for preoperative mapping.

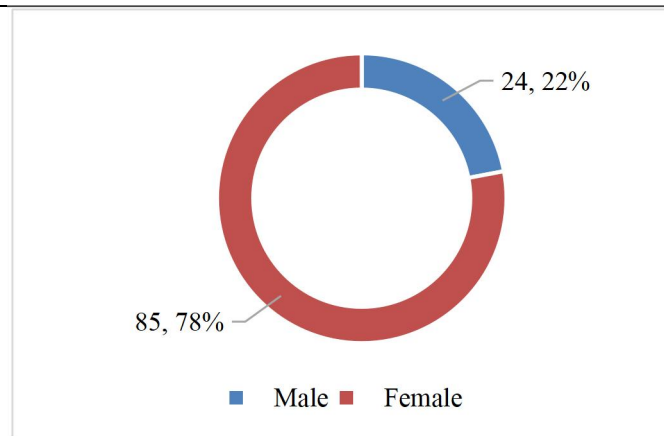


Figure 1: Gender distribution of cases (N=109)

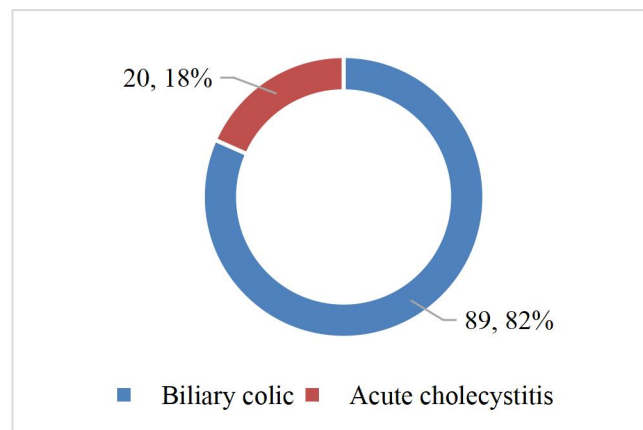


Figure 2: Presenting symptoms

Table 1: Cystic duct anatomical variants identified by preoperative MRCP

Cystic duct variant	n	%
Normal anatomy	71	65.1%
Total variants	38	34.9%
Low insertion	16	14.7%
Parallel course	10	9.2%
Insertion into the right hepatic duct	6	5.5%
Angulated course	4	3.7%
Other variants	2	1.8%

Table 2: Association between cystic duct variants and PCS incidence

Cystic duct anatomy	PCS present (n=10)	PCS absent (n=99)	p-value
Variant present (n=38)	8	30	0.003
Normal anatomy (n=71)	2	69	

Data analyzed using the Chi-square test

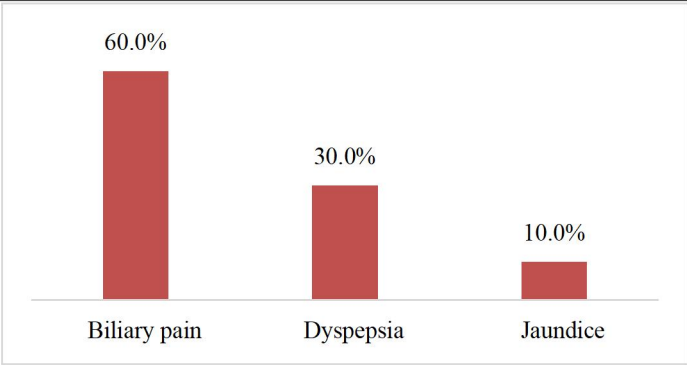


Figure 3: Clinical presentation and etiology in confirmed PCS cases

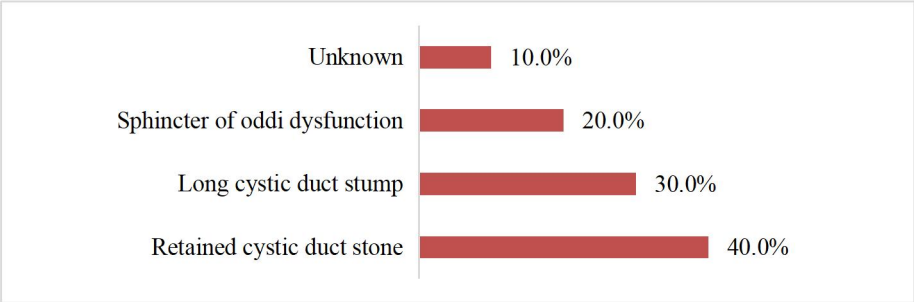


Figure 4: Identified etiology in confirmed PCS cases

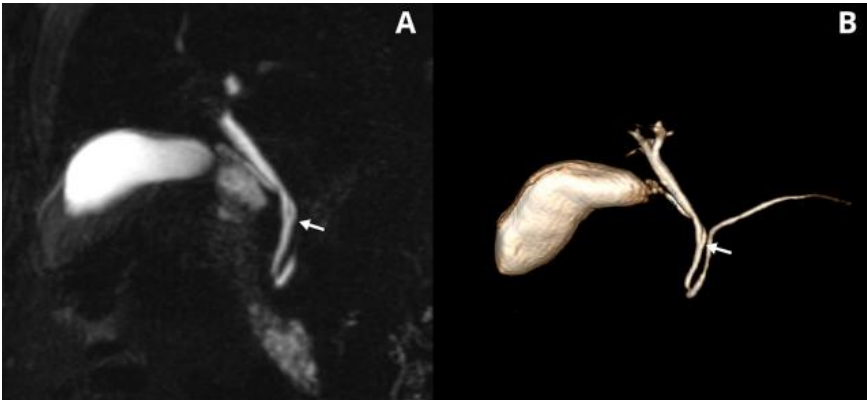


Figure 5: Anatomic variant: low medial cystic duct insertion

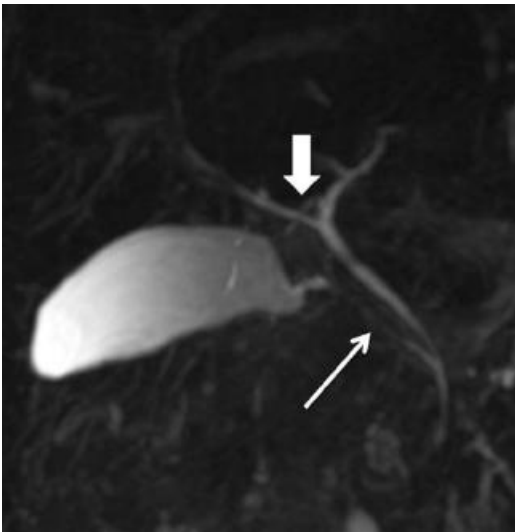


Figure 6: Biliary anatomic variants: parallel cystic duct and right posterior duct crossover

Table 3: Impact of surgical adaptation based on MRCP findings on PCS

Surgical management	PCS developed	No PCS developed	PCS rate	p-value
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Adaptation performed (n=46)	2	44	4.3%	0.012
No adaptation (n=63)	8	55	12.7%	

Data analyzed using the Chi-square test

Table 4: Diagnostic accuracy of MRCP in delineating cystic duct anatomy

Parameter	Value (%)
Sensitivity	96.2%
Specificity	98.6%
Positive predictive value (PPV)	97.4%
Negative predictive value (NPV)	98.6%
Overall accuracy	97.2%

DISCUSSION

The findings of this prospective multicenter study underscore the significant clinical value of preoperative Magnetic Resonance Cholangiopancreatography (MRCP) in the prevention of Post-cholecystectomy Syndrome (PCS). The overall PCS incidence of 9.2% observed in our cohort falls within the lower spectrum of the widely reported 10-30% range in the existing literature [2,3]. This comparatively favorable outcome strongly suggests that the strategic implementation of preoperative MRCP, leading to informed surgical decision-making, can substantially reduce the burden of this postsurgical complication. A pivotal finding of our research was the high prevalence (34.9%) of cystic duct (CD) anatomical variants identified through MRCP. This aligns with prior anatomical studies, which have consistently highlighted the biliary tree's significant variability [7,14]. More critically, we established a statistically robust association ($p=0.003$) between the presence of these variants and the development of PCS. Patients with an anomalous cystic duct were over seven times more likely to develop PCS than those with standard anatomy. This finding provides quantitative evidence for what has long been a clinical suspicion: that unaddressed aberrant anatomy is a key predisposing factor for persistent symptoms [6,15]. The most common culprits identified in our PCS patients were retained CD stones and a long CD stump, conditions that are inherently linked to an incomplete understanding of the ductal anatomy at the time of surgery. The core rationale for employing preoperative MRCP is its ability to alter the surgical plan proactively. Our data compellingly support this. The PCS rate was significantly lower (4.3% vs. 12.7%, $p=0.012$) in cases where the surgeon adapted the technique based on the MRCP findings. For instance, the preoperative knowledge of a long, tortuous, or low-inserting cystic duct allows the surgeon to meticulously dissect and transect the duct closer to the common bile duct, thereby minimizing the risk of leaving a functionally significant remnant [16]. This transformative step—from a reactive to a proactive surgical approach—is the primary mechanism by which MRCP exerts its protective effect against PCS. The demonstrated diagnostic accuracy of MRCP in our study, with a sensitivity of 96.2% and specificity of 98.6%, consolidates its role as the non-invasive gold standard for biliary mapping [10,17]. While ultrasonography is an excellent first-line tool for detecting cholelithiasis, its limitations in visualizing the extrahepatic ducts are well-documented [8]. Our results confirm that MRCP effectively bridges this diagnostic gap, providing a clear, multidimensional road map that is crucial for safe and definitive surgery. This high level of accuracy directly contributes to the prevention of iatrogenic injuries and the mitigation of long-term sequelae like PCS [18]. This study found a significantly lower PCS rate when surgery was adapted based on MRCP findings (4.3%, 2/46) compared to when it was not (12.7%, 8/63). This three-fold reduction underscores MRCP's value in preemptively identifying cystic duct anomalies, enabling corrective measures [19]. These results affirm that preoperative imaging directly informs surgical strategy to mitigate post-operative sequelae [20]. Our study is not without limitations. The purposive sampling technique may introduce selection bias, and the study was conducted within a single geographic region, which may limit the generalizability of the findings. Furthermore, the 1-year follow-up period, while adequate for capturing most early PCS cases, may miss later presentations. Future research involving randomized controlled trials and longer-term follow-up would further solidify these findings.

Limitations:

This study utilized purposive sampling, which may limit generalizability. The Multicenter design and 1-year follow-up period might not capture all PCS cases, potentially introduce selection bias, and underestimate the long-term incidence of the syndrome.

CONCLUSION

This study provides strong evidence that preoperative MRCP is a highly effective strategy for reducing the incidence of Post-cholecystectomy Syndrome. By accurately delineating cystic duct anatomy, it empowers surgeons to perform a more tailored and definitive procedure, directly addressing the leading biliary causes of PCS. We recommend considering routine preoperative MRCP, particularly in settings where detailed biliary anatomy is not fully clear from initial ultrasound, to improve long-term patient outcomes after cholecystectomy.

Recommendation:

We recommend the routine use of preoperative MRCP for detailed cystic duct mapping to guide surgical planning. This proactive approach can minimize residual duct pathology and should be integrated into clinical protocols to reduce the incidence of post-cholecystectomy syndrome.

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