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Original Article

# Anatomic Variations of the Cystic Duct in Magnetic Resonance Cholangiopancreatography in Shiraz: A Cross-Sectional Study

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## Abstract

**Background:** Anatomic variations of the cystic duct (CD) are commonly encountered. Being aware of these variants will reduce complications subsequent to surgical, endoscopic, or percutaneous procedures. Magnetic resonance cholangiopancreatography (MRCP) is the least invasive and the most reliable modality for biliary anatomy surveys. This study aimed to determine the prevalence of cystic duct variations in the Iranian population.

**Methods:** In this retrospective cross-sectional study, MRCP images of 350 patients referred to Shiraz Faraparto Medical Imaging and Interventional Radiology Center from October 2017 to October 2018 were reviewed. The CD course and insertion site to the extrahepatic bile duct (EHBD) was determined and documented in 290 cases. Descriptive statistics and Chi square test were applied for data analysis via SPSS software.

**Results:** About 77% of cases revealed the classic right lateral insertion to the middle third of EHBD. The insertion of CD to the upper third and the right hepatic duct was 10%, and the insertion to the medial aspect of the middle third of EHBD from anterior or posterior was noted to be about 7.6%. From 2.8% of insertions to the lower third, 1% demonstrated parallel course, and finally, 0.3% of cases presented short CD.

**Conclusion:** CD variations are relatively common, and MRCP mapping prior to the hepatobiliary interventions could prevent unexpected consequences.

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**Keywords** ● Cystic duct ● Bile ducts ● Extrahepatic ● Cholangiopancreatography ● Magnetic resonance ● Radiography

## What's Known

- Anatomic variations are seen in the course and the insertion point of the cystic duct.
- The three common and clinically essential variants are low insertions, medial insertion, and parallel cystic duct course. Taking these variants into consideration will reduce the complications subsequent to surgical, endoscopic, or percutaneous procedures.

## What's New

- Less invasive diagnostic and therapeutic methods are currently developing for hepatobiliary and pancreatic diseases, requiring familiarity with these variants for safe and successful outcomes.
- We observed less low insertion, medial insertion, and parallel course of the cystic duct. However, a higher frequency of high insertion was noted in the population.

## Introduction

Different anatomic variations are observed in the cystic duct course and insertion point.[1-3] Identification of the normal anatomy and variations of the cystic duct (CD) is essential before the hepatobiliary surgery or endoscopic and percutaneous interventions, such as endoscopic retrograde cholangiopancreatography (ERCP) for the prevention of iatrogenic complications.[3-6]

Different modalities exist for the demonstration of biliary anatomy. Ultrasound is the first choice for evaluating intrahepatic bile ducts and common bile ducts. However, the non-dilated cystic duct cannot be delineated in sonography. The delineation of CD in CT scan needs intravenous biliary contrast agent injection.[3]

Intraoperative cholangiography is invasive and inconclusive in several cases.[7] Magnetic resonance cholangiopancreatography (MRCP) is the modality of choice for evaluating the normal anatomy of intrahepatic and extrahepatic bile ducts and CD being non-invasive, radiation-free, and without need for contrast injection and anesthesia.[8, 9]

The cystic duct originates from the gall bladder and drains into the common hepatic duct to form a common bile duct with a length of about 2-4 cm and a diameter of 1-5 mm.[6] The variability of CD insertion site to the extrahepatic bile duct (EHBD) is observed. However, it usually joins it at the middle part (between the confluence and the ampulla of Vater) from the right lateral aspect.

Different variations of the CD insertion point are demonstrated.[10, 11] The most important ones are as follows: the low insertion of CD, the parallel course of CD, anterior or posterior spiral course with medial insertion, absent or short CD, and drainage to the right hepatic duct (RHD), left hepatic duct (LHD), or their confluence.

Shiraz has been the referral center for liver transplantation, surgical, and endoscopic biliary interventions. Taking the cystic duct patterns into consideration is extremely helpful for successful and safe performation of these procedures. To the best of our knowledge, no survey has been conducted for the evaluation of these expected variations in the Iranian population. This study aims to determine the prevalence of cystic duct variations in the population of South of Iran.

## Materials and Methods

This retrospective cross-sectional study was performed with the approval of the Shiraz University of Medical Sciences Research and Ethics Committee (IR.SUMS.Med.Rec.1395.s174). The MRCP of all cases referred to Shiraz Faraparto Medical Imaging and Interventional Radiology Center from October 2017 to October 2018 with different indications were included in the study. Written informed consent was obtained from all individuals.

Moreover, 350 images (MRCP) were included and the CD insertion site could be evaluated in 290 cases. Sixty exams were excluded due to the previous cholecystectomy, severe ascites, liver transplant, and the overlapping of structures.

Patients fasted for about six hours before the study. No anti-peristaltic agent was administered. MRCP was performed on a 1.5 Tesla MRI unit (Siemens, Erlangen, Germany) utilizing a phased array body coil.

The preferred sequences for the best information on the biliary tree's anatomy were as follows: axial 2D breath-hold half-Fourier acquisition single-shot turbo spin-echo (HASTE) sequence, 3D respiratory-triggered heavily T2-weighted fast spin-echo (FSE) sequence in the coronal oblique plane, and coronal maximum intensity projection (MIP) reformat.

MRCP images were reviewed in a picture archiving communication system (PACS) by a gastroenterologist and expert radiologist. Demographic data, the course, and the insertion site of the cystic duct were recorded in the data gathering form.

The insertion site was classified as high, mid, or low, if the cystic duct was drained into the upper, the middle, and the lower third of the common hepatic duct (CHD), respectively. Lateral insertion was defined as an insertion to the right of the CHD and medial insertion to the left of the CHD. In the parallel course, the cystic duct was considered as having a joint practice with EHBD for at least 2 cm.

*Statistical Analysis*

The statistical analyses were performed with SPSS software, version 21 (Armonk, NY: IBM Corp). The descriptive statistics of the data are described as mean±SD and frequency. The Chi square test was also applied to analyze the data. $P<0.05$ was considered to be statistically significant.

## Results

Among the 350 MRCP reviewed images we could distinguish the cystic duct insertion site to the EHBD in 290 cases (82%). The non-visualization of the cystic duct insertion site was mainly due to the previous history of cholecystectomy and liver transplant, ascitic fluid in the abdomen, adjacent ductal pathology, or the overlapping of structures. Patients had

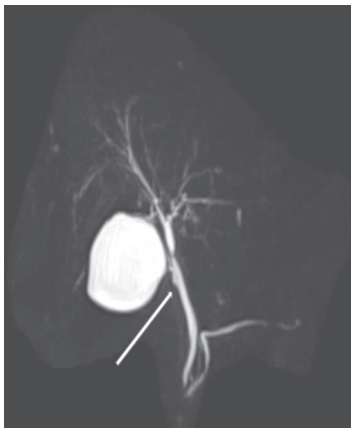

**Figure 1:** Coronal maximum intensity projection (MIP) reformat illustrates normal lateral insertion of cystic duct to the lateral aspect of the extrahepatic bile duct (EHBD) (arrow)

a mean age of 51.2±18.9 years. 144 (49.7%) cases were men, and 146 (50.3%) were women. Approximately, 247 cases (85.1%) showed mid-third insertion, 32 (11.1%) high insertion, and 11 (3.8%) low insertion. The cystic duct's classic insertion site at the middle part of EHBD from lateral was seen in 224 cases (77.2%) (figure 1). The anatomic variations of the cystic duct are summarized in table 1.

High insertion to proximal EHBD or confluence was found in 27 cases (9.3%) (figure 2), and to RHD in five cases (1.7%) (figure 3). Spiral medial insertion to the middle third from the posterior was seen in 14 patients (4.8%) (figure 4), and from the anterior was found in eight cases (2.8%).

Among the 11 cases of low insertion, three patients (1%) revealed a parallel course with the EHBD, two patients (0.7%) had a spiral low medial insertion, and six of them (2.1%) inserted low laterally. Finally, a short CD was noted in one case (0.3%). No statistically significant difference was noted between the different sexes and the CD insertion site (P=0.12) (table 2).

**Table 1:** Distribution of the anatomic variations of the cystic duct (CD)

| Types of CD insertion | N (%) |
|---|---|
| Lateral aspect of middle third of EHBD | 224 (77.24%) |
| Anterior spiral medial | 8 (2.76%) |
| Posterior spiral medial | 14 (4.83%) |
| Low insertion | 6 (2.07%) |
| Parallel course | 3 (1.03%) |
| Spiral medial low | 2 (0.69%) |
| High to proximal EHBD | 27 (9.31%) |
| High to RHD | 5 (1.72%) |
| Short CD | 1 (0.35%) |
| Total | 290 (100%) |

EHBD: Extrahepatic bile duct; RHD: Right hepatic duct

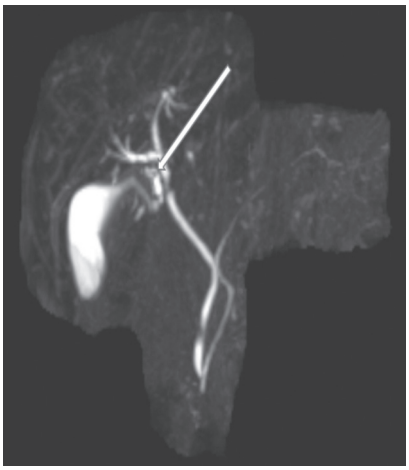

**Figure 2:** Coronal maximum intensity projection (MIP) reformat shows a high insertion of cystic duct to proximal extrahepatic bile duct (EHBD) (arrow).

**Figure 3:** Coronal maximum intensity projection (MIP) reformat shows a high insertion of cystic duct to the right hepatic duct (RHD) (arrow).

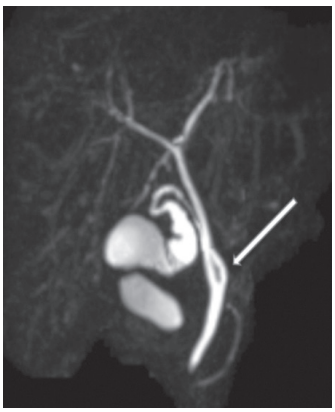

**Figure 4:** Coronal maximum intensity projection (MIP) reformat reveals a medial spiral insertion to the mid part of the extrahepatic bile duct (EHBD) (arrow).

**Table 2:** Distribution of the anatomic variations of the cystic duct according to sex

| Type of CD insertion | Man N (%) | Woman N (%) |
|---|---|---|
| Lateral aspect of middle third of EHBD | 121 (84.03%) | 103 (70.55%) |
| Anterior spiral medial | 3 (2.08%) | 5 (3.42%) |
| Posterior spiral medial | 6 (4.17%) | 8 (5.48%) |
| Low insertion | 4 (2.78%) | 2 (1.37%) |
| Parallel course | 1 (0.69%) | 2 (1.37%) |
| Spiral medial low | 1 (0.69%) | 1 (0.69%) |
| High to proximal EHBD | 6 (4.17%) | 21 (14.38%) |
| High to RHD | 2 (1.39%) | 3 (2.05%) |
| Short CD | 0 (0%) | 1 (0.69%) |
| Total | 144 (100%) | 146 (100%) |

EHBD: Extrahepatic bile duct; RHD: Right hepatic duct

## Discussion

The study revealed CD anatomic variations, which is slightly less than reported in the literature, with some differences in the subtypes.[3, 4, 6, 9]

Variability is seen in the cystic duct course and junction, which is not pathological per se, yet possibly crucial in interventional procedures. The precise assessment of the normal anatomy and the anatomic variants of the cystic duct would increase the diagnostic accuracy of diseases affecting the biliary system and reduce post-procedure unexpected complications.[3, 5, 8]

MRCP has become the modality of choice for biliary tract evaluation, which is non-invasive, radiation-free, and without need for anesthesia, helping in definite process and anatomy recognition, pre-procedure knowledge, and the avoidance of iatrogenic consequences.[9, 12, 13]

The cystic duct classically inserts to the EHBD laterally below the RHD and LHD confluence.[14] It was observed in 77.2% of the cases, with the prevalence of 51.5%, 58%, and 72% in the previous studies.[3, 15, 16] We observed anatomic variations in 22.8% of the cases.

Herein, the three common and clinically essential variants are the low insertions of the cystic duct, the medial insertion of the cystic duct, and the parallel course of the cystic duct with the frequencies of 2.8%, 7.6%, and 1%, respectively.

In these variants, distal EHBD is overly seen, which could mislead CBD cannulation and entrance into the cystic duct. It may cause CD injury or inadequacy in the treatment in laparoscopic cholecystectomy or ERCP.[3]

We detected less low insertion, including lateral and medial spiral, than other studies that indicated 9-10%.[6, 12, 17] Similarly, a lower frequency of medial insertion along with a vital variant during surgery was noted than the previous studies with a range of 10-20%.[3, 6, 9, 12, 18]

A parallel course of the cystic duct possibly leading to the false ligation of CBD was 1% in our study, with a higher rate in the literature 4%, 7.5%, and 25%.[3, 4, 17] It is shown that this variant and the medial one are associated with a high rate of CBD stone and its recurrence, technical problems during ERCP, and its complications.[19, 20]

Familiarity with these variants is crucial prior to interventions, such as laparoscopy or ERCP.

Several less common anatomic variants could also be found, such as short or absent cystic duct or a high insertion of the cystic duct.[12]

The revealed prevalence of high insertion to 1/3 proximal EHBD and RHD confluence and LHD was 9.3%. High insertion to RHD is a rare variant and reported in 0.3%-0.5%, while it was 1.7% in our study.[3] We observed a higher frequency of high insertion than the previous surveys.

This study revealed one case of the short cystic duct (0.3%), which is less than reported. This type could lead to CHD or CBD clamping, while cholecystectomy is being carried out.[3, 15, 16, 18] No CD duplication was seen.

The two sexes did not imply a significant difference between CD anatomic variants. However, this detail was not discussed in other studies.

The limitation of this study was that the comparison with ERCP or operative results was not available, and the angle of insertion point was not determined.

## Conclusion

The observed anatomic variations of the cystic duct in our population were slightly smaller than those reported in the literature, which required additional studies. However, it seems rational to aid the MRCP mapping of the biliary tract prior to interventions to prevent the iatrogenic complications subsequent to surgical, endoscopic, or percutaneous procedures.

## Conflict of Interest

Dr Alireza Taghavi, as the Editorial Board Member, was not involved in any stage of handling this manuscript. A team of independent experts were formed by the Editorial Board to review the editor's article without his knowledge.

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