

## Variations of Cystic Duct and Its Clinical Significance

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### ABSTRACT

**Background:** Cystic duct drains the bile from the gallbladder into the common bile duct. Gallstone disease is one of the most common problems affecting the digestive tract and may lead to many complications. To avoid the complications in these patients the gallbladder is removed surgically (Cholecystectomy). Ligation of cystic duct and cystic artery is a prerequisite procedure when cholecystectomy is done. Understanding about the normal anatomy & the possible variations in biliary ductal system is important for the surgeons for doing cholecystectomy surgery successfully. Errors during gallbladder surgery commonly result from failure to appreciate the common variations in the anatomy of the biliary system.

**Aim of the study:** To find out the incidence of variations in the length, course, and termination of cystic duct in cadavers.

**Materials and Methods:** Present study was done in 50 adult cadavers in the Department of Anatomy, Government Tiruvannamalai medical college, Tamilnadu. Meticulous dissection was done in the hepatobiliary system of these cadavers.

**Observations:** During the study variations in the length of cystic duct, course and different modes of insertion of cystic duct were observed.

**Conclusion:** Knowledge of variations in the length of cystic duct and knowing about different modes of course & insertion of cystic duct is necessary for surgeons while conducting cholecystectomy. The risk of iatrogenic injury is especially high in cases where the biliary anatomy is misidentified prior to surgery.

**KEY WORDS:** Cystic duct, Gallbladder, Cholecystectomy.

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### INTRODUCTION

Cystic duct (CD) drains the gallbladder (GB) into the common bile duct. It is between 3 and 4 cm long, passes posteriorly to the left from the neck of the gallbladder, and joins the common hepatic duct (CHD) to form the common bile duct (CBD). The variations in cystic duct anatomy are of considerable importance during surgical excision of gallbladder [1].

Gallstone disease is one of the most common

problems affecting the digestive tract. A gallstone is a concretion in gallbladder, cystic duct, and bile duct. These gallstones are much more common in females, and incidence increases with age. Even though most patients with gallstones will remain asymptomatic throughout life, some patients progress to a symptomatic stage, with biliary colic (intense spasmodic pain) caused by a stone obstructing the cystic duct [2]. Symptomatic gallstone disease may progress to many complications

such as acute cholecystitis, acute pancreatitis, obstructive jaundice, acute cholangitis, empyema or mucocele of gallbladder, gall stone ileus, gallbladder perforation with peritonitis and gallbladder cancer [3]. So to avoid these complications in these symptomatic patients the gallbladder is removed surgically, is known as Cholecystectomy.

In 1882, Carl Langenbuch performed the first open Cholecystectomy for a patient with biliary colic. More than 100 years later, in 1986 Muhe of Boblingen, Germany performed the first laparoscopic cholecystectomy. Because of having many advantages of Laparoscopic Cholecystectomy(LC) over Open cholecystectomy(OC), Laparoscopic cholecystectomy is recognized as the “gold standard” for the treatment of gallstone disease [4]. But for performing both these types of cholecystectomy the surgeon must have sufficient knowledge about biliary ductal system and biliary vascular system, because ligation of cystic duct(CD) and cystic artery(CA) is a prerequisite procedure when cholecystectomy is done. Ligation or clip occlusion of the cystic duct must be performed at an adequate distance from the common bile duct to prevent angulation or damage to it [1].

Understanding the variations in bile duct formation is important for surgeons when they ligate the cystic duct during cholecystectomy. Errors during gallbladder surgery commonly result from failure to appreciate the common variations in the anatomy of the biliary system.

**Anatomy of biliary ductal system and its possible variations:** The risk of iatrogenic injury is especially high in cases where the anatomy is misidentified prior to surgery. It is well known that anatomic variants of the biliary tree alone constitute one of the major groups of risk factors for bile duct injury during surgery. So, surgeons should know about the normal anatomy as well as the anatomic variants of biliary tree. The extrahepatic bile ducts consist of the right and left hepatic ducts, common hepatic duct, cystic duct, and common bile duct.

Cystic duct anatomy was first described by Francis Glisson in 1654 [5]. The right hepatic

duct (RHD) and left hepatic duct (LHD) emerge from the right and left lobes of the liver in the porta hepatis. After a short course, these hepatic ducts unite in a “Y” shaped manner to form the common hepatic duct (CHD), which is about 1.5 inch (4 cm) long and descends within the free margin of the lesser omentum. Cystic duct (CD) usually is somewhat S-shaped and it contains prominent concentric folds known as the spiral valves of Heister. Cystic duct comes from the neck of gallbladder and descends for a variable distance in the right free margin of the lesser omentum, and finally joins with the common hepatic duct(CHD) at an acute angle to form common bile duct (CBD) [6,7].

Variations in cystic duct anatomy are not uncommon. Cystic duct anatomy variants may complicate cholecystectomy and can be identified by pre-operative imaging modalities such as MRCP [8]. There may be variations in the length, course, and mode of insertion of cystic duct. Most of the times cystic duct varies in length from 1 to 5 cm [9]. Knowledge of the junction of cystic duct and common hepatic duct is essential for endoscopic management of biliary tract disease. The cystic duct most often joins the extrahepatic bile duct approximately halfway between the porta hepatis and the ampulla of Vater. However, the point at which the cystic duct joins the extrahepatic bile duct is variable, ranging from high (at the level of porta hepatis) to very low (at the level of the ampulla) [10]. When there is low union, cystic duct and common hepatic duct will be longer in length and may travel in a parallel course with each other before joining. During their parallel course they may be connected by fibrous tissue. This makes clamping the cystic duct difficult without injuring the common hepatic duct during Cholecystectomy. Any failure to recognize these variations may lead to common hepatic ductal ligation, biliary leaks or strictures after laparoscopic cholecystectomy [11]. Aberrant drainage of cystic duct into either right hepatic duct or left hepatic duct also seen in some cases. Very rarely cystic duct may drain directly into the duodenum [11].

Congenital anatomic variants of cystic duct are

common. But anatomy of cystic duct may also be altered in pathologic conditions resulting in progressive dilatation of the cystic duct due to passage of gallstones, or complete destruction of the cystic duct as in Mirizzi syndrome [12].

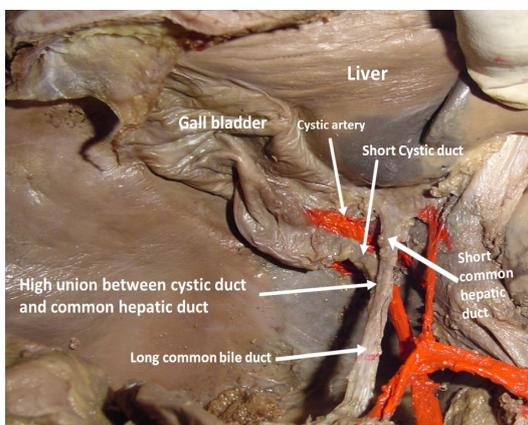
### MATERIALS AND METHODS

Present study was conducted in 50 adult cadavers in the Department of Anatomy, Government Tiruvannamalai Medical College, Tamilnadu. Meticulous dissection was done in the conventional method as given in the Cunninghams manual of practical anatomy. The abdomen was dissected for exposing the liver and gallbladder. Cystic duct and other ducts of extrahepatic biliary apparatus were traced. The normal course and abnormalities of cystic duct were observed.

**Aim of the study:** To study the variations in the length, course, and mode of termination of cystic duct, and to discuss about the probable complications caused by cystic ductal variations during cholecystectomy.

### OBSERVATIONS

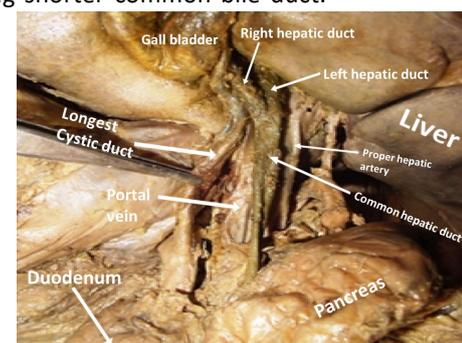
The present study was conducted in 50 adult cadavers. The length of cystic duct was measured by using vernier caliper in these cadavers. The length of cystic duct was ranging between 0.8 and 11.5 cm, with a mean average of 2.9 cm. Smallest length of cystic duct was observed as 0.8 cm in one cadaver, and it's longest length was seen as 11.5 cm in an another cadaver. This longest cystic duct was ending directly into the duodenum without joining common hepatic duct.



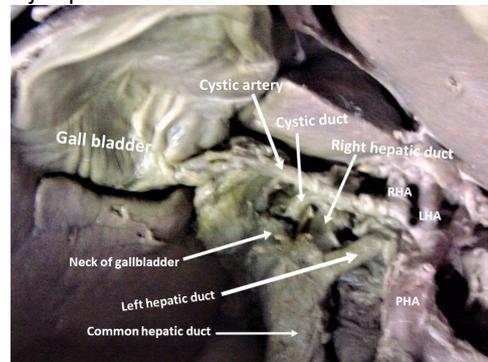
**Fig. 1:** Shorter cystic duct makes a High union with the short common hepatic duct to form longer common bile duct.



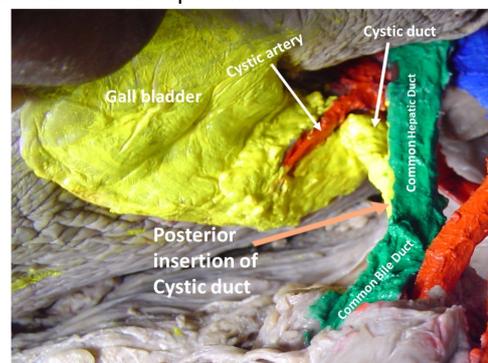
**Fig. 2:** Long cystic duct having a parallel course with the long common hepatic duct, then this cystic duct makes a Low union with that common hepatic duct for forming shorter common bile duct.



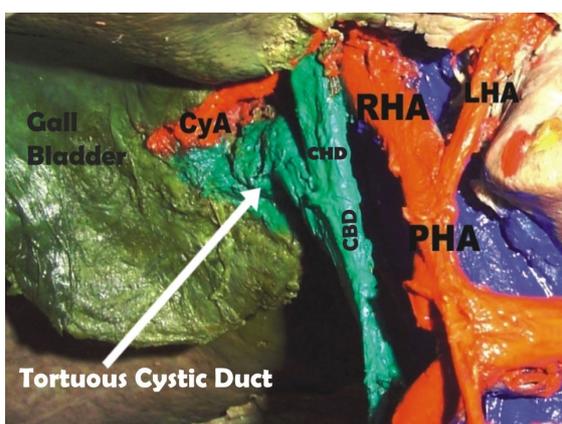
**Fig. 3:** Without having the routine pattern of joining with the common hepatic duct, Longest cystic duct of the present study opens directly into the duodenum. Common hepatic duct enters into pancreas for joining with major pancreatic duct.



**Fig. 4:** Without having the routine pattern of union with common hepatic duct, Cystic duct joins with the right hepatic duct in this specimen.



**Fig. 5:** Without having the routine pattern of joining with the right side of common hepatic duct, cystic duct is inserted on the posterior aspect of common hepatic duct in this specimen.



**Fig. 6:** Tortuous type cystic duct joins with the common hepatic duct in this specimen.

**Table 1:** Variations in length of Cystic duct in the present study.

S. No.	Types of variations in length of cystic duct in the present study	Length of Cystic duct ( in centi meters )
1	Shortest cystic duct	0.8 cm
2	Longest cystic duct	11.5 cm
3	Range of variation in length of cystic ducts of 50 adult specimens	From 0.8 to 11.5 cm
4	Mean Average of length of cystic ducts of 50 adult specimens	2.9 cm

Mode of termination of cystic duct shows many variations in the present study. Cystic duct joined with the common hepatic duct to form common bile duct In 47 cadavers (94%). Rare variation of aberrant insertion of cystic duct into right hepatic duct was seen in 2 cadavers (4 %). As I already mentioned, the cadaver having the longest cystic duct of the present study shows aberrant insertion of cystic duct into the duodenum directly without joining common hepatic duct.

**Table 2:** Different types of insertion of Cystic duct in the present study.

S. No	Different types of insertion of Cystic duct	Number of Cadavers	Percentage
1	Cystic duct ends by joining with the common hepatic duct	47	94%
2	Cystic duct ends by joining with the right hepatic duct	2	4%
3	Cystic duct ends into duodenum directly	1	2%

Among 47 cadavers having insertion of the cystic duct into common hepatic duct, termination of cystic duct on the right side of common hepatic duct was seen in 46 cadavers (92%). I did not see any cadaver having termination of cystic duct on left side of common hepatic duct in the present study. Very rare type of insertion of cystic duct into the duodenum directly without joining common hepatic duct

was present in one cadaver (2 %). But I could not see insertion of cystic duct into the anterior aspect of common hepatic duct in any cadavers. Among these 47 cadavers, in as majority as 42 cadavers (84%) I observed the cystic duct joining the common hepatic duct approximately halfway between the porta hepatis and the ampulla of Vater. In the remaining 5 cadavers I noted high confluence of cystic duct with common hepatic duct in 3 cadavers (6%) and low confluence of cystic duct with common hepatic duct in 2 cadavers (4%).

**Table 3:** Different modes of union between CD & CHD in the present study.

S. No.	Variations in mode of union between cystic duct and common hepatic duct	Number of Cadavers	Percentage
1	Termination of cystic duct on the right side of common hepatic duct	46	92%
2	Termination of cystic duct on the left side of common hepatic duct	0	0%
3	Termination of cystic duct on the posterior aspect of common hepatic duct	1	2%
4	Termination of cystic duct on the anterior aspect of common hepatic duct	0	0%
5	Cystic duct joining common hepatic duct approximately halfway between the porta hepatis and the ampulla of Vater	42	84%
6	High confluence of cystic duct with common hepatic duct	3	6%
7	Low confluence of cystic duct with common hepatic duct	2	4%

Cystic duct and common hepatic duct were running parallel with each other in 4 cadavers (8%). I found tortuosity of cystic duct in 2 cadavers (4%). I did not see spiral type of insertion of the cystic duct in the present study.

## DISCUSSION

An increase in the cystic duct resistance leads to impaired emptying of the gallbladder was claimed to be one of the etiologic factors for gallstone formation. Multiple disfigurements of cystic duct may provide a background for lithogenesis of gallbladder [13]. Variations in cystic duct anatomy are not uncommon and reported incidences vary from 18%-23%. There may be variable length of cystic duct, variable course, and variable insertion. Any failure to recognize these variations may lead to ductal ligation, biliary leaks or strictures after laparoscopic cholecystectomy [14].

Cystic duct length was measured between 0.7 and 3.9 cm, with an average of 1.9 cm in Cachoeira E et all study [15]. Cystic duct length varies from 1.5 to 9.5 cm with the mean length

of 3-4 cm in Turner MA et al study [11]. In the present study cystic duct length was measured between 0.8 to 11.5 cm, with a mean average of 2.9 cm. Variations of the cystic duct and its point of union with the common hepatic duct are surgically important. Occasionally, cystic duct runs alongside the common hepatic duct and adheres closely to it [2]. Cystic duct most often joins the extrahepatic bile duct approximately halfway between the porta hepatis and the ampulla of Vater. However, the point at which the cystic duct joins the extrahepatic bile duct is variable, ranging from high (at the level of porta hepatis) to very low (at the level of the ampulla) [10]. When there is low union of cystic duct with common hepatic duct, the two ducts may be joined by fibrous tissue, making clamping the cystic duct difficult without injuring the common hepatic duct during cholecystectomy [2].

Incidence of cystic duct joining the extrahepatic bile duct approximately halfway between the porta hepatis and the ampulla of Vater was seen in 51.5 % cases of Radha sarawagi study [16], and in 52 % cases of Ali Yasen Yasen Mohamed Ahmed et al study [17]. But this incidence is higher in the present study as 84% (42 cadavers).

High confluence of cystic duct with the common hepatic duct was seen in 5.5 % (11 cases) of Radha sarawagi study [16], and in 7.8 % (5 cadavers) of Ali Yasen Yasen Mohamed Ahmed et al study [17]. This variation was observed in 3 cadavers (6 %) of the present study. Low confluence of Cystic duct with the common hepatic duct was seen in 18 (9%) cases of Radha sarawagi study [16]. I found this variation in only 2 cadavers (4 %) of the present study.

Knowledge of the junction of the cystic and common hepatic duct is essential for endoscopic management of biliary tract disease [18]. Orientation of cystic duct for joining common hepatic duct differs in different persons. It is defined as lateral (insertion diagonally from the right), medial (insertion into the left side of the common hepatic duct), or posteroanterior (overlap of the junction with the bile duct in the posteroanterior view) [19]. Termination of cystic duct into the right side

(lateral side) of common hepatic duct was seen in 67.3 % cases of Sirisha et al study [20]. This lateral type of insertion was seen in 92% (46 cadavers) of present study. Termination of cystic duct into left side (medial side) of common hepatic duct was seen in 3.84 % cases of Sirisha et al study [20] , 17 % cases of P.Taourel et al study [21] , 18% cases of Shaw et al study [18] , 18.4 % cases of Turner et al study [11]. This medial termination of cystic duct into common hepatic duct was not seen in the present study. In Turner et al study [11], they found cystic duct entering into the extrahepatic bile duct from an anterior or posterior position in 31.7% of cases. Cystic duct opened on the anterior aspect of CHD in 11 cases (21.15%) of Sirisha et al study [20] . In the present study cystic duct opened into the posterior aspect of Common hepatic duct in 1 cadaver (2%). But opening of cystic duct on anterior aspect of Common hepatic duct was not seen in the present study.

Cystic duct has a parallel course relative to the extrahepatic bile duct in 10.6% cases of both Pavlidis et al study [10] & Turner et al study [11], in 11 % cases of Shaw et al study [18], and in 13.8 % cases of Ali Yasen Yasen Mohamed Ahmed et al study [17]. But Cystic duct and common hepatic duct were running parallel with each other in only 4 cadavers (8%) of the present study.

Incidence of aberrant insertion of Cystic duct into the right hepatic duct was seen as ranging from 0.6 to 2.3% in Cachoeira E et al study [15] .This variation is highly dangerous because right hepatic duct may be confused with the cystic duct and so it may be mistakenly cut and ligated during cholecystectomy. This type of variation was seen in 2 cases (1%) of Radha Sarawagi study [16], 3 cases (4.6 %) of Ali Yasen Yasen Mohamed Ahmed et al study [17], 1 case (1.92%) of Sirisha et al study [20]. I found this variation in two cadavers (4 %) of the present study.

Yamakava et al [22] found a rare variant of aberrant insertion of cystic duct into left hepatic duct in their study. This variation was seen in 1 case (1.92%) of Sirisha et al study [20] . But none of the cadavers of the present study showing insertion of cystic duct into the

left hepatic duct.

Turner et al [11] mentioned as cystic duct may insert directly into duodenum rarely. I found this very rare type of direct termination of cystic duct into the duodenum in one cadaver (1.66 %) of the present study.

In a study of 250 patients of Cholelithiasis, Deenitchin et al [23] found tortuosity of cystic duct in 7 patients. This tortuosity of cystic duct was observed in 2 cases (4 %) of the present study. Spiral type of insertion of cystic duct was seen in 32% cases of Shaw et al study [18], but it was not observed in the present study.

### CONCLUSION

Knowledge about the variations in the length of cystic duct and different modes of course & insertion of cystic duct is necessary to the surgeons while conducting the gallbladder surgeries. Errors during gallbladder surgery commonly result from failure to appreciate the common variations in the anatomy of biliary system. Hence I hope this study would give meticulous and comprehensive information to the surgeons about the variations of cystic duct for doing cholecystectomy successfully.

### ABBREVIATIONS

- CD** - Cystic duct.  
**CHD** - Common Hepatic Duct.  
**CBD** - Common Bile Duct.  
**RHD** - Right Hepatic duct.  
**LHD** - Left hepatic duct  
**CA** - Cystic artery  
**RHA** - Right hepatic artery  
**LHA** - Left hepatic artery  
**PHA** - Proper hepatic artery  
**GB** - Gall bladder  
**OC** - Open Cholecystectomy  
**LC** - Laparoscopic Cholecystectomy

**Conflicts of Interests: None**

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