

Study of the variations of extra-hepatic biliary apparatus among the population of West Bengal

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Abstract: *Background:* Cholecystectomy, both open and laparoscopic, are the major operations done upon upper abdomen. It is evident that, anomalies of the biliary tract are of sufficient importance to surgeons, radiologists and the gastroenterologists as well as to the anatomists from the gross anatomical and developmental point of view. *Objectives:* To note the various anomalies or variations in the biliary tract and their incidences. As most of the cadavers used in the present study are received from Kolkata this can be a regional study. *Methodologies:* Formalin-hardened specimens of liver with gall bladder from 100 adult cadavers, aged between 20-60 years were collected in the Department of Anatomy, with the help of the Department of Forensic Medicine, R.G. Kar Medical College, Kolkata between 2012-2015. *Results:* The average lengths of various parts of biliary apparatus was measured. A statistically significant difference between the means of lengths of common hepatic ducts in males and females was found. The mode of formation of duct system, the course and arrangement of the ducts, the mode of termination along with the related vessels were studied. Variations are more common in females than that of the males. *Conclusion:* Incidence of each anomaly/variations was compared with the findings of other authors. Clinical significance of anomalies/variations of extra-hepatic biliary apparatus has been discussed.

Keywords: Extra Hepatic Biliary Apparatus, Anomaly/ Variations, Cholecystectomy.

Introduction

The anatomy of biliary system has been the subject of extended research for many years largely because of their surgical importance in cholecystectomy, and interest has been centered on the extra-hepatic biliary tree because it is frequently abnormal. Many studies have attempted to determine a standard length, diameter, and thickness of various portions of the ductal system but significant normal variability in duct size and length may be encountered, according to Awazil L G (2013)[1]. Cholecystectomy, both open and laparoscopic, are the major operations done upon upper abdomen. It is evident that, anomalies of the biliary tract are of sufficient importance and a surgeon, who operates upon it should have a thorough knowledge of their existence. Hasan M.M et al (2013) [2] reported an association between abnormal anatomy and biliary tract injury. From the gross anatomical as well as developmental point of view, these variations are

of great interest to the Anatomists. The incidence of anatomical variations of extra hepatic biliary apparatus is reported as low as 7.3% to be high as 47% [3-6].

The present study thus aims to note the various anomalies or variations in the biliary tract and their incidences. As most of the cadavers used in the present study are received from Kolkata this can be a regional study. It will also be interesting to note whether incidence of these anomalies or variations are different from studies carried out in other parts of the world. And lastly to see if any anomaly is found which is not reported in the world literature so far.

Material and Methods

For the present study we have taken 100 adult cadavers, all of them between 20-60years of age and all of them were collected in the

Department of Anatomy, with the help of the Department of Forensic Medicine, R.G. Kar Medical College, Kolkata between 2012-2015.

Instruments:

- 1) Scalpel blade
- 2) Forceps
- 3) Scissors
- 4) Measuring tape
- 5) Dividers
- 6) Formalin

Methods:

After collection the specimens were kept in formalin for hardening. After thorough washing of the specimens in running water, the hepatoduodenal ligament was opened by tracing the bile duct upwards and to secure the point where the cystic duct and the common hepatic duct unite. Cystic duct was traced upwards up to the neck of the gallbladder. Common hepatic duct then traced upwards to locate the right and left hepatic ducts emerging from the porta-hepatis. During the above procedure the mode of formation of duct system, the course and arrangement of the ducts, the mode of termination were studied. Length of the individual duct was measured then by the following way-

- *Hepatic ducts:* The right and the left hepatic ducts were measured from the origin of the ducts at the porta-hepatis of liver to the mid-point of their unions and the common hepatic duct from this point to the mid-point of its junction with the cystic duct.
- *Common bile duct:* It was measured from the mid-point of junction of the common hepatic duct with the cystic duct up to its termination into the duodenum.
- *Cystic duct:* The gallbladder was put on stretch, just enough to straighten the cystic duct. The duct was then measured from its commencement to the mid-point of its junction with the common hepatic duct.

Study was conducted using following parameters:

- 1) *Hepatic ducts:* a) Length of right hepatic duct (RHD).b) Length of left hepatic duct (LHD) and c) Site of union of right and left hepatic ducts: Extra-hepatic or Intra-hepatic.
- 2) *Cystic duct:* a) Length of cystic duct. b) Type of union of cystic duct with the common hepatic duct: Angular, Parallel or Spiral and c) Level of termination of cystic duct in common hepatic duct: High level, Low level or Normal level.

- 3) Length of common hepatic duct with variations.
- 4) Variations of ductal system: Presence of any accessory hepatic duct or cystic duct and mode of termination of that duct.

Inclusion Criteria: All cadaveric en-bloc livers during course of study-Age limit 20-60 years.

Exclusion Criteria: Cadaveric en-bloc livers during the course of study-

- Who had undergone any reconstructive surgery?
- Livers with burn and which were traumatized.
- All pathological livers.

Results

Hepatic Ducts:

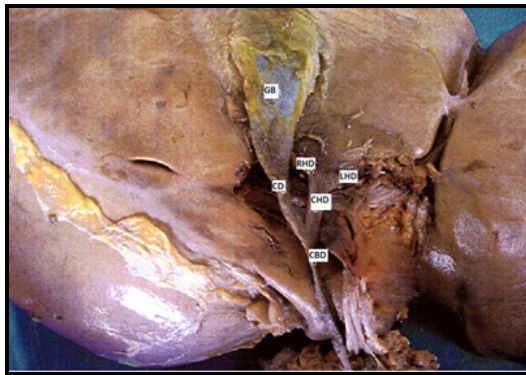
(A) *Length of Hepatic Ducts:* The length of right hepatic duct varied from 0.5cm to 4.9cm with an average of 1.359cm in total 100 specimens. The left hepatic duct in almost all cases was greater than the right hepatic duct due to its more oblique course. It ranged between 0.5 to 5.6 cms. with an average of 1.538 cms. There was also no statistically significant difference between the mean values of male and female hepatic ducts on both sides.

(B)*Union Of Right And left Hepatic Ducts:* In the present series the union of two hepatic ducts was found to be extra-hepatic in 85 specimens (85%) and intra-hepatic in 15 specimens (15%) shown in Table-1. There was no statistically significant difference in the extra-hepatic and intra-hepatic union of hepatic ducts between male and female. $X^2=0.092, p>0.05$.

Table-1: Mode of Union of Right and Left Hepatic Ducts		
No. of Specimens	Extra-Hepatic Union	Intra-Hepatic Union
Males-70	60(85.71%)	10(14.28%)
Females-30	25(83.33%)	5(16.66%)
Total-100	85(85%)	15(15%)

* Among all of the extra-hepatic unions, most of all occurred within a short distance of the hilum except in 4 specimens where the unions were considerably below the level of the hilum. So, in these four specimens the unions were therefore extra-hepatic low union. Out of these four specimens, in one specimen the right and left hepatic duct and the cystic duct joined at the same level and in one specimen the cystic duct directly joined the right hepatic duct. Hence the common hepatic duct was absent in two specimens.

Fig-1: Extra-hepatic Union of RHD and LHD



Extra-Hepatic Union:

Normal Union Site: 81 (male-56, female-25) 95.29%

Low Union: 4 (all male) 4.7%

*The right and left hepatic ducts formed an acute angle in 20 specimens (23.52%) of the extra-hepatic unions, and in remaining 65 specimens (76.47%) they formed a wide angle.

Common Hepatic Duct:

Length of Common Hepatic Duct: The absence of common hepatic duct in two specimens has already described previously. In the remaining 98 specimens it coursed downwards with a slight inclination to the right before being joined by the cystic duct and was placed anterior to either the right division or the trunk of portal vein. The length of common hepatic duct varied from 2.4 to 5cm (average of 3.403cm) with statistically significant difference between male and female.

Cystic Duct:

(A) *Length of Cystic Duct:* Out of 100 specimens the cystic duct was present in 99 specimens and its length varied from 1.4 cm to 7 cm with an

average of 3.458 cm. Cystic duct was absent in 1 specimen where the gallbladder directly opened into the common hepatic duct. No statistical significant difference between male and female was observed.

(B) *Mode of Union of Cystic Duct with the Common Hepatic Duct:* In case of left sided gallbladder, the cystic duct was found to be opening into the common hepatic duct from its left side. The mode of union of cystic duct with common hepatic duct are described in the following Table-2.

Types of union	No. of specimens	Percentage
1. Angular union	70	70.70%
2. Parallel union	18	18.18%
3. Spiral union	11	11.11%
a) Anterior spiral	8	8.08%
b) Posterior spiral	3	3.03%

Fig-2: Angular type union of cystic duct



Fig-3: Parallel type union of CD



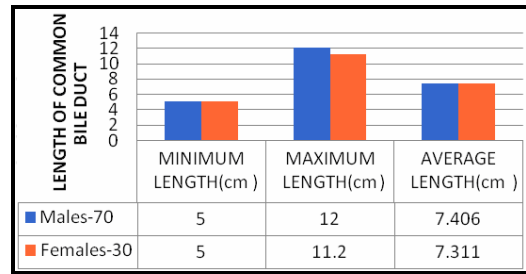
Common Bile Duct:

Length of Common Bile Duct: In this series common bile duct was present in all specimens. Only in two specimens the supra-duodenal part of common bile duct were absent as in these two cases the cystic ducts joined the common hepatic ducts at the upper border of first part of duodenum. In 80 specimens (80%) the common bile duct was found to be lying directly anterior to the trunk of the portal vein and in 20 specimens(20%) it was on a plane anterior to that of the vein but to its right.

As mentioned in Chart No. 1 the length of common bile duct varied from 5 cm to 12 cm with an average of 7.5 cm. Choledochal cyst was found in one case but no stone was found on exploration. There was no statistically significant

difference between the mean values of male and female common bile duct. $p>0.05$.

Chart-1: Analysis of length of common bile duct

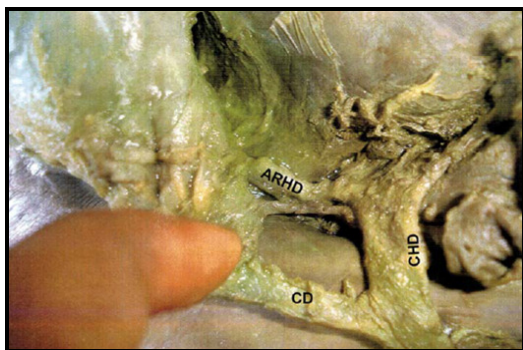


Accessory ducts with their mode of termination:

In our present study, we found 11 specimens (11%) having accessory ducts. Mode of termination of accessory ducts are illustrated in the Table-3.

Name of the ducts	No. of specimens	Mode of termination
1) Accessory right hepatic duct	7(7%)	a) Common hepatic duct-6 b) Cystic duct-1
2) Accessory left hepatic duct	1(1%)	Common hepatic duct
3) Accessory cystic duct	2(2%)	a) Common hepatic duct-1 b) Cystic duct-1
4) Cholecystohepatic duct	1(1%)	Both ducts arose from right lobe of the liver and entered the gallbladder.

Fig-4: Accessory right hepatic duct joining at the upper part of CHD



Discussion

***Hepatic Ducts:**

1)*Length of Hepatic Ducts:* The findings of the present series are not corresponding to the findings of Johnston EV et al [7]and Dowdy GS et al [8].The average lengths of right and left

hepatic ducts were found to be more in present series than their findings.

2) *Site of Union of Right and Left Hepatic Ducts:* Intra-hepatic and extra-hepatic unions of both hepatic ducts to form common hepatic duct were noted by various authors. Paul S et al [9] in 2013 noted 4% of specimens showing intra hepatic union of hepatic ducts whereas Hollinshead WH [10], Maingot R [11], and Rugg Ernst [12] noted 9%, 10%, and 21% respectively. In the present study we have found 15% of specimens showing intra hepatic union and 85% showing extra hepatic union of hepatic ducts to form common hepatic duct.

Extra-hepatic union of hepatic ducts is important surgically because of the case with which choledochenteric anastomosis can be effected in these cases, which is in contrast to

the situation which obtains in case of intra-hepatic unions. The wide angle unions are found where the ducts are shorter and acute angle ones where the ducts are relatively longer than the normal range.

*Common Hepatic Duct:

In the present series common hepatic duct was absent in 2 specimens, among which in one specimen the cystic duct directly joined the right hepatic duct and in other specimen, cystic duct and the right and left hepatic ducts joined at the same level. The significance of these type of presentation has already been described previously. No duplication of common hepatic duct was found in present series. Johnston E V et al [7] reported as 80% of common hepatic ducts falling between 2-3.5cm. Where as in our study we found 50% specimens had common bile duct ranging between 2-3.5 cm.

In the present study the average length of common hepatic duct was more than the previous studies. The length of common hepatic duct was found to be more in females than in males. However, we could not find out any exact explanation regarding this difference.

*Cystic Duct:

1) *Length of Cystic Duct:* Hollinshead WH [10] reported that about 55% of cystic ducts are 2 to 4cm long, 20% less than 2cms. long and 25%, 4cm long or longer. Whereas in the present study these ranges were found as 58.4% , 13.8%, and 27.6% respectively. The average length of the cystic duct was found 3.46 cm which was more in comparison to the findings of other authors. There is unfortunately not much reporting of findings for the ranges of length. Dowdy GS et al (1962) [8] have mentioned the lengths of the longest and the shortest ducts as 6 and 0.4cms. (in present series it was 7 and 1.4 cm respectively).

A short cystic duct is surgically of utmost importance, because the common hepatic duct or the common bile duct may be clamped or injured during its ligation. A long cystic duct is also surgically important. If not removed by its entire during cholecystectomy, stone may lodge in it, giving rise to recurrence of symptoms (cystic duct remnant syndrome). Also a miniature gallbladder may form from the remnant.

2) *Absence of Cystic Duct:* Congenital absence of cystic duct may lead to severe complications during open cholecystectomy [13] where lies its importance to note the absence of cystic duct. The cases where cystic duct are absent, the gallbladder directly open into the common hepatic duct. Sirisha V et al [14] in 2017 noted 1 such case among 52 specimens where as in present series we found 1 such case among 100 specimens. Adam Y and Metcalf W (1966) [15] found 17 reported cases of absence of cystic duct and they added one of their own. Maingot R (1980) [11] in his last 500 consecutive cholecystectomies found 7 such cases. During cholecystectomy in such case the right hepatic artery which may be lying behind the gall-bladder may be traumatized, when broad isthmus it being clamped or divided.

3) *Type of Union of Cystic Duct with Common Hepatic Duct:* In the present series, angular, parallel, and spiral type of union of cystic and common hepatic ducts were found in 70 (70.70%), 18 (18.18%) and 11 (11.11%) specimens respectively. When the parallel type of union of the cystic duct exists, the two ducts may be closely adherent to each other, so that it is very difficult to put a clamp upon the cystic duct or to isolate it without injuring the common hepatic duct. In spiral and parallel unions, a variable length of cystic duct is bound down to the common hepatic duct and the two are enveloped in a common connective tissue sheath (producing a 'double barrelled' common bile duct). Failure to recognize these during operation may result in injuries to the duct system.

Johnston EV and Anson BJ (1952) [7] reported that it is obvious that both parallel and spiral type of union presents difficulties in surgery. High and low level of union of cystic duct with common hepatic duct carries significance because of the potential for injury in cholecystectomy. During cholecystectomy, the lower the union, the greater are the chance of leaving behind a long cystic duct stamp.

In obstruction of the lower part of common bile duct in carcinoma of head of the pancreas, a bypass-operation between the biliary and gastrointestinal tracts becomes necessary. The

higher is the union of the ducts, the longer is the length of the common bile duct available for such anastomosis and longer is the palliation.

***The Common Bile Duct:**

Higher degree of peculiarities are seen in common bile duct regarding its size, course and position. It's size ranges from 6-8 cm on average with a larger size among males than females [16].

Length of Common Bile Duct: Average length of common bile duct in the present study is 7.5 cm which corresponds to that of Maingot R [11].

***Accessory Ducts:**

(1) *Accessory Hepatic Duct:* Various authors have reported the incidence of accessory hepatic ducts, issuing from the liver and joining the extra hepatic biliary apparatus. Sharmila A et al [17] studied on the South Indian population, the incidence being 15% whereas according to Bharat NV et al[18]revealed 26.7% out of 30 specimens in North Indian population. Anandhi PG et al [19]in 2018 reported a total of 14% of specimens having accessory ducts out of which 10% were accessory right hepatic ducts. On another study Devi KP et al [20] found 17% of specimens having accessory hepatic ducts while Khayat MF et al [21]on 2014 observed in only 3.33% of specimens. In present series out of 8 accessory hepatic ducts 7(7%) were found to be present on the right side and 1(1%) on left side. An accessory duct is usually the size of a normal cystic duct but in some cases it may be minute.

Flint E R (1923) [22] dissected 200 specimens. He classified 29 accessory right hepatic duct on basis of termination as-

	Flint Study	Present study
a) Junction occurs in upper half of CHD/in right hepatic duct-	4.5%	4%
b) Junction occurs in lower half of CHD-	4.5%	3%
c) Junction occurs at the union of cystic duct and CHD-	5%	Nil

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The present study thus coincides with the Flint's study except in termination at the union of cystic and common hepatic duct. Lurje A M (1963) [23] stated that 2.8% of accessory ducts from right lobe of liver entered cystic duct. In present series, we noted 1% of accessory duct from right lobe of liver joined cystic duct.

Clinical importances:

- a) An undetected injury to one of these accessory hepatic ducts during cholecystectomy may subsequently produce a troublesome external biliary fistula or bile peritonitis, with attendant complications.
- b) When an accessory duct passes through the cholecystohepatic triangle it is subjected to inadvertent transection and bile leakage.
- c) Importance of having knowledge of likelihood of accessory hepatic ducts along with their positions, lies in laparoscopic cholecystectomy as the incidence of bile duct injuries is twice as high when compared to open cholecystectomy [24].

(2) *Accessory Cystic Duct:* Schanchner A (1916) [25] studied 76 specimens in that, he noted a double cystic duct in 2 cases, absence of cystic duct in 1 cases. In the present study, we found 2 specimens (2% of total) having accessory cystic duct. One of them joined with the common hepatic duct and another with the main cystic duct.

Conclusion

Incidence of each anomaly/variations was compared with the findings of other authors. Clinical significance of anomalies/variations of extra-hepatic biliary apparatus has been discussed.

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Conflicts of interest: There are no conflicts of interest.

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