

Original Research Article

Anatomical variations in the extra hepatic biliary system: a cross sectional study

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ABSTRACT

Background: The anatomy of the biliary system has been the subject of extended research for many years. Largely because of their surgical importance in cholecystectomies and the ease with which they may be studied. Though, interest has been focused on the extrahepatic bile ducts very few studies have been carried out in the Indian subcontinent. Objectives was to study the anatomical variations in extrahepatic biliary system in sample of Indian cadaveric specimens.

Methods: The study material consisted of 20 adult dissection room cadavers and 30 enbloc post-mortem specimens. Cadaver specimens were studied from dissection room. Post-mortem enbloc specimens were collected from the Department of Forensic Medicine, Madurai Medical College, Madurai. They were studied by conventional dissection method.

Results: The key abnormalities found in all bladder were Hartman's pouch shape and neck in 2 (4%) subjects each. Gallstones were present in 2 (4%) subject. The length of the common Bile duct was ranging from as short as 6.5 cm in 24% of the subjects to 9cm in 4% of the subjects. High level of the cystic duct union with the common hepatic duct was noted in 16% of specimens and in remaining 2% it was low union. Abnormal arrangement of structures in hepatoduodenal duct was normal in 98% but was abnormal in 2% of subjects. A total of 14% of the specimens had accessory ducts. Double and accessory cystic artery was found in 2% of the subjects each. In 8% of the subjects, cystic artery had abnormal course and division. The right hepatic artery was had shown abnormal course and division in 4% of the subjects. Abnormal boundaries of Calot's triangle was found in 2% of the subjects. Abnormal contents of Calot's triangle include Accessory hepatic ducts in 10% of subjects.

Conclusions: Anatomical variations of the extrahepatic biliary system are very common and a through an understanding of them is essential for surgeons to avoid damage to vital structures during surgical procedures and better surgical outcomes.

Keywords: Anatomy, Extrahepatic biliary system

INTRODUCTION

Extra-hepatic biliary tract (EHB) is one of the commonest sites of surgical procedures. The incidence of anatomical variations in this system is reported as low as 7.3% to be as high as 47%.¹⁻⁴ Common anomalies of the

biliary system and gallbladder include disparities in number and location of the gallbladder. Multiple gallbladders may sometimes have separate cystic ducts, or two or more may share one cystic duct. Such extra gallbladders may lie below the right or left lobe of the liver or within the liver or gastrohepatic ligament. They may arise from the common bile duct (CBD), hepatic

duct, or right or left hepatic duct. In some cases, however, a separate duct from the liver enters the gallbladder, cystic duct, or junction of the cystic duct and CBD. These ducts have become known as Luschka's ducts.^{5,6} During laparoscopy, these extra ducts should be treated by ligation, suture, clipping, cauterization, or exclusion when they are identified.

The common disorders of the extrahepatic biliary system are cholelithiasis, cholecystitis, gallbladder atresia, malignant neoplasms of the gall bladder or other parts of the biliary tract.⁷ Jaundice is frequently the primary presenting sign in humans with disorders involving the gallbladder or extrahepatic biliary structures; abdominal effusion may indicate bile peritonitis. A higher bilirubin concentration in an effusion relative to serum (>10-fold difference) confirms leakage of bile into the abdominal cavity and constitutes a surgical emergency.⁸

For routine cholecystectomy and for procedures involving exploration of the biliary tree, surgeons must have knowledge of the potential variations in the location and course of the arterial supply of the region. The cystic artery that usually anterior to the CBD and superior to the cystic duct can sometimes be a paired artery. It may be immediately adjacent to the cystic duct.⁹ Also, variations and anomalies of the arterial supply to the gallbladder and extrahepatic biliary tree occur are very common and can present significant challenges to surgeons. The hepatic artery can have an accessory right hepatic artery from the superior mesenteric artery. An abnormal course for the hepatic artery arises when it crosses anterior to the hepatic duct or when the right branch is situated anterior to the right hepatic duct. The clinicians should be aware of possible venous varicosities or aneurysmal dilations of the right hepatic artery, either of which may occur in Calot's triangle.

In some cases, an accessory cystic artery arises from the main hepatic artery or from the right hepatic artery. During open cholecystectomy or laparoscopic cholecystectomy, incomplete visualization before dissection of the cystic artery can inadvertently lead to damage of these other major vessels.¹⁰ The course and location relative to other structures of the cystic artery can be highly variable. The cystic artery can be seen in the hepatic ducts or even behind the common hepatic duct.

The cystic artery arises from the right hepatic artery and runs parallel and medial to the cystic duct in as much as 95% of cases.¹¹ If it arises more proximally, it originates from the common hepatic artery (in 33% of cases), or rarely, from the celiac trunk and in 16% of cases the artery may lie posterior to the hepatic duct.⁵ In these instances, the artery runs more parallel to the CBD posing obvious problems to surgeons, who must clearly identify this vessel in preparation for and during cholecystectomy. Double cystic arteries may be seen in 8-15% of patients, and a rarely (0.3%) patients have a triplicate arterial

supply to the gallbladder while in 12% of patients, accessory cystic arteries are present.¹²

The most common surgical pitfalls include inadequate visualization and exposure of the cystic artery at the level of the gallbladder neck. Regardless of its proximal origin, the cystic artery by default must at some point terminate at the gallbladder. In most cases, surgical dissection of the cystic duct and cystic artery should begin adjacent to or near the point of origin of the cystic duct or near the point of entry of the branch vessels of the artery into the gallbladder wall. This is probably the most important step in the prevention of accidental bile duct or hepatic arterial injury during open or laparoscopic cholecystectomy.¹³

Common bile duct injuries, although uncommon, can be devastating to patients. Proper exposure of Calot's triangle and careful identification of the anatomic structures are keys to avoiding these injuries. Once a bile duct injury is diagnosed, the best outcomes are seen at large referral centers with experienced biliary surgeons. Knowledge of the various anatomic anomalies of the cystic duct and artery is helpful in guiding the dissection of these structures as well as avoiding injury to the common bile duct during cholecystectomy.

The anatomy of the biliary system has been the subject of extended research for many years. Largely because of their surgical importance in cholecystectomies and the ease with which they may be studied. Though, interest has been focused on the extrahepatic bile ducts very few studies have been carried out in the Indian subcontinent.

METHODS

Study materials

The study material consisted of 20 adult dissection room cadavers and 30 enbloc postmortem specimens.

Specimen collection

Cadaver specimens were studied from dissection room. Postmortem enbloc specimens were collected from the Department of Forensic Medicine, Madurai Medical College, Madurai. They were studied by conventional dissection method. The autopsies had been carried out by laparotomy midline incision from xiphisternum towards umbilicus. Incision extended laterally, from xiphisternum along the coastal margin. Rectus muscle cut open in the midline. Peritoneum opened and entered into the abdominal cavity. Stomach identified and its curvatures were defined. Pulling the lesser curvature, lesser omentum identified and its right free margin was defined and then hepatoduodenal ligament was identified. Now the greater omentum was cut transversely below it was pushed forwards towards the right. Coils of small intestine were pushed towards left and 2nd part of duodenum was exposed and two ligature were put, one at

the pyloric end of the stomach and second just below 2nd part of the duodenum.

Now, the stomach was reflected fully upwards to expose the pancreas and then it was cut at the level of the neck. This makes the visceral surface of the liver, free along with duodenum and head of the pancreas. The ribs were cut open along the midaxillary line on both sides and reflected upwards along with sternum, to make the parietal surface of liver free. Inferior vena cava identified and cut, and now the liver along with gallbladder, duodenum, and head of pancreas was removed in total. They were transported in closed plastic containers to the Institute of anatomy for further dissection.

Dissection procedure

After thorough washing of the specimens in running water, the gallbladder, cystic artery, cystic duct, right, left and common hepatic ducts were dissected in all specimen. The gallbladder was looked for its number, position, peritoneal relations, shape, interior, dimensions and distance from the inferior border of the liver.

The hepatoduodenal ligament was opened by tracing the bile duct upwards and to secure the point where the cystic duct and common hepatic duct units. Cystic duct traced upwards up to the neck of the gall bladder. The common hepatic duct was then traced upwards to locate the right and left duct emerging from porta hepatica. Lateral to the duct system towards left the common hepatic artery was identified and traced upwards where it divides into right and left hepatic arteries. From the right hepatic artery, the cystic artery was identified and traced. The boundaries of calot's triangle were defined and the cystic artery inside the triangle was traced up to the gall bladder. Posterior to all above structures, the portal vein was defined. During the above procedure, the mode of formation of the duct system, the course, and arrangement of the ducts, the mode of termination along with related vessels was studied. Then the length of the individual ducts was measured.

RESULTS

A total of 50 specimens were included in the current study. All the study subjects had a single gallbladder, situated in the Inferior surface of the right lobe of the liver and positioned in extrahepatic fossa of the right lobe. Mesentery of the gallbladder was absent in all the specimens. The key abnormalities found in all bladder were Hartman's pouch shape and neck in 2 (4%) subjects each. Fundus and body were normal in all the subjects. Gallstones were present in 2 (4%) subject. In the majority (56%) of the subjects, the length of common bile duct was 7cm. It was ranging from as short as 6.5cm in 24% of the subjects to 9cm in 4% of the subjects. The width of the gallbladder was ranging from 3 to 4cm and was 3.2cm in the majority (42%) of the subjects. The fundus of the bladder was below the inferior border of the liver

in 68% of the subjects, Above the inferior border in 20% of the subjects and at the level of the inferior border in remaining 12% of the subjects (Table 1).

Table 1: Gross anatomical features of gall bladder in the study population (N=50).

Anatomical feature	Details	Number	%
Number	Single	50	100
Position	Inferior surface of the right lobe of the liver	50	100
Situation	Extrahepatic in fossa for gallbladder in right lobe of liver	50	100
Mesentery of gallbladder	Absent	50	100
Shape	Pear-shaped	48	96
	Hartman's pouch	2	4
Fundus	Normal	50	100
Body	Normal	50	100
Neck	Normal	48	96
	Hartman's pouch	2	4
Interior of gallbladder	Normal	48	96
	Gallstones	2	4
Length of gallbladder	6.5	12	24
	7	28	56
	7.5	3	6
	8	3	6
	8.5	2	4
	9	2	4
Width	3	14	28
	3.2	21	42
	3.5	10	20
	4	5	10
Position of the fundus from the inferior border of liver	Below the inferior border	34	68
	Above the inferior border	10	20
	At the level of inferior border	6	12

The place of union of CBD was extrahepatic in 64% and intrahepatic in 36% of the subjects. The type of union was angular in 80% and parallel in 20% of the subjects. In this study, normal level of the union was observed in 82% specimens.

High level of the cystic duct union with the common hepatic duct was noted in 16% of specimens and in remaining 2% it was low union. Length of cystic duct was ranging from 2 to 4cm. Length of the common hepatic duct was ranging from 1.5 to 3.5cm. Length of common bile duct was ranging from 5.5 to 8cm (Table 2).

Table 2: Gross anatomy of extrahepatic ductal system in study population (N=50).

Anatomical feature	Details	Number	%
Place of union CBD	Extrahepatic	32	64
	Intrahepatic	18	36
Type of union CBD	Angular type	40	80
	Parallel	10	20
Level of termination of cystic DUSCT	Normal	41	82
	High	8	16
	Low	1	2
Length of cystic duct (cm)	4	2	4
	3.5	4	8
	3	18	36
	2.5	16	32
	2.2	5	10
	2	5	10
Length of common hepatic duct (cm)	3.5	5	10
	3	11	22
	2.8	2	4
	2.5	15	30
	2	14	28
Length of common bile duct (cm)	1.5	3	6
	5.5	1	2
	6	5	10
	6.5	7	14
Length of common bile duct (cm)	7	11	22
	7.5	18	36
	8	8	16

The arrangement of structures in hepatoduodenal duct was normal in 98% but was abnormal in 2% of subjects. The key abnormalities found were, cystic duct joined to the left side of the common hepatic duct, abnormal position, and division of the hepatic artery proper and right hepatic artery and abnormalities of cystic artery position and division.

A total of 14% of the specimens had accessory ducts were noted. Out of which, 10% were accessory right hepatic ducts and 4% were accessory cystic duct. Accessory ducts emerging from the left lobe of liver were not noted in this study.

Double and accessory cystic artery was found in 2% of the subjects each. In 8% of the subjects, cystic artery had abnormal course and division. The right hepatic artery was normal in 96% of the subjects and in 4% of the subjects had shown abnormal course and division.

Abnormal boundaries of Calot's triangle was found in 2% of the subjects. Abnormal contents of Calot's triangle include Accessory hepatic ducts in 10% of subjects. Double cystic artery, Aberrant accessory cystic artery and Cystic artery branch from right hepatic artery outside triangle were present in 2% of the subjects each (Table 3).

Table 3: Gross anatomy of other structures in hepatoduodenal ligament.

Anatomical feature	Details	Number	%
Hepatoduodenal ligament	Normal	49	98%
	Abnormal	1	2%
Accessory ducts	NIL	43	86%
	Right hepatic	5	10%
	Cystic duct	2	4%
Cystic artery	Normal	44	88%
	Double	1	2%
	accessory	1	2%
	Abnormal course and division	4	8%
Right hepatic artery	Normal	48	96%
	Abnormal course and division	2	4%
CALOT'S triangle boundaries	Normal and well defined	49	98%
	Abnormal	1	2%
CALOT'S triangle contents	Normal	42	84%
	Accessory hepatic ducts	5	10%
	Double cystic artery	1	2%
	Aberrant accessory cystic artery	1	2%
	Cystic artery branch from right hepatic artery outside triangle	1	2%

DISCUSSION

Deviations in the anatomy of gallbladder, bile ducts and the arteries that supply them and liver are essential to the surgeon as failure to recognize them may lead to inadvertent ductal ligation, biliary leaks and strictures after laparoscopic cholecystectomy.^{14,15} Incidence of EHBT abnormal anatomy varies ranging from as low as, though it is reported to be as high as 47%.^{3,4}

Proper identification of EHBT anatomy and its possible abnormalities would allow surgeons to perform a safe operation with no or minimal injuries. It is important to the surgeons to be aware of the most common abnormalities. The key abnormalities found in all bladder were Hartmann's pouch shape and neck in 2 (4%) subjects. In contrast, a higher proportion (4.3%) of Hartmann's pouch was observed by Leena AB¹⁶ in south Keralites and van Eijck et al, found a very high prevalence of Hartmann's pouch (52%) in their study.¹⁷ The pouch of Hartmann can be a frequent but variable feature of both physiologic and pathologic gallbladders and its presence is often associated with gallstones.¹⁷

The common bile duct may present a higher degree of peculiarities regarding its size, course, and position. However, on an average, its size ranges from 6-8cm with a larger size and among men and relatively smaller

among women.¹⁸ In the majority (56%) of the subjects of our study, the length of common bile duct was 7cm, while it was 6.5cm in 24% of them.

A total of 14% of the specimens had accessory ducts were noted in our study. Out of which, 10% were accessory right hepatic ducts and 4% were accessory cystic duct. Accessory ducts emerging from the left lobe of liver were not noted in this study. In comparison Devi et al, found 17% of the subjects having accessory hepatic ducts, while Khayat et al, observed in only 3.33% of subjects.^{19,20} Having the knowledge of the likelihood of the accessory hepatic ducts and their position is especially important during laparoscopic cholecystectomies as the incidence of bile duct injuries is twice as high when compared to open cholecystectomies.²¹

The cystic artery is the important structure to be clipped or ligated during laparoscopic or conventional cholecystectomy. The likely complications like hemorrhage or hepatobiliary injury are always focused on the search, dissection, and clipping or ligation of the cystic artery, many a time because of the likelihood of variations in its course and relations to the biliary ducts.²² The present study found cystic artery having an abnormal course division in 8% of the subjects.

It requires a thorough understanding of the intra- and extra-hepatic anatomical relationships between the portal vein, hepatic artery, biliary tract, and hepatic vein, and also their respective contributions to liver physiology. Anomalous biliary anatomy is frequently encountered by surgeons during cholecystectomy. Importance of its recognition lies in avoiding serious biliary injuries. Congenital anomalies and normal variants of biliary tree, are not common but may be of significance during laparoscopic surgery as failure to recognize them leads to iatrogenic injuries and can increase morbidity and mortality.²³

CONCLUSION

The key abnormalities found in all bladder were Hartman's pouch shape and neck in 2 (4%) subjects each. Gallstones were present in 2 (4%) subject. The length of the common Bile duct was ranging from as short as 6.5cm in 24% of the subjects to 9cm in 4% of the subjects. High level of the cystic duct union with the common hepatic duct was noted in 16% of specimens and in remaining 2% it was low union. Abnormal arrangement of structures in hepatoduodenal duct was normal in 98% but was abnormal in 2% of subjects. A total of 14% of the specimens had accessory ducts. Double and accessory cystic artery was found in 2% of the subjects each. In 8% of the subjects, cystic artery had abnormal course and division. The right hepatic artery was had shown abnormal course and division in 4% of the subjects. Abnormal boundaries of Calot's triangle was found in 2% of the subjects. Abnormal contents of

Calot's triangle include Accessory hepatic ducts in 10% of subjects.

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