

A STUDY ON THE ANOMALIES OF GALLBLADDER AND ASSOCIATED STRUCTURES

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ABSTRACT

The gallbladder is a piriform structure on the undersurface of liver. It collects bile from the liver to concentrate it and to store it. The gallbladder has a cystic duct which joins the common bile duct and through these ducts bile passes into the duodenum. There is usually a single gallbladder (arising from the cystic bud of hepatic diverticulum) with one cystic duct supplied by a cystic artery taking origin from the right hepatic artery. But in few persons there are double gallbladder or double cystic ducts or different variations in the origin and course of cystic arteries. A study was undertaken in 2006 to detect the anomalies of these structures among the people Kolkata (a metropolis of eastern part of India), by dissection of cadavers. This study was conducted from the year 2006 to 2009 in the Department of Anatomy of Calcutta National Medical College and in other medical colleges of Kolkata. Three cases of double gallbladder and few other variations like double cystic duct were found in this study. These findings will help the clinicians (specially the surgeons, radiologists of the eastern part of India) to undertake any investigative or surgical procedure in the region of extra hepatic biliary apparatus. This study will enhance our knowledge not only surgical Anatomy, but also in embryology and in gross anatomy.

KEY WORDS: double gallbladder, cystic duct, cystic artery, right hepatic artery.

INTRODUCTION:

The gallbladder is a slate-blue, piriform sac partly sunk in a fossa in the right hepatic lobe's inferior surface. It is 7-10 cm long, 3 cm broad at its widest part and it is 30-50 ml. in capacity. It has a fundus, body and neck. The neck is curved to become the cystic duct. The cystic duct is 3-4 cm long, it passes downward, backward and to the left from the neck of the gallbladder and joins the common hepatic duct to form the common bile duct (CBD) Standring et al (2005)¹.

The cystic artery arises usually from the right branch of the hepatic artery proper, it passes behind the common hepatic duct and over the cystic duct to the superior surface of the gallbladder's neck where it divides into superficial and deep branches [Standring et al, (2005)¹]. The former ramifies on the inferior surface and the latter on the superior surface. The cystic artery may arise from the hepatic artery itself, rarely from the gastroduodenal artery, passes anterior or posterior to the bile duct or the common hepatic duct to reach the gallbladder. An accessory cystic artery may arise from the common hepatic artery or

from any of its branches. There are many variations of the gallbladder, cystic duct, cystic artery and the other structures of the biliary tree (Standring et al, 2005)¹.

The liver develops from an endodermal evagination of the foregut and from the septum transversum mesenchyme. The developing liver is first seen in the stage 11 (somite) of embryo. By stage 12, the diverticulum has two parts, a caudal part (that will produce the cystic duct and the gallbladder) and a cranial part that will form the liver biliary system - Williams et al, (1999)².

Rarely during the fifth or early sixth embryonic week, occasionally, the gallbladder primordium bifurcates and results in duplication of gallbladder. The gallbladder may be bifid or completely duplicated, usually with a duplicated cystic duct (Standring et al, 2005¹ and Ozen et al, 1999³). The anatomical location of double gallbladder can vary; most gallbladders share a common peritoneal coat and are usually adjacent to each other. Occasionally, one gallbladder could be entirely intrahepatic or even sub-hepatic vide Standring et al, (2005)¹.

Garica et al (1993)⁴ gave the statement that true gallbladder duplications may share a common cystic duct, arterial or have separate cystic ducts and blood supply According to Garica (1993)⁴, Boyden (1926)⁵, Miyajima et al (1995)⁶ Gallbladder duplication is an unusual biliary anomaly with a reported

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incidence of 1:4000 in autopsy studies of humans. Meticulous dissection of any additional cystic or tubular structures in the subhepatic region, identification of anatomical details prior to transection along with a high degree of awareness of gallbladder anomalies could possibly prevent catastrophic consequences (Goel et al, 2003)⁷ in the hepatic or biliary surgery.

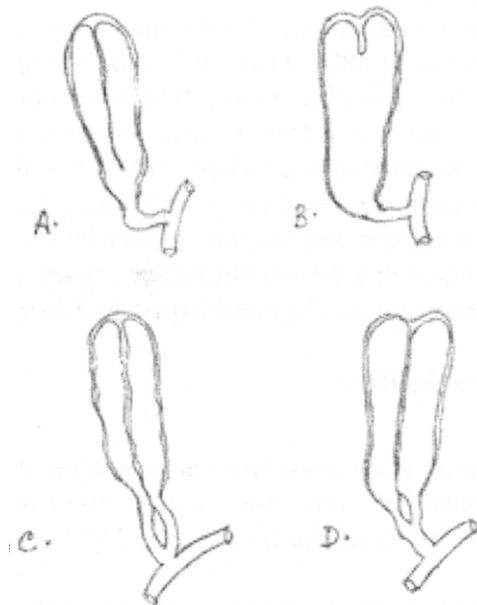


Fig - 1 Types of Gallbladder

A & B are actually bilobed or cleft gallbladders (vesicae divisae).

C & D are true double gallbladders (vesicae duplisis)- Hollinshead⁸.

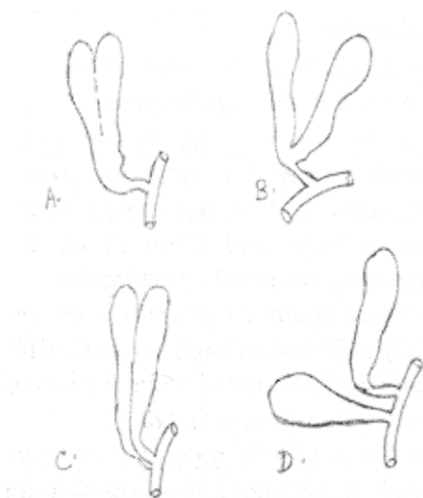


Fig- 2: Interior of Gallbladders

A & B are cleft or septate gallbladders.

C & D are true double gallbladders (Hollinshead⁸).

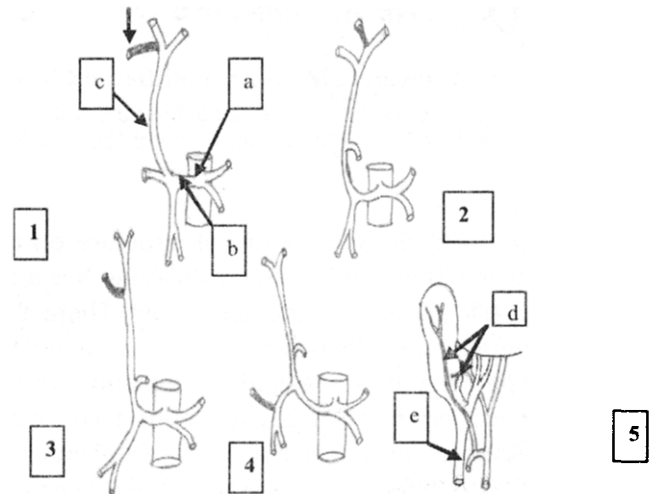


Fig-3: Different Origins of Cystic Artery

1. From the right hepatic artery.
2. From the left hepatic artery.
3. From the hepatic artery proper.
4. From the gastroduodenal artery .
5. Two Cystic Arteries one arising from the gastroduodenal artery and the other from the right hepatic artery (Hollinshead⁸).

Indications:

- 'a' Coeliac trunk
- 'd' cystic artery
- 'b'- Commom hepatic artery
- 'e'- gastroduodenal artery
- 'c' Hepatic artery proper

MATERIALS AND METHODS:

1. Different anomalies of the biliary tree were detected while doing the routine dissection for the undergraduate students. A study was undertaken to detect the anomalies of the gallbladder and associated structures among the people of Kolkata. About 150 cadavers were dissected in different Medical Colleges of Kolkata from the year 2006 to 2009.
2. The structures of abdomen were dissected properly, relevant structures were coloured and photos were taken. Anomalies like the double gallbladder were detected carefully.
3. The number of the cystic duct, their position and mode of drainage were also noted along with the study of the origin, course and number of the cystic arteries.

OBSERVATIONS:

Different findings were mentioned below.

1. (a) Number of Gallbladder :

There was no case with absence of gallbladder. Double gallbladder with separate cystic ducts were found in 3 cases (2%) among 150 subjects in this study.

(b) Position of the Gallbladder :

One Intrahepatic gallbladder (0.7%) was found in one case of double gallbladder (with two separate cystic ducts). In the other 149 cases (99.3%) gallbladders were extrahepatic, present on the undersurface of the right lobe of liver.

2.(a) Types of termination of the cystic duct (into the common hepatic duct) :

- i) Angular 105 cases (70%)
- ii) spiral 12 cases (8%),
- iii) parallel 33cases (22%)

(b) Length of the cystic duct was 3-4cm.

(c) Number of the cystic duct :

Double cystic ducts were found in 4 cases or in 2.7% cases (3 double gallbladder cases and one case of single gallbladder with two cystic ducts). In rest of the 146 cases (97.3%) there was a single cystic duct in each case.

3. (a) Number of the Cystic artery:

Single gallbladder with double cystic artery (both arising from the right hepatic artery) was found in 18 cases (12%), and double gallbladder with two cystic arteries was found in 3 (or 2%) cases (in two of these cases both arteries were arising from the right hepatic artery and in the third case one from the right hepatic artery and the other from the gastroduodenal artery). So in total 21 cases (14%) had double cystic arteries and in 129 cases (86%) had a gallbladder with single cystic artery.

(b) Origin of the Cystic artery

Cystic artery was arising from the right branch of the hepatic artery in 147 cases (98%) and from the gastroduodenal artery in 3 cases (2%).

(c) Relation between the cystic artery and the cystic duct:

- i) In 87 cases (58%) the right hepatic & cystic arteries were parallel to the cystic duct.
- ii) In 39 cases (26%) the cystic artery was passing in front of the duct
- iii) In 24 cases (16%) the cystic artery was passing dorsal to the duct.

These findings are presented in a tabulated form :

	Number	percentage
Congenital absence	0	0
Single gallbladder	147	98%
Double gallbladder	3	2%
Multiple gallbladder	0	0

Table I(a)- According to the number of gallbladder

Position of the Gallbladder	Number	Percentage
Normal	149	99.3
Intrahepatic	1	0.7

Table I(b): According to the position of the gallbladder

Types of Termination into the common hepatic duct	Number	Percentage
Angular	105	70
Parallel	33	22
Spiral	12	8

Table II (a)- According to the variations of the cystic duct.

Chi square (χ^2) = 142.74, O.F = 2, p < 0.05, Significant.

Number of the cystic duct	Findings	Percentage
Single	146	97.3
Double	4	2.7

Table II (b)- According to the Number of the Cystic Duct

Number of cystic arteries	Findings	Percentage
Single artery	129	86
Double artery	21	14

Table III (a)- According to the number of the cystic artery

Types of Origin	Number	Percentage
Right Hepatic Artery	147	98
Gastroduodenal Artery	3	2
Left Hepatic Artery	0	0

Table III (b)- According to the origin of the cystic artery

Types of Relations	Number	Percentage
Right hepatic artery & cystic artery parallel to the cystic duct	87	58
Cystic artery passing in front of the duct	39	26
Cystic artery passing dorsal to the duct	24	16

Table III (c)- According to the relation between the cystic artery and the cystic duct

Chi - square (χ^2) = 64.98, D.F = 2, $p < 0.05$, significant.

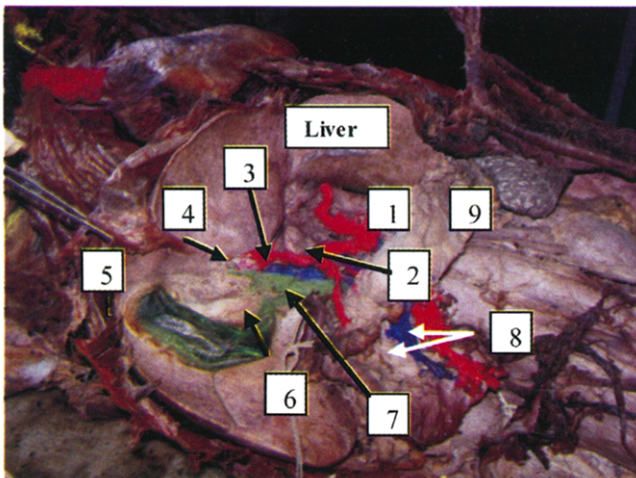


Fig- 4-Normal Anatomy of the hepatobiliary region. **Indications:** (1)- Coeliac Trunk, (2)- common hepatic artery, (3)- hepatic artery proper, (4) right & left hepatic arteries, (5)- Gallbladder, (6)- Cystic duct, (7)- common bile duct, (8) Superior mesenteric vessels. (9) Pancreas.

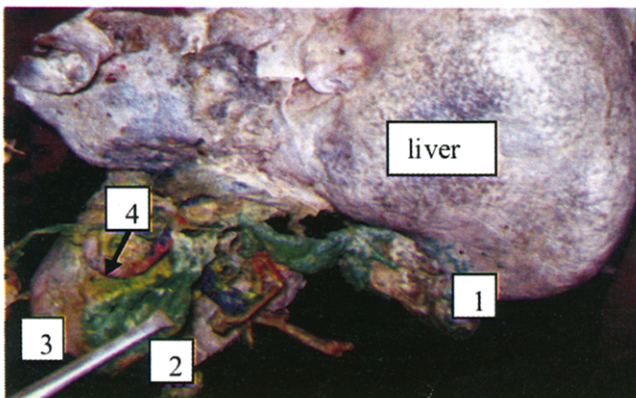


Figure 5-Double gallbladder on the undersurface of right lobe of liver. (1)- 1st Gallbladder, (2)- 2nd Gallbladder, (3) Duodenum. (4) Gastroduodenal artery,

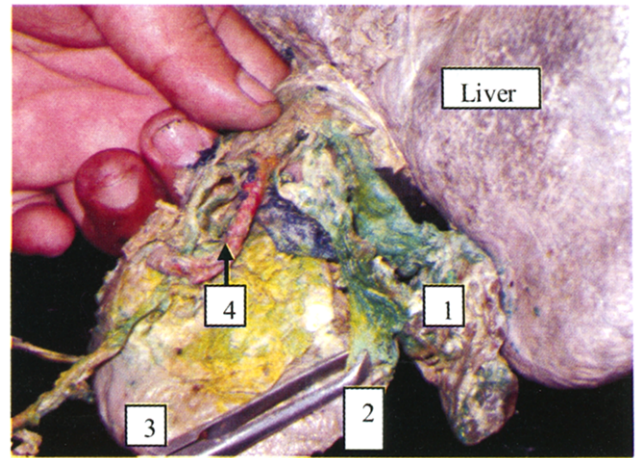


Figure 6-Double gallbladder and duodenum with the gastroduodenal artery. (1) - 1st Gallbladder, (2) - 2nd Gallbladder, (3) - Duodenum, (4) Gastroduodenal artery.

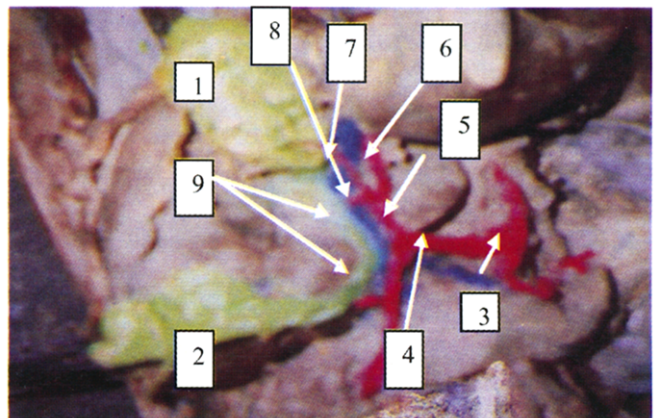


Figure 7-Another case of Double gallbladder with the two cystic ducts opening into the common bile duct, the common hepatic artery and its branches. (1)- 1st Gallbladder, (2)- 2nd Gallbladder, (3)- Coeliac Trunk, (4)- common hepatic artery, (5)- hepatic artery proper, (6)- left hepatic artery, (7) - right hepatic artery, (8) Cystic artery arising from (7), (9) Two Cystic Ducts.

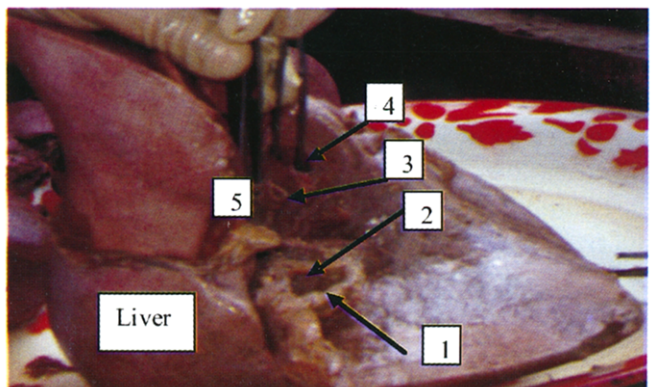


Figure 8- Double cystic duct in a single gallbladder. (1) One Cystic duct, (2) Another Cystic duct, (3) Common bile duct, (4) portal vein, (5) Hepatic artery proper.

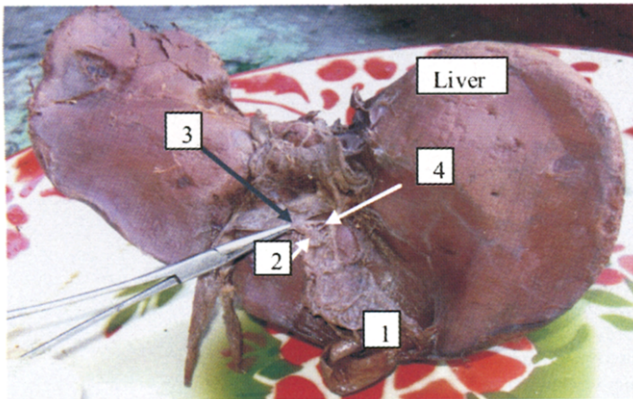


Figure 9- Liver with gallbladder, cystic duct , common bile duct (the junction between the cystic duct and common hepatic duct is angular). The cystic artery was passing in front of the Cystic duct. (1) Gallbladder, (2) Cystic duct, (3) Common Bile Duct, (4) Cystic Artery.

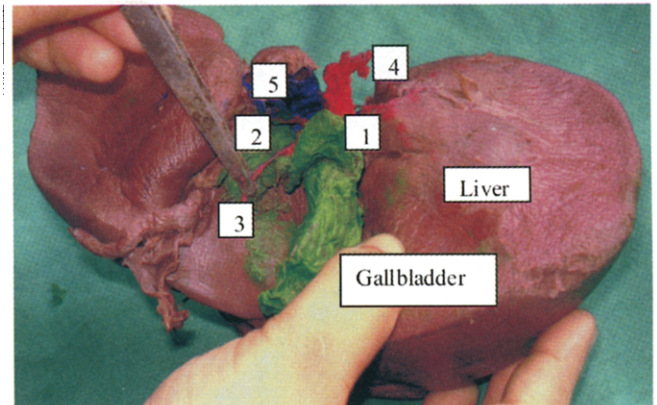


Figure 12- Liver with gallbladder, cystic duct , common bile duct etc.(the cystic duct had a spiral course before opening into the common hepatic duct). The cystic artery was passing in front of the Cystic duct. (1) Cystic duct, (2) Common bile duct, (3) Cystic artery, (4) Hepatic artery proper, (5) Portal vein.

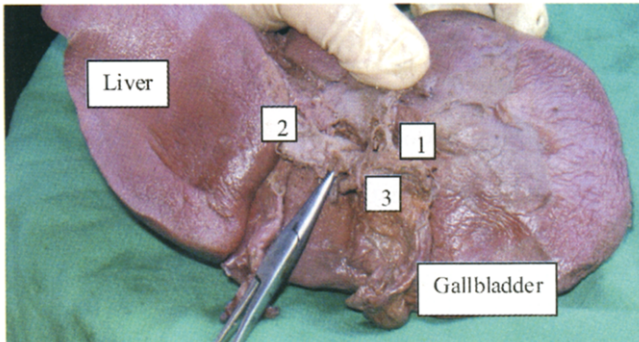


Figure 10- Liver with gallbladder, cystic duct , common bile duct (the cystic duct was running parallel to the common bile duct before opening into it.). The cystic artery was passing in front of the Cystic duct. (1) - Cystic Duct, (2) - Common bile duct, (3) Cystic artery.

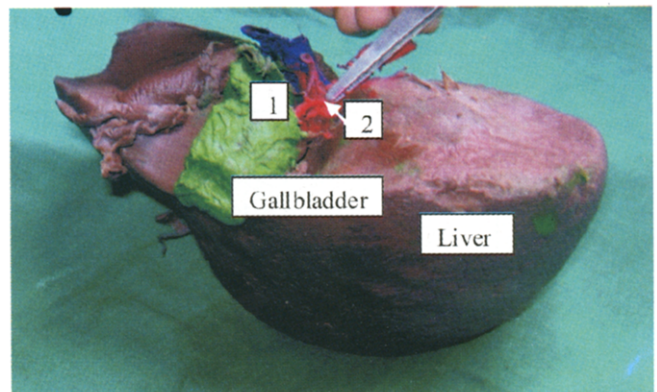


Figure 13- Gallbladder on the undersurface of liver with two cystic arteries. (1) One cystic artery, (2) Another cystic artery, both arising from the right branch of the hepatic artery.

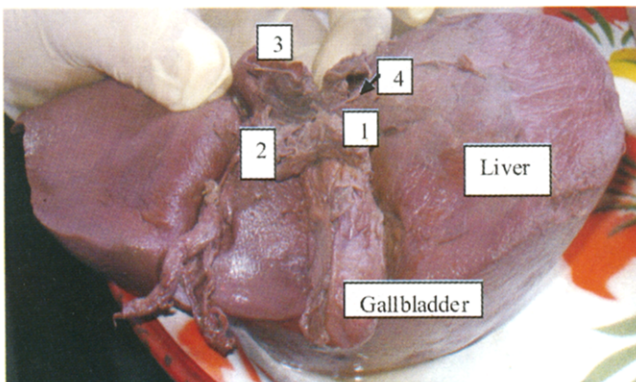


Figure 11- Liver with gallbladder, cystic duct , common bile duct, portal vein etc.(the cystic duct had a spiral course before opening into the common hepatic duct). (1) Cystic duct, (2) Common bile duct, (3) Portal vein, (4) Cystic artery.

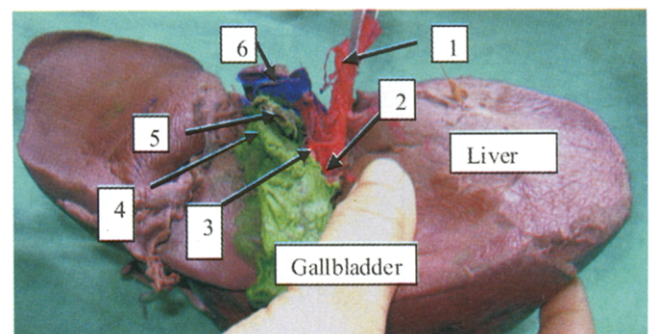


Figure 14- Liver with gallbladder, cystic duct , common bile duct (the cystic duct was running parallel to the common bile duct before opening into it.). One cystic artery was passing behind the Cystic duct to reach the gallbladder. (1) - Hepatic artery proper, (2) - Right hepatic artery, (3) Cystic artery, (4) - Cystic duct, (5) - Common bile duct, (6) Portal vein

DISCUSSION:

Findings of the Previous Studies and the Present Study (in the tabulated form):

Number of Cases	Congenital Absence	Double Gallbladder	Multiple Gallbladder
Previous Study	Rare, 2 among 10,000 cases ⁸ . One case was reported by Known et al ⁹ in 2006.	1 in 4000 -5000 persons ⁵ . Among 30 cases of double gallbladder, 28 cases had double cystic ducts and two cases had a single cystic duct - found by Gross ¹⁰ . One case was found by Guyton ¹¹ with a single cystic duct.	Very Rare, Hollinshead ⁸ .
Present Study	Nil.	2 in 150 cases in the period 2006-2009 (2% cases).	Nil.

Table IV (a)- According to the number of gallbladders

Number of cases	Intrahepatic	Floating	Left sided Gallbladder	Normal
Previous Study	Very rare, Hollinshead ⁸ Few cases were found by Slaughter et al ¹² .	Very rare, Hollinshead ⁸	Very rare, Hollinshead ⁸ One case of left sided gallbladder was found by Mc Gowan ¹³	Most of the cases – under the right lobe of liver in the gallbladder fossa, Standing et al ¹ .
Present Study	1 in 150 cases- (0.66%)	0	0	149 cases- (99.33%).

Table IV(b)-According to the position of the Gallbladder

Number of cases	Types of Termination into the common hepatic duct			Length In cm.	Number of Ducts	
	Angular	Spiral	Parallel		Single	Double
Previous Study	75% by Eisendrath ¹⁴ and 63 % by Johnston & Anson ¹⁵	8% by Eisendrath ¹⁴ 17% by Johnston & Anson ¹⁵ .	17% by Eisendrath ¹⁴ 20% by Johnston & Anson ¹⁵	2.5- 7.5 Hollinshead ⁸	In majority of the cases ¹ ,	Rarely the cystic duct may be double ¹ . In most of the cases of double gallbladder cases have two cystic ducts Gross ¹⁰ .
Present Study	105 cases (70%)	12 cases (8%)	33 cases (22%)	3-4 cm.	146 (97.3%)	4 (3 cases of double gallbladder and one case of single gallbladder) - 2.7 % cases.

Table V - Anomalies of Cystic Duct

Number of cases	Gallbladder with double or multiple cystic artery	Single Gallbladder with single cystic artery
Previous Study	15% (Thompson) ¹⁶ 14% (Dasler) ¹⁷	80 - 85% (Thompson) ¹⁶
Present Study	21 cases (14%)	129 cases (86%)

Table VI (a)- Anomalies of the Cystic Artery - According to number

Number of cases	Right hepatic artery	Left hepatic artery	Gastroduodenal artery	Others
Previous Study (vide Hollinshead ⁸)	85-90%, Hollinshead ⁸ , 90% by Micheles ¹⁸ & Dasler ¹⁷	5-7%	1 - 2.5%	1 - 2.5%
Present Study	147 cases (98%).	Nil	3 among 150 cases (2%).	Nil

Table VI (b)-According to the origin of the cystic artery

Cystic Artery can take origin from any branch of the coeliac trunk.

	Right hepatic artery & cystic artery parallel to the cystic duct	Cystic Artery passing in front of the duct	Cystic Artery passing dorsal to the duct
Previous Study	About 50% cases (Thompson) ¹⁶	24% (Thompson) ¹⁶	18% (Thompson) ¹⁶
Present Study	87 cases (58%)	39 cases (26%)	24 cases (16%)

Table VI (c)- Relation of the cystic artery and cystic duct

ANOMALIES OF THE GALLBLADDER-

i) Double gallbladder:- According to Boyden⁵, the incidence of the double gallbladder has been estimated not to be more than 1 per 4000 to 5000 persons. The majority were the complete ones. Boyden (1926)⁵ found only 5 authentic cases of completely duplication of gallbladder among 19,000 examinations of cadavers and patients. He found the anomalies of the gallbladder to be much less frequent in man than in lower animals as depicted in the book of Hollinshead (1971)⁸ 'Anatomy for Surgeons', volume - 3.

In the present study three double gallbladder cases (2%) with separate cystic ducts were found

among 150 cadavers. In two cases the two gallbladders were extrahepatic, but in one case one gallbladder was intrahepatic and the other was extrahepatic. In each case there were two cystic ducts draining separately.

Among 148 reported cases of anomalies of the gallbladder by Gross (1936)¹⁰, 30 of the cases had double gallbladder. In 28 cases of those 30 cases two cystic ducts were reported while in 2 cases gallbladders drained by a single duct.

Meyer et al (1949)¹⁹ reported 48 cases of double gallbladder. In one case reported by them the two components of double gallbladder shared a common internal septum, yet drained by a separate cystic duct which in turn drained separately, rather than uniting. In Guyton's (1946)¹¹ case the two gallbladders (of a double gallbladder case), were widely separated except at their necks, yet drained through a single cystic duct.

In the case of double gallbladder as stated by Slaughter et al (1993)¹² the second gallbladder was largely buried in the liver and was visible only after removal of the first and the two cystic ducts joined to form the common cystic duct which drained into the common bile duct.

ii) Congenital absence of gallbladder: It is very rare, two cases were found among 10,000 cases in Mayo clinic by 19658. No such case was found in the present study.

According to Gross (1936)¹⁰, this anomaly is commonly associated with atresia of some part of the extrahepatic duct system. He found approximately 200 cases of atresia of this system and in about one sixth (about 33 cases) of these there was absence of the gallbladder. Known et al (2006)⁹ reported a case of agenesis of gallbladder with hypoplastic duct diagnosed by laparoscopy.

iii) Position of the gallbladder: In Most of the cases the gallbladder is present on the undersurface of the right lobe of the liver and the incidences of left sided gallbladder, intrahepatic gallbladder and floating gallbladder are very rare vide Hollinshead (1971)⁸. Left sided gallbladder cases are usually associated with situs inversus (reported only a few times⁸). McGowan (1948)¹³ et al reported a case of left sided gallbladder.

In the present study one intrahepatic gallbladder was found in a case of double gallbladder, but no floating gallbladder or left sided gallbladder was found.

VARIATIONS OF THE CYSTIC DUCT:

i) **Types of termination of the cystic duct into the common bile duct** : According to Eisendrath (1920)¹⁴ :

a) Angular - 75% cases, b) spiral 8% cases, c) parallel - 17% cases. According to Johnston and Anson (1952)¹⁵, angular type of termination was found in 63% cases.

In our study a) angular 70% cases, b) spiral nil, c) parallel - 30% cases.

ii) **Length of the Cystic Duct**: The length of the cystic duct, on an average is 2.5 to 7.5 cm. vide Hollinshead (1971)⁸. In the present study the length of the cystic duct was 3-4 cm.

According to Lichtenstein et al (1937)²⁰ the cystic duct is 2-4cm. long in 55% cases, less than 2 cm. in 20% cases and more than 4 cm. in 25% cases.

iii) **Number of the cystic duct**: It is usually single, but may be double in few cases. In this study one case of double cystic duct was found with a single gallbladder and in three cases of double gallbladder two cystic ducts were found (in each case). In the case reported by Meyer et al (1949)¹⁹ two components of double gallbladder shared a common internal septum, yet drained by separate cystic ducts.

VARIATIONS OF THE CYSTIC ARTERY -

i) **The number of cystic artery**: When there are two cystic arteries, both may arise from hepatic artery, one may arise from normal and another from an anomalous source (Hollinshead, 1971)⁸.

According to Thompson (1933)¹⁶ double cystic arteries are found in 15% cases and according to Daseler et al (1947)¹⁷ it is found in 14% cases, whereas Micheles (1953)¹⁸ found a higher percentage of double cystic arteries (in 25% cases of 200 bodies).

In the present study single cystic artery was present in 129 cases (86%) and double cystic arteries were present in 21 cases (14%cases).

ii) **Variations in the origin of cystic artery**:

The cystic arteries vary markedly in regard to the arterial stem from which they arise and in relation (regarding their origin) to the Calot's triangle. Daseler et al (1947)¹⁷ found that 69.8% of all the cystic arteries were arising in the Calot's triangle. In 85-90% cases it arises from the right branch of the hepatic artery and in 2.5% cases from the gastroduodenal artery. This artery may arise from the aberrant right hepatic, the left hepatic (in about 5% cases or more), branches of

the coeliac trunk, or even from the superior mesenteric artery according to Hollinshead (1971)⁸.

Micheles (1953)¹⁸ found a cystic artery arising from a source other than the right hepatic artery in about 10% of the bodies, so also Daseler (1947)¹⁷ and his colleagues. According to their study Pushpalatha et al (2010)²¹ stated that the cystic artery arises from the right hepatic artery in 54% cases, from the hepatic artery proper in 22% cases, from the common hepatic artery in 12% cases, from the gastroduodenal artery in 8% cases, from the superior mesenteric artery in 2% cases and from the accessory hepatic artery in 2% cases. In case of double cystic arteries the superficial branch may arise from the gastroduodenal artery, while the deep branch from the right hepatic artery (Hollinshead, 1971)⁸.

In the present study cystic artery arose from the right branch of the hepatic artery in 147 cases (98%) and from the gastroduodenal artery in 3 (2%) cases (in a case of double gallbladder also).

iii) **Relation of the cystic artery and the cystic duct**:

In about 50% cases the right hepatic artery and the cystic artery run parallel to the cystic duct, in 24% cases the cystic artery runs in front of the cystic duct and in 18% cases dorsal to the duct vide Thompson (1933)¹⁶.

In the present study in 87 cases (58%) the right hepatic artery and the cystic artery were parallel to the cystic duct, in 39 cases (26%) it was passing in front of the duct and in 24 cases (16%) it was passing dorsal to the duct.

CONCLUSION

Utility of the Study :

An accurate, preferably preoperative diagnosis, identification of all gallbladders during laparoscopy is mandatory to prevent inadvertent damage to the biliary ductal system and possible overlooking of the second or third gallbladder (Goel, 2003)⁷.

Puneet et al (2006)²² stated that lack of awareness, non-specific symptoms and signs and inadequacy of imaging methods are possible reasons for the reported problem of overlooking of the additional gallbladder/s during surgery. It is also necessary for the gastroenterologists and radiologists to be familiar with the variations of the biliary tree to make correct diagnosis and treatment (Sharmila et al, 2011)²³. The various modalities like ultrasound, Oral cholecystogram (OCG), scintigraphy, ERCP, PTC, CT scan and MRI can be used pre-operatively to diagnose double gallbladder cases. Intra-operative cholecystography and

cholangiography are essential to clarify the ductal anatomy and to identify additional anomalous structures (Goel,2003)⁷. Careful appraisals of reported literature clearly emphasizes the need for removal of accessory or duplicate gallbladders to prevent repeated explorations (Miyajima et al, 19956 and Goel, 2003⁷).

This study will fulfil these purposes to some extent, Specially the radiologists, gastroenterologists and the surgeons (performing biliary surgery) of the eastern region of India will be benefitted by this study which will also enhance our knowledge in embryology and gross anatomy.

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