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Study of normal anatomy and variations in gall bladder

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Abstract--Background: The extra hepatic biliary apparatus consists of right and left hepatic ducts, common hepatic duct, gall bladder, cystic duct and common bile duct which collects and delivers the bile from liver to second part of duodenum. Anatomical variations of biliary tree occur with sufficient frequency to be of concern to the surgeons operating in this area. Identification of anatomical details is necessary for accurate detailing of biliary tree to avoid inadvertent damage to biliary ductal system. Objective: To study the normal anatomy and variations of gall bladder by dissection method. Methods: In the present study a total number of 50 adult human livers with lesser Omentum, duodenum and pancreas were collected from the dissected cadavers from the department of anatomy KVG Medical College Sullia and Chamarajanagar institute of medical sciences, Chamarajanagar. The various parameters of the gall bladder and biliary ductal system were recorded and photographed. Observations and results: The following variations were observed in the present study. Hartmann's pouch was observed in 42% (21/50).

Hourglass GB was observed in 2% (1/50). Folded fundus was observed in 2% (1/50). Intrahepatic GB was observed in 4%. Hypoplastic GB was observed 2% (1/50). Gallstones were observed in one specimen as an incidental finding and the gall bladder was associated with Hartmann's pouch. The length of gall bladder varied from 4 cm to 10.5 and the width varied from 2.3cm to 5.5 cm. In the present study supramarginal type of gall bladder was observed in 24 specimens (48 %), marginal type was observed in 15 specimens (30%), inframarginal was observed in 11 specimens (22%). In the present study angular union of cystic duct with common hepatic duct was observed in 62% (31/50), parallel union in 16% (8/50) and spiral union in 22% (11/50) specimens. The length of cystic duct varied from 0.5 cm to 4 cm and the diameter varied between 0.4cm to 1 cm. Conclusion: The knowledge of relevant anatomy of variations of gall bladder is important for the safe execution of any operative procedure. Specially for cholecystectomy, it has been recognized since long that misinterpretation of normal anatomy as well as the presence of anatomical variations contribute to the occurrence of major post-operative complications. Hence, it is important for biliary surgeons to appreciate basic anatomical facts as these variations can contribute to complications.

Keywords--gall bladder, normal anatomy, variations.

Introduction

The biliary tree consists of system of ducts which collect and deliver the bile from liver parenchyma to the second part of the duodenum. It can be divided into intra hepatic and extra hepatic parts. Intra hepatic part consists of bile canaliculi from different segments of liver which join to form right and left hepatic ducts at porta hepatis. Extra hepatic part begins from porta hepatis where right and left hepatic ducts join to form common hepatic duct which is joined by the cystic duct on right side to form common bile duct which opens into the second part of the duodenum. Gall bladder plays an important role in storage and concentration of the bile. (1)

The biliary tract disease was recognized as early as 5th century BC by the Greek Anatomists. (2) The anatomical variations of common hepatic duct such as absence of confluence, atrophy of duct, absent hepatic duct, abnormal opening into the neck of gall bladder and abnormal opening into cystic duct are noted. Persistent foetal connections are also described between liver and gall bladder or extra hepatic biliary system. These are pericholecystic anomalies, sub-vesical ducts of Luschka and cholecystohepatic ducts. (1,3) Variations in the site of insertion of cystic duct are also noted such as low insertion, absence of cystic duct, accessory cystic duct, short duct is seen. (1,4) Variations in the gall bladder such as duplicate gall bladder, septate gall bladder and Phrygian cap are also noted.(4,5,6,7)

Gall stones are the most commonly observed biliary pathology. It is estimated that 10-15% of adult population worldwide including our country is affected by gall stones/cholelithiasis. (8) With the advances in diagnostic imaging modalities such as Ultrasonography (USG), CT scan and MRI scan, such diseases are increasingly being reported. (9)

Objectives

- To study the normal anatomy and variations associated with the gall bladder
- To aid the surgeons to know the specific anatomical variations during surgeries, thus to avoid the intra-operative and postoperative complications.
- To aid the anatomists in teaching.

Methodology

In the present study a total number of 50 adult human livers with lesser omentum, duodenum and pancreas were collected from the dissected cadavers from the department of Anatomy of KVG Medical College Sullia and Chamarajanagar institute of medical sciences, Chamarajanagar. The various parameters of the gall bladder and biliary ductal system were recorded and photographed. Adult cadavers of both sexes with intact abdominal viscera were selected. Altered anatomical relations in diseases and inflammatory conditions affecting gross structural changes, adhesions, and cadavers without intact abdominal viscera were excluded. The various parameters of the gall bladder and cystic duct were noted. A special attention was given to identify and record the anomalies of gall bladder.

Observations and results

The following variations were observed in the present study.

- Hartmann's pouch was observed in 42% (21/50)
- Hourglass GB was observed in 2% (1/50).
- Folded fundus was observed in 2% (1/50).
- Intrahepatic GB was observed in 4%.
- Hypoplastic GB was observed 2%.(1/50)

Gallstones were observed in one specimen as an incidental finding and the gall bladder was associated with Hartmann's pouch.

- The length of gall bladder varied from 4 cm to 10.5 and the width varied from 2.3cm to 5.5 cm.
- In the present study supramarginal type of gall bladder was observed in 24 specimens (48 %), marginal type was observed in 15 specimens (30%), inframarginal was observed in 11 specimens(22%).
- In the present study angular union of cystic duct with common hepatic duct was observed in 62% (31/50), parallel union in 16%(8/50) and spiral union in 22%(11/50) specimens.

- The length of cystic duct varied from 0.5 cm to 4 cm and the diameter varied between 0.4cm to 1 cm.

Discussion

The region of extra hepatic biliary apparatus exhibits frequent variations in ductal and also vascular system and are increasingly common. Misinterpretation of normal anatomy and anatomical variations contribute to the occurrence of major post-operative complications like biliary injuries. Such injuries can in-turn cause significant morbidity and occasionally even mortality. Anatomical variations also predispose to the complications such as formation of stones, recurrent pancreatitis, cholangitis and biliary malignancies. Hence, it is important for biliary and minimally invasive surgeons to appreciate basic anatomical facts as they apply to the performance of surgeries as well as understand from literature how anatomical distortions or variations can contribute to complications. (10) A thorough knowledge of exact configuration of the extra hepatic biliary system is essential to avoid complications during hepatobiliary surgical, endoscopic and percutaneous procedures.

Gall bladder

Variations in the size, shape, and position of the gall bladder have been studied extensively by many workers, is shown in table no 1. In present study the length of gall bladder varied from 4 cm to 10.5. The width of the gall bladder reported by Henry Gray is 3cm, Romanes GJ is 3 cm. In the present study the width varied from 2.3cm to 5.5 cm. Relationship of gall bladder to the inferior border of the liver is studied by different authors, shown in table no 2. In the present study supramarginal was observed in 24(48 %) specimens, marginal was observed in 15(30%) specimens and inframarginal in 11(22%) specimens.

Hourglass gall bladder

Fig no 1: It was described by Boyden and Gross. (11) Septate gall bladder is characterized by the presence of a septum that divides the gall bladder in two chambers. When the septum dividing the gall bladder lies longitudinally it is called bilobed gall bladder and when there is a transverse septum separating the fundus from the rest of the gall bladder it is called hourglass gall bladder. (6) In present study a transverse partial septum was observed in one specimen, the septum was present at the middle and lower third of the gall bladder, dividing it into upper larger compartment and lower smaller compartment, the incidence being 2%. Gall bladders bearing transverse septa with minimal communication between the two cavities are liable to produce bile stasis, stones and increased pressure symptoms in the organ. Septations predisposes to cholelithiasis in these isolated compartments with supervening chronic or acute inflammation. Isolation of the inferior compartment predisposes to the formation of stones in them due to sequestration of bile in the lower part of the gall bladder. Once stones are formed in the isolated inferior section of the organ, it is trapped in the compartment due to the narrow communication between the two cavities. Infection and distension, therefore, are common presentations associated with this variation. (11)

Phrygian cap

Boyden described the anomaly of folded fundus as a “Phrygian cap”. (12) In present study folded fundus was observed in one specimen. Recognition of a Phrygian cap gall bladder by nuclear scanning or sonography, with its potential for biliary stasis, cholelithiasis and cholecystitis, may warrant a prophylactic cholecystectomy. (12)

Intrahepatic gall bladder

Fig no 2 & 3: A partial or total intrahepatic gall bladder is associated with an increased incidence of cholelithiasis. (13) An intrahepatic gall bladder has usually impaired function because it does not empty completely. This may result in gall stone formation due to stasis. Most intrahepatic gall bladders are only partially embedded within the hepatic parenchyma and then usually are easily identified at the time of cholecystectomy. Those that are completely buried within the liver may be a challenge for the general surgeon. (14) In the present study it was observed in 2 specimens. The incidence was 4%.

Hypoplastic gall bladder

Fig no 4: There is a close relationship with the condition where a hypoplastic, vestigial gallbladder lies as a rudimentary tube beside the common duct within the same sheath, with or without connection to the bile ducts. Only a few cases have been reported before by Gross in 1936, Alden and Sterner in 1957, Banks and Lawrence in 1955, Geraci in 1959 and Maingot in 1969. (15) In present study it was observed in 1 specimen.

Gall stones

Fig no 5: Gall stones are the most common biliary pathology. It is estimated that 10-15% of adult population worldwide are affected with gall stones.(8) Benson A and Pagi RE observed in their study that the higher incidence of anatomical anomalies was found in patients with gall stones than those without gall stones. The incidence of gall stones was higher in females than in males.(16) Hartmann’s pouch is a common site for impaction of gall stones.(17) In the present study few gall stones were observed in one specimen of male cadaver, lying in the neck of the gall bladder around 0.5 cm in diameter. Gall bladder was associated with the Hartmann’s pouch. The incidence being 2 %.

Hartmann’s pouch

Hartmann’s pouch is an out- pouching of the wall of the gall bladder in the region of neck. It is recognized more as an outcome of pathology in the form of dilatation or presence of stones. The pouch is variable in size but a large Hartmann’s pouch may obscure the cystic duct and the Calot’s triangle. This may be result of plain enlargement or due to adherence to the Cystic duct or bile duct. Thus, a small Cystic duct can get completely hidden and traction on the gall bladder can lead to the bile duct looking like a Cystic duct. An exaggerated form of the same process is the ‘Mirizzi’s syndrome’ in which a large stone in the Hartmann’s pouch area is

either adherent to or erodes into the bile duct. This can create major difficulty during cholecystectomy. (10) Hartmann's pouch is not a feature of the normal gall bladder and is always associated with a pathological condition; (18) If Hartmann's pouch is large, cystic duct arises from the left side of the neck of the gall bladder and not from the apex of the gall bladder.(17) In the present study it was observed in 21 specimens.(42%). The other anomalies of gall bladder like agenesis, double gall bladder, triple gall bladder, left sided gall bladder, floating gall bladder, bilobed gallbladder described in the literature were not observed in the present study.

Cystic duct

Cystic duct varies in length from extremely short to long type. The commonest duct anomaly is the long cystic duct fusing low with the common hepatic duct. Hayes et al. in 1958 found a long cystic duct to be the commonest anomaly occurring in 23% of their cases. In case of long cystic duct with low fusion with common hepatic duct, the cystic duct is invariably longer than the normal. It may run alongside and parallel with the common hepatic duct before joining it, or twist around the common hepatic duct, fusing with it either anteriorly or at its left-hand border. In this case a variable length of cystic duct is always tightly bound down to the common hepatic duct before the two actually fuse. Thus, the vigorous traction on the cystic duct may produce marked angulation and tenting of the common hepatic duct and bile ducts which may then be caught in a clamp. The over aligent efforts meticulously to dissect the ducts apart so as to put a 'flush- tie' on the common duct as well result in either immediate direct injury to the common hepatic duct or delayed damage if a length of this duct is revascularized.(16). Various authors have reported the length of cystic duct in their studies, shown in table no 3. In the present study the length of cystic duct varied from 0.5 cm to 4 cm. The diameter of cystic duct according to Russell RCG varied between 0.1- 0.3. In the present study the diameter varies between 0.4cm-1cm.

Union of cystic duct with common hepatic duct

The union of cystic duct with common hepatic duct is variable. By normal angular mode of union or Type 1, referred to the acute angle formed by the cystic duct with the hepatic duct when they unite to form the common duct. Type 2 or parallel mode of union referred to those cases in which the cystic duct runs parallel to hepatic duct for a variable distance the two ducts held together by a more or less from connective tissue septum. If the two ducts are parallel for only a short distance, as 2.5 cm., it is called the "short parallel" type, while if they take a parallel course for a longer distance, as 5 cm or more, the term "long parallel" type is applied. The third of the chief divisions of modes of union is called the "spiral type". Here the cystic duct winds either around the front or the posterior surface of the hepatic duct before entering it to form the common duct. Thus, the cystic duct can describe either a quarter, half, three quarters or complete spiral around the hepatic duct. Both these variations, the parallel and the spiral type are, of ut most importance from a surgical stand point.(19) Fig no 7, 8 & 9 shows the angular, parallel and spiral union respectively.

Various authors have observed different types of union of cystic duct with the common hepatic duct shown in table no 4 and length of cystic duct in each type of union is shown in table no 5. In present study angular union was observed in 31(62%) cases, parallel was observed in 8(16%) cases, spiral was observed in 11(22%) of cases. According to Limthankhan et al. cystic duct usually joined the common hepatic duct from right side in 92.7% and from left side in 2.1%.(20). In present study in all the 50 specimens the cystic duct joined the common hepatic duct from right side. According to the study by Rune GA and Moosman DA, angular type was most frequently found followed by parallel type and spiral type.(26) According to the study by Berci G spiral type was found the most followed by angular and parallel type.(20) In all the above studies the observers found angular union was most frequent. In the present study also the angular union was more frequently observed (31 specimens) followed by spiral and parallel type.

Calot's triangle

It was described by Calot in 1891. It is bounded superiorly by inferior surface of liver, cystic duct forms right boundary and common hepatic duct forms the left boundary. The content usually includes cystic artery, right hepatic artery, cystic lymph node of Lund, connective tissue and lymphatics. Occasionally it may contain accessory hepatic ducts and arteries. It is this triangular space, which is dissected in cholecystectomy to identify the cystic artery and cystic duct before ligation and division. In reality it may be a small potential space rather than a large triangle making the dissection of its contents without damaging the bordering structures the most challenging step of a cholecystectomy. In addition the space may be obscured and shrunken by various mechanisms. The left boundary of the triangle formed by the bile duct is the most important structure which needs to be safeguarded.(10) The safe approach to avoid injury to aberrant bile ducts during cholecystectomy is adhering to the gall bladder itself, identifying the triangle of Calot and using the "critical view of safety (CVS)", as described by Strasberg, before dividing the cystic structures. The CVS involves 3 steps i) clearing the triangle of Calot's of fat and fibrous tissue, ii) separation of lowest part of gall bladder from liver bed, iii) only 2 structures (cystic artery and cystic duct) should be seen entering gall bladder.(21)

Conclusion

There is a high incidence of anatomical abnormality in the disposition and relations of the extrahepatic bile ducts and gall bladder. In present century it has been the subject of numerous investigations. It has been recognized since long that misinterpretation of normal anatomy as well as the presence of anatomical variations contribute to the occurrence of major post- operative complications. In view of the congenital nature of these extrahepatic anatomical abnormalities, it may be suggested that this anatomical abnormality may have some bearing on stone formation. Recurrent attacks of cholecystitis may conceivably alter the basic anatomy. The likeliest explanation is that it is the pathology which modifies the anatomy. The surgeon will meet some anomaly in every other case upon which he operates. Thus, it is likely that a series with a related high incidence of the more

esoteric anomalies reflects a more meticulous and obsessional technique on the part of the investigator.

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Figures

In this specimen Hourglass gall bladder with a transverse partial septum was observed. The septum was present at the middle and lower third of the gall bladder, dividing it into upper larger compartment and lower smaller compartment. GB was Supra marginal type. Type of union of CD with CHD was angular type.



Fig 1. Hourglass gallbladder

In this specimen Intra hepatic gall bladder was observed. The GB was partially embedded within the liver tissue. GB was infra marginal type. Type of union of CD with CHD was angular type.



Fig 2. Intra hepatic gall bladder

In this specimen Intrahepatic gall bladder was observed. The GB was partially embedded within the liver tissue. GB was supra marginal type. Type of union of CD with CHD was spiral type.



Fig 3. Intrahepatic gall bladder

In this specimen Hypo plastic gall bladder was observed. The GB was very small and appeared like a bile duct diverticulum. GB was infra marginal type. Type of union of CD with CHD was parallel type.



Fig 4. Hypoplastic gallbladder

In this specimen Gall stones were observed. There were few stones of 0.5 cm diameter present within the gall bladder. GB was marginal type. Type of union of CD with CHD was angular type.



Fig 5. Gallstones

Hartmann's pouch was observed in 21/50 specimens. Hartmann's pouch was present as an out-pouching of the wall of the gall bladder in the region of neck



Fig 6. Hartmann's pouch

In present study angular union was observed in 31 specimens.



Fig 7. Angular union of cystic duct with common hepatic duct

Parallel union was observed in 8 specimens



Fig 8. Parallel union of cystic duct with common hepatic duct

Spiral union was observed in 11 specimens. Out of 11 specimens anterior spiral type was observed in 6 specimens and posterior spiral in 5 specimens.



Fig 9. Spiral union of cystic duct with common hepatic duct

Table 1
Length of gall bladder

Observer	Length (cm)
Henry Gray	7-10
Decker GAG	7.5 – 10
Romanes GJ	8
Russell	7.5 – 12
In present study	4 -10.5

Table 2
Relation of gall bladder to the inferior border of liver

Relation to the inferior border of the Liver	No of specimens	Percentage
Supramarginal	24	48%
Marginal	15	30%
Inframarginal	11	22%

Table 3
Length of cystic duct

Observer	Length (cm)
Rajaguru J	3-5
Limthanakhom	0-6
In present study	0.5 – 4

Table 4
Union of cystic duct with common hepatic duct

Observer	Type 1 Angular (%)	Type 2 Parallel (%)	Type 3 Spiral (%)
Kune	75%	20%	5%
Limthankhan	79.2%	8.3%	6.3%
Ibingira CBR	19%	67%	19%

Ruge	33%	29%	38%
Descompos	80%	12%	8%
Kunze	51%	49%	0%
Eisendrath	75%	17%	8%
In present study	62%	16%	22%

Table 5
Length of cystic duct in each mode of union with common hepatic duct

Type	Length in cm		
	Max	Min	Mean
Angular	3	0.5	1.72
Parallel	3	0.9	1.95
Spiral	4	0.7	2.35