"STUDY OF EXTRAHEPATIC BILIARY APPARATUS"

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fulfillment of the requirements for MS DEGREE EXAMINATION
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CERTIFICATE

This is to certify that this dissertation titled ***"STUDY OF EXTRAHEPATIC BILIARY APPARATUS "*** submitted by

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<u>DECLARATION</u>

I, **Dr.P.G.ANANDHI,M.B.B.S,D.G.O , (M.S)(ANATOMY***)*, Solemnly declare that the dissertation titled ***"STUDY OF EXTRAHEPATICBILIARY APPARATUS"*** has been prepared by me.

This is submitted to the TamilNadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the regulations for the award of MS Degree Branch-V (ANATOMY).

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CONTENTS

INTRODUCTION

The study of extra hepatic biliary system is not only interesting but also useful to operating surgeons and radiologist. Recently increased rate of recent advances like “Living donor liver transplantation with duct to duct anastomosis and cholecystectomies performed by laproscopic procedures has made it imperative that the surgeon should have an adequate knowledge of the normal anatomy and its variations of extra hepatic biliary system. Recent investigations like magnetic resonance cholangio pancreatography **(MRCP)** require definitive knowledge about the anatomy of ductal system.

The gall bladder plays an important role in the metabolisms of bile salts and subsequently that of fat. The gall bladder in addition to congenital anomalies has various metabolic, endocrine, obstructive, inflammatory and malignant diseases. In United States about 15% of population suffered from biliary tract disease **(Cliason and Stevena in 1994)** and this increased about 30% after the age of 45 and above. The gallstone obstructing the passage results in surgery about 80% of operations done upon gall bladder and bile ducts.

The gall bladder has been an organ of speculation since the times immemorable. **Jacopo da carpi (1522)** “sometimes a man lack gall bladder; he is then of infirm health and shorter life.

AIM OF THE STUDY

In no region of the human body is anomaly so common as in the biliary ducts and its adjacent blood vessels. In analysis of the literatures, many investigations have been carried about the variational anatomy of extra hepatic biliary apparatus.

The importance of the variational anatomy of the extra hepatic duct system and its related vessels, in operative and invasive procedures, was first predicted by

“Schachner” (1916).

Abnormalities of the major ducts and accessory hepatic duct during Cholecystectomy is the most frequent cause for postoperative complications such as leakage of bile, fistula, necrosis of liver and hepatic failure. Biliary peritonitis

leads to more serious trouble, if unrecognized during surgery.

Similarly, arterial variations give rise to frequent hemorrhage during surgery. They may lead to injuries to duct, as during the process of clamping the anomalous vessels, ducts can also be included in ligature along with artery.

Moreover, recognition of the structures in the calot’s triangle is considered to be important to minimize injuries of bile ducts and their related vessels.

Narrow exposure and variational anatomy are the two major things that contribute to operative difficulties to the surgeons. It is like wise true, that anatomical knowledge is critical to prevention of injuries of the structures in hepatoduodenal ligament for interpretation of cholangiograms like Percutaneous Transhepatic Cholangiography (PTCA), Endoscopic Retrograde Cholagio Pancreatography (ERCP) and Magnetic Resonance Cholangio Pancreatographic (MRCP) procedures.

The importance of variations in the extrahepatic biliary ductal system and calot’s triangle has been much observed by the surgical gastroenterologist, radiologist and general surgeons.

Such an extensive clinically oriented topic created much interest in me which in turn provoked me to dissect and analyse the variations in extrahepatic biliary apparatus.

Review of literature

The nomenclature of gall bladder was derived from Latin word “GALL” which means a storage receptacle. The importance of gall bladder was stressed by **Jacopo Da Carpi** in1522, also stated the presence of an extra bile duct going to the pylorus of stomach.

Von Wyss, (1870) first stated about the variations in formation of common bile duct. **Brewer, (1900)** found that extrahepatic union of right and left hepatic duct was 100%, intrahepatic union of right and left hepatic duct was 0% and the presence of accessory hepatic duct was 0.5%.

Situs inversus first described by **Fabricus** (1600). **Glisson** (1654) was first describing a ring of muscle fibers surrounding the common bile duct, oblique course via the duodenum. **Blastius** (1676) reported a case of double gall bladder. Absence of gall bladder reported by **Bergman** (1701). **Vater (**1748) showed that the bile and pancreatic ducts come together in a tubercle or diverticulam. **Morgani** (1769) first noticed the diverticulam of gall bladder. **Morgani** (1760) also describe an hourglass gall bladder. **Luscha** (1858) described glandular structures in the wall of gall bladder. The first case of left side gall bladder without situs inversus described by **Hochstetter** in 1886**.**

Oddi in 1887 noted a bank of muscle fibers around the terminal part of bile duct. **Sappey** (1889) studied the opening of bile and pancreatic ducts into duodenum.

In **1891 Calot** defined a triangular interval bordered by the cystic duct, hepatic duct and lower border of liver. In 1892, **Hugh** renamed the Calot's triangle as hepato-biliary triangle. **Schimer** in 1893, by injecting air into the ducts, demonstrated that the bile and pancreatic ducts opened into the duodenum. **Carmichael** (1902) made a note on the position of gall bladder.

Deve (1903) first described a condition in which the gall bladder was completely submerged in liver. **Rugg Ernst et al., (1908)** in their study showed various types of union of cystic duct with common hepatic duct.

Kehr (1913) reported the three cases of intra hepatic gall bladder in adults. **Schachner (1916)** described 8 anomalies of extrahepatic biliary duct system, in which double cystic duct was present in 2 cases, anomalous hepatic duct in 5 cases and absence of common duct in one case.

Barte (1916) first described a Phrygian cap deformity, produced by a folding over of tip of the fundus, resulting from the presence of a partial transverse septum.

Holmes (1916) described a gall bladder with the cystic duct almost absent, represented only by a fibrous band.

Reich (1918) first demonstrated the roentgenography of biliary tree, by injection bismuth paste and petrolatum into an external fistula.

Eisendrath (1918), in his study on 100 specimens, showed the types of union of cystic duct with common hepatic duct. In that, angular type of union observed in 75 cases, parallel type of union in 17 cases and spiral type in 8 cases.

He also described the intra hepatic union and accessory duct was 0% in his study and extrahepatic union of right and left hepatic duct is 100%. Also observed 24% of cases, the cystic artery arising from the left hepatic artery or duodenal artery.

E.R.Flint (1923) in his study on 200 subjects, discussed about origin, course of right hepatic and cystic artery. The various origin given by him as follows;

* From main hepatic artery in 158 cases
* From superior mesenteric artery in 42 cases
*Presence of two right hepatic arteries in 7 cases.

(One arising from hepatic proper, other from superior mesenteric artery)

* 2 cases, the right hepatic arteries from the hepatic artery

He also described about the course of right hepatic artery, in relation to common hepatic duct.

* Behind the common hepatic duct in136 cases
* Front of common hepatic duct in 25 cases

He stated that right hepatic artery, when it passes behind the common hepatic duct, low down near the junction of the cystic duct, is more liable to injury during cholecystectomy.

About the origin of cystic artery, he says

* From right hepatic artery in 196 cases
* From left hepatic artery in 3 cases

* From gastro duodenal artery in 1 case

Regarding the course of cystic artery to common hepatic duct, it passes in front of the common hepatic duct in 32 cases and passes behind it in 168 cases (to the right side of common hepatic duct).

In his study, he noted the accessory cystic artery in 31 cases out of which it arises from right hepatic artery in 16 cases, from left hepatic artery in 3 cases, from gastro duodenal artery in 11 cases and from superior pancreatico duodenal artery in 1 case. Ignorance of occurrence of accessory cystic artery is responsible for severe hemorrhage.

Diagram -1 illustrating various abnormalities in the arteries and bile ducts met with gall bladder surgery as shown by flint is given in Pic-1. His study on the ductal system shows, presence of 29 accessory bile ducts. All were accessory right hepatic ducts, joins the extra hepatic ducts, any where between the right and left hepatic ducts and the point at which the cystic duct opens into the main duct.

He also classified accessory ducts into three types, according to the level at which they enter the main duct.

1. The junction occurs in the upper half of common hepatic duct and right hepatic duct (high level union) in 9 cases.

2. The junction occurs in the lower half of common hepatic duct, the union is so near that of the cystic and common hepatic duct in 9 cases.

3. The junction is at the union of cystic and common hepatic ducts. The junction is usually in the acute angle of cystic and common hepatic ducts, but may be in extreme lower end of the common hepatic duct or in cystic duct in 10 cases.

In one specimen, it leaves the right hepatic duct and enters cystic duct.

Mcwhorter in 1923, found the occurrence of 1% accessory bile ducts.

Beaver (1929); found 5 accessory bile ducts from 59 cadavers (9%).

Thompson (1933) dissected 50 specimens, and stated that extra hepatic union of right and left hepatic duct in 10%. The union of cystic with common hepatic duct was angular in 45 cases, parallel in 3 cases and spiral in 2 cases.

Miller (1936), Found a small cystic duct. **Henry Gray (1936),** observed the following variations in the extra hepatic ducts and its related arterial system.

1. Cystic duct occasionally joins the right hepatic duct.
2. Cystic artery passes behind or in front of the common hepatic duct.
3. Accessory hepatic ducts are more common from right lobe of liver.
4. Accessory cystic artery may arise from the common hepatic artery.

A. Lurje M.D. (1937) studied details on extra hepatic biliary passage by dissecting 194 cadavers. They classified the union of cystic duct with common hepatic duct as follows, Pic-2.

Cystic duct joined hepatic duct at acute angle in 46.9% of cases Pic-2a.

Cystic duct followed the right border of the hepatic duct for some distance before entering it in 30.9% of cases, Pic.2b.

Cystic duct made a spiral course behind the hepatic duct and entered it on its left anterolateral surface in 6.7% of cases, Pic.2c.

Cystic duct made a spiral course and followed the posterior surface of hepatic duct for some distance and entered it posterior in 15.5% of cases, Pic.2d.The supernumerary bile ducts, the supplementary bile duct noted 22 times (11.3%). In 1.6% the cystic duct entered the point of confluence of the hepatic duct with accessory duct. The cystic duct passed the right and left hepatic ducts and joined them at a common point, to form a single hepatic duct. In 2.8% large and small passages emerged from right lobe of liver, entered cystic duct. These accessory passages may be the cause of postoperative biliary fistulae.

Lichenstein (1937), account for the significance of the "folded fundus gall bladder". **Batson (1938),** described the anatomy of gall bladder incisions.

S.Dana Weeder, M.D, and Doctor Swartley (1939) reported a case of choledochus cyst with double common bile duct, in which the right and left hepatic ducts were separate and did not join as normal. They proceeded separately to duodenum.

Finney and Owen (1942) accounted for the surgical aspect of congenital absence of the gall bladder. **Dixon and Litchman in 1945** described a case of congenital absence of the gall bladder. **Bullard (1945)** described a case of the gall bladder in the abdominal cavity. **Robertson and Ferguson in 1945,** considered diverticula of the gall bladder to be an acquired condition.

Clyde Everett, M.D, and Harold E Machumber M.D, in 1942, described about anomalous distribution of extrahepatic biliary ducts, from a case report of ‘Barium’ study of a white female, in which gall bladder cannot be visualized. In the same case, during autopsy they found that a single hepatic duct emerging from each of the two lateral lobes of liver. These joined immediately to form a single main hepatic duct, 4 cm from hilum of liver divided into 2 branches. One branch emptied into the second part of duodenum at ampulla of vater and the other branch emptied into poterosuperior aspect of the lesser curvature of stomach, 1 cm proximal to pyloric ring.

Paul Campiche, M.D, in 1944, from a surgical case during cholecystectomy, described about an ante-duodenal position of the cystic duct in which cystic duct passed in front of duodenum.

Edward H Daseler M.D, et al., (1947) from a study of 500 specimens stated about various origin of right hepatic artery, Pic-3. A normal common hepatic artery was present in 83.2%. A replacing type of right hepatic artery is one by which the right lobe is supplied from some other source, was present in 16.8%. In that 11.2% the replacing right hepatic artery originated from superior mesenteric artery, in 0.2% from aorta, in 4.4% cases, right hepatic branch of common hepatic artery was derived from superior mesenteric artery. In 0.2%, the common hepatic artery arose directly from aorta. In 0.8%, the right hepatic artery arose as a direct branch of celiac axis.

Accessory right hepatic arteries in addition to normal or replacing arteries occurred in 7.2%. Among that,

in 3%it arose as a branch of superior mesenteric artery.

in 26%, as a branch of left hepatic artery.

in 1%, from the gastro duodenal artery.

in 0.4%, from the celiac axis.

in 0.2%, directly from aorta.

Regarding the relationship of right hepatic artery with ductal system, in 65% cases the artery, crossed posterior to the common hepatic duct.

In 11.6% cases, it crossed anterior to common hepatic duct

in 3.6% cases, it crossed posterior to right and left hepatic duct.

In 0.8% cases, it crossed anterior to right and left hepatic duct.

In 11.6% cases, it crossed posterior to common bile duct.

In 1.4% cases, it crossed anterior to common bile duct.

In 4.4% cases, it crossed entirely to the right of common bile duct and hepatic ducts.

In 1.6% cases the hepatic ducts crossed entirely to the left common bile duct.

In 11.4% cases the artery crossed posterior to cystic duct.

In 0.8% cases the artery crossed anterior to cystic duct.

Regarding the various origin of cystic artery, he classified into 12 distinct types as follows, Pic-3a.

Type I: Commonest arrangement in, which, hepatic artery of celiac origin divides to supply right and left hepatic lobes. The gall bladder receives its cystic branch from nearer or right division. This is encountered in 58.6%(340 of 580cystic arteries).

Type II: Cystic artery arises from the proximal portion of the right hepatic artery. This arrangement occurred in 13.1%(76/580) of cases.

Type III: Cystic artery originates from an aberrant right hepatic artery, derived from superior mesenteric artery. This pattern occurred in 11.9%(69/580) of cases. In another 4.2% cases, it was not the right hepatic but common hepatic artery took origin from superior mesenteric artery.

Type IV: Cystic artery derived from left hepatic artery in 6.2%(36/580)

Type V: Cystic artery arose as a branch of common hepatic artery in 2.8%(16/580).

Type VI: Cystic artery arose from gastroduodenal artery in 2.6%(15/580).

Type VII: In 0.4% cases cystic artery arose as a branch of celiac axis.

Type VIII: In 0.6% cases it was derived from a replacing or from an accessory type of hepatic artery. The later was derived from a source other than superior mesenteric artery.

Type IX: In 0.2% (1) case the sole source of arterial supply to gall bladder was along, slender cystic artery derived from first portion of superior mesenteric artery.

Type X: In 0.2%(1) case it is from superior pancreaticoduodenal artery.

Type XI: Lipschutz has reported 2 cases in which cystic artery originated as a direct branch from aorta.

Type XII: Kosinski in which cystic artery arising branch of right gastroepiploic artery has reported a single case. No such cases were encountered in present series.

Regarding double arteries he showed 15.6% cases, the course of dual cystic arteries are most commonly derived from right hepatic artery. However branches from left hepatic, common hepatic and from the gastroduodenl arteries also occur in a decreasing order of frequency. Accessory artery he noted was 11.26%(65). Their study revealed about the relationship of cystic artery and duct system.

In 69.8%(405/580) cases, cystic artery arose from right hepatic artery in calot’s triangle which was regularly described as normal. In 21.2%(123/500) cases, it crossed ventral to common hepatic duct. In 2% (12/500) cases, it crossed dorsal to common hepatic duct. In 3% it crossed ventral to common bile duct. In 0.52%(3) it crossed dorsal to common bile duct. In 1.05%(6) cases cystic artery arose from right hepatic artery in the interval between the right and left hepatic ducts, crossing the right hepatic duct anteriorly to reach the gall bladder. In 1.05%(6) cases, it arose to the right of the ductal system and crossed superiorly to cross the cystic duct. In 0.17% (1) case artery is posterior to cystic duct. In 1%(5) cases, it is entirely to the right of the duct system, crossing neither the common hepatic duct, cystic duct nor common bile duct. In 0.34%(2) cases, it arose within portal fissure as a high point it crossed ventral to right and left hepatic duct to reach the gall bladder.

Edward H. Daseler et al., from the above same series, worked in 500 cases to show 12 major anomalies in the duct of liver. They were as follows,

* Accessory right hepatic duct entered the common bile duct in 1 case.
* Cystic duct drained directly into the right hepatic duct in 3 cases.
* Accessory right hepatic duct drained to cystic duct in 3 cases.
* Small accessory right hepatic duct drained directly to gall bladder in 2 cases.
*Small hepatic duct from right or quadrate lobes of liver, which drained into common hepatic duct in 2 cases.
* Cystic, right and left hepatic ducts joined together at a common point of fusion so that no common hepatic duct was formed in one case.

Latimer and Mendez in 1947 described a case of congenital absence of the gall bladder. Latimer and his colloquies also described the presence of cystic duct without gall bladder. **In 1947, Dasler et al.,** described variations in the cystic artery origin and classified them into 12 main types.

Milroy Paul in 1948 from an operative finding, described that right hepatic duct drained directly to gall bladder at Hartmann's pouch and left hepatic duct and cystic duct opened into common hepatic duct.

Charles B. Ripstein M.D., and G. Gavin Miller, M.D., in (1948) described about choledochus cyst associated with congenital Artesia of gall bladder.

Moosman, in 1948 from a dissection of about 147 cadavers, described about moosan's area which about the size of half a dollar centering on the cystohepatic angle. He also stated that it was the most critical angle and found with in this, was cystic artery in 90%, right hepatic artery in 82%, all the accessory right hepatic arteries in 95% and 23 accessory bile ducts in 91%.

Meyer, Dowlin and Reinglass (1949) discussed a case of double gall bladder. **Rachlin (1951) Nicolas** described a case, where the presence of gall bladder was in the falciform ligament. **A.Michels, M.A., D.Sc., (1951),** statistically estimated about the origins of cystic artery from 200 bodies.

Typically the cystic artery arises from celiac right hepatic to the right of the hepatic duct in calot's triangle, after a short, medium or long course, it divides into superficial and deep branch. The superficial branch passes to the free peritoneal surface of gall bladder and deep branch to non-peritoneal surface of gall bladder.

In about quarter of the subjects, the superficial and deep branches of cystic artery have a separate origin. The deep cystic arteries from right hepatic, superficial from right hepatic or from other sources namely left hepatic, hepatic proper, and retroduodenal and gastroduodenal arteries.

Single cystic artery:

In the 200 bodies, cystic artery was single in 75% of cases. Out of which 70%(140), arises from celiac right hepatic. In 5%(10), it arises from left hepatic, hepatic proper, retroduodenal and gastroduodenal arteries.

Double cystic artery:

In 25% (50) cases, the superficial and deep branches arise separately from the same artery or from different sources. The 50 cases of double cystic comprised 12 types.

In 14.5% cases, both the superficial and deep cystic

arteries branch with in calot’s triangle.

The deep cystic artery was seen the in calot’s triangle in 7% of the cases.

In 2% cases, the superficial cystic artery was seen the in calot’s triangle.

In 1% cases did not contain the origin of cystic from the right hepatic artery in the triangle.

In 3.5% two accessory hepatic ducts present, the two joined the hepatic duct or one joined the right branch of hepatic duct, the other the hepatic duct.

He observed the aberrant right hepatic artery in 26%(52) cases. Of which

18% (36) were replaced right hepatic and 8%(16) were accessory right hepatic. The most common site of origin of an aberrant right hepatic artery is superior mesenteric artery.

In their study on the biliary ducts, the incidence of accessory hepatic ducts is greater having been observed in 18%(36) cases.

In 10% they joined the hepatic duct.

In 3.5% they terminated in the right branch of hepatic duct.

In 1% they joined the common bile duct.

The arterial relations to accessory hepatic ducts are surgically dangerous and difficult to analyze. The course of the right hepatic artery may be above or below the accessory ducts. The cystic artery may cross anterior to posterior to it or it may arise below or above it. When the cystic artery arises from right hepatic artery it passes posterior to common hepatic duct. If it arises form other sources it crosses anterior to common hepatic duct.

In 88% of cases right hepatic artery crosses posterior to common hepatic duct and in 22% of cases it crosses anterior to common hepatic duct.

Edward V. Johnston and Barry J. Anson, Ph.D., (1952), studied 35 specimens described,

I. The union of cystic with hepatic ducts

1. Cystic duct joins the common hepatic duct at an acute angle in 18 cases, which was described as angular type.

2. Cystic duct and common hepatic duct may run parallel to each other for a

varying distance. They are held by firm tissue, which may be indistinguishable on gross inspection.

They also classified the ducts with the parallel course, shorter than 2 cm, belonging to acute angular type (4 cases); 2 to4 cm as short parallel (6 cases); 4 cm and over as long parallel type (1 case). The average length of parallel course was 2.7 cm.

3. Cystic duct winds round the hepatic duct for a quarter turn, half way or more or even a through full turn described as spiral type. The actual point of junction may be on the anterior, posterior or the medial or left surface of common hepatic duct. 6 cases showed spiral type of union, of these 5 were posterior and 1 was anterior.

Henry Hollinshead, in 1954, commented about the term “hepatic pedicle”, as it is commonly used to designate the upper end of “hepatoduodenal ligament” and the structures, which it contains.

The three structures namely common bile duct, normally lies anterior and to the right, in the actual edge of hepatoduodenal ligament, while the hepatic artery also lies anterior just to the left of common bile duct, the portal vein larger lies behind the duct and artery to the left of the duct shown in (pic.4).

In his description, he says, “variations in length of the hepatic and cystic ducts are quite common”.

The length of common hepatic duct is usually determined by the respective levels of union of two proper hepatic ducts and the level at which it is joined by the cystic duct.

The length of common hepatic duct varies from 2.5 to7.5 cms. The length of common bile duct varies from 5 to15 cms. The length of cystic duct is 5 cms. The angle of union between the cystic and hepatic ducts also varies.

Cystic duct some times joins the hepatic duct at almost a right angle. Sometimes, parallels it for some distance before joining common hepatic duct. Sometimes cystic duct may pass behind or in front of common hepatic duct to empty into the left side to form a spiral course (pic.4a).

According to him the most common and usually the most important variations in the arterial system is related to the two vessels, namely, right hepatic artery and cystic artery, since these two vessels lie with in the calot's triangle.

Some variations in the course and relationship of right hepatic artery are given in (pic.4b).

It is usually the right hepatic artery, which presents itself in the area of danger in biliary surgery, the manner in which it enters calot's triangle and its relations with in the triangle subject to variation.

Normally, the right hepatic artery passes dorsal to the common bile duct or common hepatic duct but it can also pass ventral to both these ducts.

More over the artery is in close contact with the cystic duct, either paralleling it or bulging forwards or to the right.

The common anomalies of cystic artery encountered by him were

1. Doubling of cystic artery.
2. Origin to the left of common bile duct and to the common hepatic duct.
3. An origin to the left of calot’s triangle.
4. Passes ventral to common hepatic or common bile duct.

Some variations in the origin and course of the cystic artery is given in the (pic.4c).

Carington William M.D., et al., in1955, stated that the most frequent anomalies of the ductal system were the accessory ducts. Almost these accessory ducts arose from right lobe of liver and most of them emptied into the gall bladder, a few entered the cystic duct.

They also added that the division of small ducts could be readily overlooked and may not be suspected until there was drainage of bile via the wound.

G.Hossein Mahour M. D., et al., in1961, studied 200 autopsies and described about the height of termination of cystic duct.

In 80% of cases, the cystic duct terminates by running obliquely downwards to the junction of common hepatic duct. This type gives a short hepaticus and longer common duct.

In 18% of cases, its downward course is steeper and terminates close to the bifurcation in 0.5%, in the bifurcation 0.25%, to the right hepatic duct in 0.75%.

Deward O.Ferris, M.D., et al., in 1965, from a case found absence of cystic duct with normal biliary tree, which was confirmed by cholangiography.

Levin and Saksenberg et al., in 1980, reported a case of left sided gall bladder and left side bile duct in the absence of situs inversus.

Paul H, Sugarbaker, M. D., et al., in 1985, from a case report during operation on hepatoduodenal ligament, revealed two cystic ducts, each communicates independently with common bile duct and the right hepatic artery was placed anterior to the common bile duct. He also noted the presence of two cystic arteries arising from right hepatic artery to enter gall bladder independently.

Stremple, JF in 1986, stressed upon the need for careful operative dissection in moosan's area during cholecystetomy.

The southern surgeon club, during 1991, mentioned that in 1518 laproscopic cholecystectomies performed by 59 surgeons, 4.7% was converted to open cholecystetomy due to presence of aberrant anatomy.

Ricardio L. Rossi M.D., et al., in 1992, gave a review of 11 patients, who underwent biliary reconstruction after laproscopic cholecystectomy, in which ductal injuries occurred due to failure to define the ductal anatomy and the calot's triangle.

A.R.Mosso, M.D., et al., in 1992, mentioned that laproscopically it is not conveniently possible to begin the dissection at the fundus of gall bladder as that in open cholecystectomy, in order to avoid injuries.

So, in order to avoid injuries during laproscopic cholecystectomy, the ductal length are to be noted and the variations of ductal anatomy should be made out.

According to **Andrew M. Ress M.D., et al., in 1993,** bile duct injuries were far more common and constituted 86% of laproscopic complications. So, routine laproscopic cholangiography, via gall bladder prior to dissection of calot's triangle or routine cystic duct cholangiography has been advocated to clear the anatomy of biliary system to prevent biliary tract injuries.

Juan R. Madariaga, M.D., F.A.C.S., et al., in 1994, gave a study design on 15 patients with complex laproscopic cholecystectomy injuries who underwent corrective surgery. The injuries consisted of 14 bile ducts. They finally concluded that knowledge of anatomy is critical in prevention of injuries to the hepatobiliary tree and related structures during cholecystectomy.

L.H.Blumgart during 1995 observed that the extrahepatic biliary ducts are represented by extrahepatic segments of right and left ducts, joining to form common hepatic duct. In extrahepatic segment the right hepatic duct is shorter but the left duct has a much longer course.

Balija et al., in 1999, presented a laproscopic visualization and classification of various origins of cystic artery which is shown in the (pic.5).

Fritscher Ravers et al., in 2000 stated that in comparison of laproscopic cholecystectomy with open cholecystectomy, laproscopic cholecystectomy is associated with the higher incidence of bile duct injuries and one of the reasons for that was failure to recognize the anatomical variations of that area.

Nicholas et al., in2002, described that anatomical location of the bile ducts and the related structures are important for conventionally classifying or for grading of the tumors of hilar cholangiocarcinoma.

Strasberg S.M., (2002), in a paper on avoidance of biliary injury during laproscopic cholecystectomy, mentioned that careful dissection and cautery usage in the triangle of calot is needed.

From the **journal of Gastrointestinal Endoscopy (2003),** the approach to the patient with hilar cholangiocarcinoma involving the bifurcation requires definition of the anatomy to determine operative respectability. Magnetic resonance cholangio pancreatography (MRCP) and Magnetic resonance imaging (MRI) should be performed to determine the ductal anatomy.

M Hribenk et al., in2003, did a study of variations of proximal extrahepatic bile duct, which revealed that overlooked and surgically mistreated variations, could be the cause of post operative bilomas, partial atrophies of the remnant liver after resections.

Sharif K. Deville de Goyet J., (2003), states that variations of biliary anatomy in gall bladder bed and cholecysto-hepatic triangle of calot are reviewed, in order to avoid bile leakage after cholecystectomy.

Tomoz Benedik et al., in 2003, in their principles of safety laproscopic cholecystectomy article concluded that avoid misidentification of ducts one should conclusively identify cystic duct and cystic artery, the two structures to be divided in every cholecystectomy. To achieve that goal, calot's triangle must be dissected free of fat and fibrous tissue.

Masanori Asanda, M.D., et al., in 2003, explains that in living donor liver transplantation (LDLT), the duct to duct biliary reconstruction, requires perfect anatomical location of the biliary system that of duct arising from right lobe. Since the study in 51 live donors, it was observed that 19(37%) had double bile ducts with separate orifice, duct to duct reconstruction with right lobe living donor transplants therefore is often more complicated.

Kyng Suk Sub M.D., Ph.D., et al., in 2004, also explained that preoperative evaluation of the anatomy of bile duct before living donor liver transplantation is done through Magnetic resonance cholangiography (MRC) and Intra Operative cholangiography (OPC). With OPC, the anatomy of the intrahepatic and extrahepatic biliary tree can be explained.

In the latest edition of **Gray's anatomy (2005),** regarding the variations occurring in cystic duct, it is mentioned that rarely cystic duct lies along the right edge of lesser omentum, all the way down to the level of duodenum, before the junction is found. But in these cases cystic duct and common bile duct are usually closely adhere.

Cystic duct occasionally drains into right hepatic duct in which case it may be elongated lying anterior or posterior to common hepatic duct and joins the right hepatic duct on its left border. Rarely the cystic duct is double or even absent in which case the gall bladder drains directly into common bile duct.

One or more accessory hepatic duct occasionally emerge from segment five of liver and join either the right hepatic duct, left hepatic duct, common bile duct, cystic duct or gall bladder directly.

He also mentioned that ligation or clip occlusion of cystic duct must be performed at an adequate distance from the common bile duct to prevent angulations or damage to it. Accessory ducts must not be confused with right hepatic or common hepatic ducts.

Regarding the vessels related to the duct system cystic artery usually arises from right hepatic artery. It passes posterior to common hepatic duct and anterior to cystic duct to reach the superior aspect of gall bladder and divides into superficial and deep branches.

Cystic artery may arise from common hepatic artery, left hepatic artery and gastro duodenal or superior mesenteric artery. In these cases it lies anterior to common hepatic duct and common bile duct.

An accessory cystic artery may arise from common hepatic artery or one of its branches and it often bifurcates close to its origin giving rise to two vessels which approach gall bladder.

The near triangular space formed between the cystic duct, common hepatic duct and the inferior surface of segment five of liver has been described as calot's triangle. Double layer of peritoneum encloses it. This space usually contains cystic artery, cystic lymph nodes, one or two cystic veins. It may also contain any accessory ducts, which drain into gall bladder from liver.

MATERIALS AND METHODS

Study materials:

The study material consisted of:

1. 20 adult dissection room cadavers.
2. 30 enbloc postmortem specimens.

Specimen collection:

1. Cadaver specimens were studied from dissection room.
2. 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 costal margin. Rectus muscle cut open in the midline. Peritoneum opened and entered into 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 right. Coils of small intestine was pushed towards left and 2^{nd} part of duodenum was exposed and two ligature were put, one at the pyloric end of stomach and second just below 2^{nd} part of duodenum.

Now, the stomach was reflected fully upwards to expose the pancreas and then it was cut at the level of neck. This makes the visceral surface of liver, free along with duodenum and head of 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 gall bladder, duodenum and head of pancreas was removed in total.

They were transported in closed plastic containers to the institute of anatomy for further dissection.

Instruments used

Stainless steel students' scalpels

Stainless steel scissors

Stainless steel forceps – Long, toothed

Stainless steel forceps – Long, Non - toothed

Stainless steel forceps – Short, Non – toothed

Measuring scale

Cotton thread. No- 10.

Dissection procedure:

After through washing of the specimens in running water, the gall bladder, cystic artery, cystic duct, right, left and common hepatic ducts were dissected in all specimen. The gall bladder was looked for its number, position, peritoneal relations, shape, interior, dimensions and distance from inferior border of 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 unites. Cystic duct traced upwards up to the neck of gall bladder. Common hepatic duct was then traced upwards to locate the right and left duct emerging from porta hepticus. 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, 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 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 were studied. Then the length of the individual ducts was measured.

METHOD OF STUDY

1. Gall bladder

The gall bladder was studied with regard to

a. Number:

1. Single
2. Supernumerary
3. Absence

b. position:

1. Extra hepatic in the fossa for gall bladder in the right lobe of liver.
2. Intrahepatic

3. Partially intrahepatic

4. Left lobe of liver.

c. Peritoneal relations:

1. Inferior surface covered with peritoneum
2. Suspended by a mesentry and covered by peritoneum

d. Shape:

1. Pear shape
2. Presence of Phrygian’s pouch
3. Presence of Hartman’s pouch
4. Presence of bilobed gall bladder
5. Hour-glass gall bladder.

e. Interior of gall bladder

The gall bladder opened by a longitudinal incision and the interior was studied for rugae, gall stones, diverticulum and septum.

f. Dimensions of gall bladder

1. Length

Length of gall bladder was measured as the linear distance between the fundus and the point of commencement of the cystic duct.

2. Breadth

The maximum breadth of gall bladder was measured and its distance from the fundus also observed.

3. Distance from inferior border of liver to fundus.

The projection of gall bladder beyond the liver was measured as the distance between the inferior border of liver to fundus of gall bladder.

II. Cystic duct

The cystic duct was studied in relation to

1. Number

a. Single

b. Multiple

c. Absence.

2. Length

The length was measured from its commencement to its junction with common hepatic duct.

3. Termination

Acute union (Right side)

Parallel union (Right side)

Anterior spiral union (Left side)

Posterior spiral union (Left side)

Non-union / cystic duct independently opening into the duodenum.

III. Hepatic duct

The common hepatic duct is formed close to the right end of porta hepatis, by the union of right and left hepatic ducts. The common hepatic duct was joined by the cystic duct. The common hepatic duct was studied in relation to

1. Length
2. Relation to hepatic artery.
3. Relation to the portal vein.
4. Relation to aberrant hepatic artery.

IV. Common bile duct

The common bile duct is formed close to the right end of porta hepatic, by the union of common hepatic duct and cystic duct. The common bile duct was studied in relation to

1. Number

2. Position

3. Length

V. Calot’s triangle and cystic artery :

Calot’s triangle is the space bounded by cystic duct on the right side, by the common hepatic duct on the left side and above by the lower edge of the liver . This space was dissected in all the specimens. The cystic artery, a content of this triangle was studied with relation to

1. Number
2. Course
3. Variations.

The results were tabulated and statistically analyzed.

VI. Right hepatic artery

The right hepatic artery arising from the common hepatic artery, passes behind and to the right of common hepatic duct (Datta).

The right hepatic artery was studied

1. Number
2. Course (Anterior / Posterior to common hepatic duct)
3. Termination.

After dissection, the specimens were immersed in the preservative solution kept in containers. The preservative solution contains 10% formalin.

OBSERVATIONS

The findings noted in the dissected specimens of adult human were given below.

1. Gall bladder

The gall bladder presented the following features in this study.

The gall bladder present single in all specimens. The position was inferior surface of the right lobe of liver. The gall bladder was situated in the right lobe of liver was extrahepatic. The inferior surface was covered by peritoneum in all gall bladders. Mesentry was not noted in any specimens. The shape of gall bladder was normal in 48 specimens. Hartman’s pouch seen in 2 specimens. The fundus and body were normal the fundus noted at different levels from the inferior border. The neck revealed Hartman’s pouch in 2 specimens out of 50 specimens.

Table-1

Gall bladder number	Frequency
Single	50
Absence	Nil
More than one	Nil

The gall bladder number in the 50 specimen studied was single.

Table-2

Gall bladder position	Frequency
Inferior surface of the right lobe of the liver	50
Others	Nil

The position was inferior surface of the right lobe of the liver in all specimens.

Table-3

Gall bladder situation	Frequency
Extra hepatic in fossa for gall bladder in right lobe of liver	50
Complete intra hepatic	Nil
Partially intra hepatic	Nil
Left lobe of liver	Nil

The situation was extrahepatic in the fossa for gall bladder in the right lobe of liver in all specimens.

Table-4

Mesentry of gall bladder	Frequency
Absent	**50**
Present	Nil

Mesentry of the gall bladder could not be seen in any specimen.

Table-5

Gall bladder shape	Frequency
Pear shaped	48
Hartman’s pouch	2
Bilobed	Nil
Hour glass	Nil
Phrygian cap	Nil

The shape of the gall bladder studied in the 50 specimens was normal in 48 specimens (96%). Hartman's pouch was observed in 2 specimens (4%).

Table-6

Part of gall bladder studied	**Normal**	**Others**
Fundus	50	Nil
Body	50	Nil
Neck	48	Hartman's pouch 2

The fundus and body were normal in all the 50 specimens studied. The neck revealed Hartman's pouch in 2 specimens and normal in the rest of the specimens.

Table-7

Interior of the gall bladder	**Frequency**
Normal	48
Ironed out	Nil
Gall stones	2
Diverticulum	Nil
Septum	Nil

The mucosa was normal in 50 specimens. Gallstones were observed in 2 specimens associated with Hartman's pouch. The septum and diverticulum were not noted here.

Dimensions of gall bladder

Length

Table-8

Length in centimeters	Frequency
6.5	**12**
7	**28**
7.5	**3**
8	**3**
8.5	**2**
9	**2**

The length of gall bladder varied from 6.5 to 9 cm. with an average of 7.06 cm. The length 7 cm was observed in maximum frequency.

Width

Table-9

Width in centimeters	Frequency
3	14
3.2	**21**
3.5	10
4	5

The width varied from 3 to 4 cm with an average of 3.33 cm. The width 3.2 cm was observed in maximum frequency.

Table- 10

Position of the fundus from the inferior border of liver	**Frequency**
Below the inferior border	34
Above the inferior border	10
At the level of inferior border	6

The fundus of gall bladder noted in this study below the inferior border in 34 specimens, above the inferior border in 10 specimens and at the level of inferior border in 6 specimens.

The fundus of gall bladder below the level of inferior border is seen in most of the specimens.

II. Formation of common hepatic duct:

1. Extrahepatic union of right and left hepatic ducts:

The right and left hepatic ducts united outside the porta hepatis to form common hepatic duct in 32/50 specimens.

2. Intrahepatic union of right and left hepatic ducts:

In the remaining 18/50 specimens right and left hepatic ducts united intrahepatically.

II. A. Types of union of cystic duct with common hepatic duct:

There are 3 types of union of cystic duct with common hepatic duct.

1. Angular type:

In this type, cystic duct makes an angle to join with the common hepatic duct. This type of union is observed in 40 specimens (80%) in this study (Pic8). In all the Specimens, cystic duct united at the right side of common hepatic duct. In one case, cystic duct was seen at the left side of common hepatic duct and unites with common hepatic duct at its left side with out situs inversus (Pic-11).

2. Parallel type:

In this type, cystic duct runs parallel with the common hepatic duct for a varying distance before it unites with the common hepatic duct. 10 specimens were observed to be parallel type of union in this study (Pic-9).

3. Spiral type:

The cystic duct makes a spiral course before joining with the common hepatic duct either on anterolateral or posterolateral side of it. In this study, none of the specimens were found to be spiral type of union.

B. Level of termination of cystic duct:

The point at which the cystic duct joins the common hepatic duct is either at a high level, at a low level or at normal level.

1. High level of union.

Here, the cystic duct joins the common hepatic duct close to the bifurcation of right and left hepatic ducts. This type of union makes the common hepatic duct shorter and the common bile duct longer (Pic-10).

The length of the common hepatic duct given in Gray's is 3 cm.

The length ranges from 1.5 to 2 cms in high level of union of the common hepatic duct.

2. Low level of union.

In this type, the cystic duct joins the common hepatic duct further away from the bifurcation. In low level of union of the common hepatic duct longer than the common bile duct.

In this study normal level of union was observed in 41 specimens. High level of the cystic duct with the common hepatic duct was noted in 8 specimens. Low level of union of cystic duct with the common hepatic duct was noted in one specimen (Pic-18).

III. Length of individual ducts.

The length of the cystic duct, common hepatic duct, common bile duct and accessory duct if present.

a. Cystic duct

Table-11

Length of cystic duct in centimeters	Frequency
4	2
3.5	4
3	18
2.5	16
2.2	5
2	5

The length of the cystic duct is measured from the neck of the gall bladder to the part joining the common hepatic duct. The length of the cystic duct maximum was 4 cms; the minimum length measured was 2 cms. The average length of the cystic duct was 2.74 cms.

b. Common hepatic duct

Table-12

Length of common hepatic duct in centimeters	Frequency
3.5	5
3	11
2.8	2
2.5	15
2	14
1.5	3

The common hepatic duct is formed close to the right end of porta hepatis by the union of the right and left hepatic ducts. The length of the common hepatic duct ranges from 1.5 to 3.5 cms in this study, with the average of 2.52 cms.

c. Common bile duct

Table-13

Length of common bile duct in centimeters	Frequency
5.5	1
6	5
6.5	7
7	11
7.5	18
8	8

The common bile duct is formed close to the porta hepatics by the union of common hepatic and cystic duct. The length of the common bile duct ranges from 5.5 to 8 cms in this study, with the average of 7.14 cms.

d. Accessory ducts

The length of the accessory right hepatic ducts was 0.5cm (3 specimens), 1.5 cms (2 specimens). The length of the accessory cystic duct was 0.5 cm (2 specimens).

IV. Course and arrangement of structures in hepatoduodenal ligament:

The normal arrangement of structures in hepatoduodenal ligament as given in Hollinshead is that common bile duct lies anterior and to the right in the actual edge of hepatoduodenal ligament. Hepatic artery lies anterior just to the left of common bile duct. Portal vein lies behind the duct and artery and is usually larger and to the left of the duct. This normal arrangement noted in 49/50 specimens.

The arrangement of these structures was found to be varying in one specimen (Pic-11, 11a). The variation observed in specimen are given below,

1. Cystic duct joined to the left side of common hepatic duct.

2. The hepatic artery proper was found to lie on the extreme left and divides into three branches, namely,

i) right hepatic artery
ii) superficial branch of cystic artery
iii) left hepatic artery.

3. The right hepatic artery passed behind the common hepatic duct and ran parallel to it outside the calot's triangle to dip into the right lobe of liver. From the right hepatic artery, deep branch of cystic artery arose and passed upwards inside the calot's triangle to reach the gall bladder bed.

4. Superficial branch of cystic artery arising from hepatic artery proper ran upwards, parallel and close to the cystic duct on the left side to reach the anterior surface of gall bladder.

5. Left hepatic artery arising from the hepatic artery proper passed to the left of the duct to reach the left lobe of liver.

6. Portal vein larger and behind the duct and artery was seen on the extreme right of common hepatic duct.

Hence in specimen no.35,

i)The hepatic artery divides into 3 branches, right hepatic artery, and superficial branch of cystic and left hepatic artery.

ii) The right hepatic artery is seen outside the calot's triangle.

iii) The common bile duct lies between the artery and portal vein.

iv) Portal vein is behind the duct and artery to the extreme right side.

V. Variations in ductal system:

The variations in the extra hepatic ductal system were observed under following headings.

1. Presence of accessory ducts
2. Mode of termination of accessory ducts

By dissecting 50 specimens a total of 7 accessory ducts were noted. Out of which, 5 were accessory right hepatic ducts and 2 were accessory cystic duct. Accessory ducts emerging from the left lobe of liver were not noted in this study. The details of the accessory right hepatic and cystic ducts are given below.

A. Accessory right hepatic ducts

i) In specimen No.2, accessory right hepatic duct, arising close to inferior surface of gall bladder was visualized. It descends downwards, coursing parallel to the left hepatic duct, to terminate in the common hepatic duct, just below the union of right and left hepatic ducts (pic.12).

ii) From specimen No.3, a small accessory hepatic duct emerging from the right lobe of liver was dissected. The mode of termination of accessory right hepatic duct is that opens in the middle of the common hepatic duct. (Pic.13).

iii) specimen No.10, presents with an accessory right hepatic duct. It emerges below the two divisions of cystic artery running downwards and parallel to common hepatic duct. Just above the junction of cystic duct with common hepatic duct it joins the common hepatic duct, in its lower half (Pic.14).

iv) Specimen No.20 (Pic-15), a small accessory right hepatic duct arising close to the gall bladder fossa was seen. It passes below and close to the lower half of common hepatic duct, just above the union of cystic duct with common hepatic duct.

v) Specimen No.25 (Pic-16), shows an accessory hepatic duct arising closer to the gall bladder fossa emerging from the right lobe of liver. It courses above and parallel to the cystic artery. It drains into the upper half of the common hepatic duct just below the left hepatic duct.

B. Accessory cystic duct

I) In specimen No.26, a small accessory cystic duct emerging from the inferior surface of gall bladder was dissected. It runs downwards, close and parallel to the common hepatic duct and drains into common hepatic duct, close to the junction of cystic duct and common hepatic duct. (Pic.7).

ii) Specimen No.20 (Pic-19), a small accessory cystic duct arising from the anterior surface of gall bladder, just above the Hartman's pouch was noted. It decends downwards close and parallel to cystic duct to terminate in the middle of cystic duct itself (Pic.19, 19 a).

Thus the frequency of occurrence of accessory ducts was found to be 14% in this study.

Out of 5 accessory right hepatic ducts, all terminates in the common hepatic duct, at various levels.

***** In two cases accessory right hepatic ducts terminate in the upper half of common hepatic duct, close to the bifurcation of right and left hepatic ducts.

* In one specimen, the accessory right hepatic duct terminates in the middle of common hepatic duct.

* In other two specimens, the accessory right hepatic duct terminates in the lower half of common hepatic duct.

* Out of two accessory cystic ducts noted, one terminates in the common hepatic duct and the other in the cystic duct itself.

VI. Variations in arterial system related to ductal system:

The two main arteries related to extrahepatic duct system are cystic artery and right hepatic artery.

The cystic artery, normally arising from the right hepatic artery with in the calot's triangle, passes in the triangle, towards the neck of gall bladder, where it typically divides into superficial and deep branches. The superficial branch passes on its peripheral surface, while the deep branch runs on the attached surface of gall bladder.

As given in Hollinshead, the common subdivision of aberrant arteries into accessory and replacing ones, based upon the extrahepatic dissection of the vessels is that, the term “accessory” implies at least the passive assumption that artery so named is one of two or more to a given part of the liver and that these arteries anastomose freely in supplying that part of liver.

Similarly, the term “replacing” implies that the vessel so named is the sole supply to a given portion of the liver and has been used to denote only a vessel of aberrant origin, which supplied the entire liver or one, which appeared to be the only supply of an entire lobe of liver.

Specimen No.4 (Pic.20), presents with double cystic artery. In this both the superficial and deep branches arise separately from right hepatic artery itself. Both the branches are seen inside the calot’s triangle. They run parallel to the cystic ducts to reach the respective surfaces of gall bladder.

Specimen No.8 (Pic.9), an aberrant replacing cystic artery was visualized. This arises from aberrant right hepatic artery. This aberrant replacing cystic artery is seen to lie on the right side of the common hepatic duct.

Specimen No.10 (Pic.14) shows, presence of an accessory cystic artery. It arises from the hepatic artery proper running upwards towards right, crossing ventral to the common hepatic duct to reach the anterior surface of gall bladder and sending small twigs to supply it.

In addition to the accessory cystic artery it also shows presence of normal cystic artery arising from the right hepatic artery. It divides into superficial and deep branches inside the calot's triangle (Pic.14).

* In specimen No.23 (Pic.21), cystic artery arising from right hepatic artery is visualized. It passes ventral to the common hepatic duct to reach the anterior surface of gall bladder, whereas the usual course of cystic artery is dorsal to common hepatic duct. Right hepatic artery was seen at a higher division close to porta hepatis, arising from hepatic proper.

* Specimen No.22 gives cystic artery issuing from common hepatic artery, passing ventral to the common hepatic duct to reach gall bladder.The right hepatic artery is also visualized arising from hepatic proper. It lies to the left of the common hepatic duct, dipping inside the substance of liver to supply the right lobe (Pic.22).

* From specimen No.39, both the right hepatic and cystic arteries are seen at a higher division of origin close to the porta hepatis. The cystic artery found to be from right hepatic artery, but passing ventral to common hepatic duct, to reach the anterior surface of gall bladder. The usual course of it was that it passes dorsa to common hepatic duct to reach the gall bladder. The origin of the cystic artery is found to be very high close to substance of liver (Pic-23).

The right hepatic artery arising from hepatic proper also noted. This artery is also found to be higher division close to the substance of liver, to the left side of the ductal system.

* In specimen No.30, the origins of the cystic artery and right hepatic artery were noted to be normal. But both the right hepatic and cystic arteries were passing anterior to common hepatic duct. (Pic.17).

VII. Calot's triangle :

Hollinshead states that, the boundaries of calot's triangle are common hepatic duct on the left side, cystic duct on the right side and hilum of liver above.

The two important vessels that lie inside the triangle are hepatic artery and cystic artery.

The study of calot's triangle was conducted under two headings.

1. Boundaries
2. Contents.

1. Boundaries:

In the present series of 50 specimens, the boundaries of the calot's triangle were defined normal in 49 specimens. Specimen No.35 shows cystic duct on the left side, common hepatic duct on the right side and hilum of liver above (Pic.11).

2. Contents:

In addition to the two usual contents the following specimens show variations which are described below,

i) presence of accessory hepatic ducts in all emerging from right side of liver was noted in five specimens.

ii) presence of double cystic artery in one specimen.

iii) presence of aberrant accessory cystic artery from aberrant accessory right hepatic artery in one specimen.

iv) cystic artery branch from right hepatic artery, not seen inside the calot’s triangle and is given outside the triangle from hepatic proper in one specimen.

DISCUSSION

An extensive study on extrahepatic biliary apparatus was previously done by many authors. With due respect, I compare and quote the present study on 50 specimens with those eminent workers.

Gall bladder

Number

The gall bladder is single in number in human beings as described in standard textbooks.

Blastius reported double gall bladder as early as 1676. Meyer, Dowlin and Reinglass found about 48 cases of doubling of gall bladder in 1949 and estimated the incidence not more than one per 4000 to 5000 people. The two components of double gall bladder shared a common internal septum, yet drained by separate cystic duct.

Gross reported 148 cases of anomalies of gall bladder, out of that 30 cases represented duplications of gall bladder. In 28 out of these 30 cases, two cystic ducts were reported, only in 2 cases of the gall bladder they were drained by single cystic duct. Gross reported in 1936, a case in which a normal gall bladder and cystic duct were accompanied by an accessory gall bladder, without cystic duct.

Holmes (1916), reported a patient whose gall bladder was reduced to a pair of small connecting vesicles with an atretic cystic duct. Margagni (1769) reported a similar type earlier.

In Guyton's case (1946), the two gall bladders were widely separated, except at their necks, yet drained via a single cystic duct.

In the case reported by Slaughter and Tout (1933) the second gall bladder was largely buried in the liver, and became visible only after removal of the first, and two separate cystic ducts joined to drain by a common cystic duct.

Skielboe (1958) reported a case of triple gall bladder and cystic duct. All the three organs lie in a common fossa with a common serosa, and all the cystic ducts entered the common duct separately, but close together.

Corcaran and Wallace in 1954 described the presence of two gall bladders with different size.

Estimates of frequency of absence of gall bladder, by different workers were as follows: Tallmadge (1938) 1:1530 autopsies (0.065%), Mouzas and Wilson (1953) in 2403 (0.042%). Latimer and Huge (1947), quoted the congenital absence of gall bladder as 0.065% and 0.75%. Bower (1928), reported a case in which the gall bladder, cystic and common hepatic ducts as well as the left lobe of liver, were all absent. Frey and his colleagues (1967) accepted only 56 confirmed cases of congenital absence of gall bladder. Dixon and Litchman (1945) described a case of congenital absence of gall bladder and the head of pancreas. Latimer and his colleagues 1947 reported 6 cases in which part of cystic duct was present without gall bladder.

The gall bladder was observed to be single in all the 50 specimens studied. Absence of gall bladder, double gall bladder and triple gall bladder, reported earlier was not found in the present study.

Gall bladder position

The gall bladder is located on the inferior surface of the right lobe of the liver, in a depression known as the fossa of the gall bladder (Hollinshead, 1966). It is this fossa, which separates the right lobe of the liver from the quadrate lobe, and along which occurs the division between the functional right and left halves of the liver. In its bed the gall bladder is attached to the liver by connective tissue, via which run apparently some lymphatic and veins that connect these systems on the gall bladder with those of the liver.

In the present study, the gall bladder was observed to lie in the fossa, on the inferior surface of right lobe of liver in all 50 specimens.

Peritoneal relations:

The gall bladder is normally covered by peritoneum only on the surface, which is not in contact with the liver at bed of the gall bladder, the peritoneum simply passing from the surface of the liver, across the sides and posterior surface of the gall bladder (Hollinshead, 1966). Usually the fundus of the gall bladder, project somewhat below the lower border of the liver, and is therefore more or less completely surrounded by the peritoneum. The veins of the gall bladder enter the hepatic tissue, in the bed of the gall bladder or the quadrate lobe. Morgagni (1769) was first noted a case of mobile gall bladder, resulting in torsion. In 1973

Dr.Banumathi observed a mesentery of gall bladder.

All the gall bladders studied were covered with peritoneum only on the posterior surface. The presence of mesentry, although reported earlier was not seen in this study.

Shape of gall bladder :

The gall bladder is a pear shaped hollow viscus, slate blue in colour, situated obliquely in a non peritoneal fossa on the under surface of the right lobe, and extends from right end of porta hepatis to the inferior border of liver.

Bartel described Phyrigian cap deformity in 1916. This deformity according to him is produced by a folding over the tip of the fundus, resulting from the presence of a partial transverse septum.

The folded fundus of gall bladder according to its appearance in cholecystograms is referred to as" Phyrigian cap". Liechenstein (1937) stated that folded fundus is a common congenital anomaly, having been reported in from 3 to 7.5% of cases studied. Flannery and Caster (1957) have discussed an hour glass gall bladder. Flannery and Caster (1954), in their study they believed, that the Phyrigian cap deformity of the gall bladder was more prone to lithiasis. Boyden (1935) suggested that the fold represents a persistent embryonic bend; formed at the time, the lumen is reestablished.

Hartmann's pouch is probably an acquired deformation, resulting from dilatation of infundibulum, produced by long continued resistance to gall bladder emptying. Kaiser (1961) considered the Hartmann's pouch to be a normal variation, associated with a short, stocky habitus.

The gall bladder was pear shaped in 48 specimens studied. Hartmann’s pouch was observed in 2 (4%) specimens.

Interior of gall bladder

The mucous membrane of the gall bladder is thrown into numerous folds or rugae, producing a honeycomb appearance.

The septate form of gall bladder reported by Boyden (1932). Knetsch in 1952 first reported a rare congenital anomaly multiseptate gall bladder. Bigg reported another case of multiseptate gall bladder in 1964. Robertson and Ferguson (1945) considered the diverticula of gall bladder to be an acquired condition. Margagni first noted diverticula of the gall bladder in 1769. Flannery and Caster (1956) reported 10 cases of diverticula of the gall bladder between 1936 and 1953.

Gallstones have been demonstrated in 10% of all autopsies in individuals of all ages (Crump 1931). Robertson (1945) found that 16.3% had gallstones.

Gallstones were observed in 2 out of 50 specimens in present study (4%). No septum and diverticula were noted in present study.

II) Formation of common hepatic duct:

Site of union of right and left hepatic ducts

The right and left hepatic ducts from the corresponding lobes of liver unite to form common hepatic duct either extrahepatically or intrahepatically.

Brewer (1900) from dissection of 50 specimens found 100% of extrahepatic union of right and left hepatic ducts.

Rugg (1908) studied 43 cadavers observed, extrahepatic union of right and left hepatic ducts in 79% and intrahepatic union of right and left hepatic ducts in 21%.

Eisendrath (1918) gave similar report as Brewer. He also observed 100% union of extrahepatic right and left hepatic ducts from 100 specimens.

Thompson dissected 50 specimens in 1933 noted that 90% extrahepatic union and 10% intrahepatic union of right and left hepatic ducts.

In the present study on 50 specimens extrahepatic union of right and left hepatic ducts was noted in 64% and intrahepatic union of right and left hepatic ducts in 36% of cases.

On comparing the above studies the extrahepatic union of right and left hepatic ducts is found to be more than intrahepatic union.

Types of union of cystic duct with common hepatic duct:

The junction of cystic duct with common hepatic duct, which is of surgical importance, is highly variable. Three types of union of cystic duct with common hepatic duct were noted namely, angular, parallel and spiral.

Rugg (1908), reported angular - 35%, parallel -20% and spiral -45% in 43 cadavers dissection.

Eisendrath's (1918) study on 100 specimens showed angular- 75%, parallel -17% and spiral -8%.

Thompson (1933) dissected 50 cases and observed angular - 90%, parallel - 6% and spiral -4%.

A.Lurje M.D., (1937), an elaborate study on 194 cadavers noted angular - 46.9%, parallel -30.9% and spiral -22.2%.

Edward V Johnson (1952) in his work on 35 specimens, noted angular - 51.4%, parallel -31.4% and spiral -17.1%.

But in present study, I observed angular type in 80%; parallel type in 20% and spiral type of union was not found. On comparing the above studies the most common type of union of union of cystic duct with common hepatic duct is angular type.

Surgical importance:

In parallel type of union, both the cystic duct and common hepatic duct are closely bound together. Hence, their separation becomes difficult. Moreover, in parallel type of union, two ducts may closely adherent to each other. So it is difficult to put a clamp without injuring common hepatic duct.

B. Level of termination of cystic duct.

The levels of termination of cystic duct with common hepatic duct are high level, low level and normal level.

In high level of union cystic duct unites with common hepatic duct close to the union of right and left hepatic ducts. In this level the common hepatic duct length is very small than its average and common bile duct length is more.

In low level of termination, cystic duct unites with common hepatic duct further away from the bifurcation to make common hepatic duct longer than common bile duct.

In normal level of union common bile duct is longer than common hepatic duct.

Hossein Mahour in (1961), from a study of 100 specimens, described about the height of termination of cystic duct. In that, 80% of cases cystic duct runs obliquely to join common hepatic duct. This type gives a short hepaticus and long common bile duct, this type was observed to be more common. In 18.5% of cases low level of union and in 1.5% of cases high level of union was noted.

In the present study, normal level of union was observed in 41 (82%) specimens, high level union of the cystic duct with the common hepatic duct was noted in 8 (16%) specimens, low level union of cystic duct with the common hepatic duct was noted in one specimen (2%).

Hence the present study coincides with that of Hossein Mahour in terms of normal level of union but not regarding high and low level of union.

The level of union, high or low insertion of cystic duct carries significant, because of the potential for injury in biliary surgery.

III. Length of individual ducts

Hollinshead (1954), stated the length of cystic duct as 2.5 –7.5 cms.

The length of common hepatic duct as 2.5 –7.5 cms.

The length of common bile duct as 5 – 15 cms.

Edward V Johnston (1952) in his work on 35 specimens, gave the length of cystic duct was 2.9 cms; and length of common bile duct as 6.6 cms.

Leistenin and Ivy (1952), stated that in 55% the length of cystic duct was 2 – 4 cms; in 20% it was <2 cm and in 25% it was 4 cms.

The latest Gray's anatomy (2005), mentioned the average length of cystic duct is 3 - 4 cms, the length of common hepatic duct is 3 cms and the length of common bile duct is 7.5 cms.

In present study,

The average length of the cystic duct was 2 – 4 cms.

The average length of the common hepatic duct was 2 - 3.5 cms.

The average length of the common bile duct was 5.5 – 8 cms.

Thus the present study coincides with that Gray’s and with that of Leistenin and Ivy in terms of cystic duct length and dose not correlate with Hollinshead’s study.

Clinical significance:

The clinical significance of the measurement of individual duct length is that during laproscopic cholecystectomy, the length of the ducts measured, in order to avoid injuries to the ductal system. Moreover the length of individual ducts also signifies the level of union of cystic duct with common hepatic duct to note, either high level or low level of union, which is at risk of injury during cholecystectomy. Failure to ligate cystic duct at its correct point mainly 1 – 2 cm proximal to its junction with common hepatic duct and common bile duct leads to tenting of common bile duct pinching of its wall by the ligation.

IV. Course and arrangement of structures in hepatoduodenal ligament.

The arrangements of structures in hepatoduodenal ligament described by Hollinshead are common bile duct lies anterior and to the right. The hepatic artery lies anterior just to the left of common bile duct. The portal vein lies behind the duct and artery usually larger and to the left of the duct. He also mentioned that not more than one third of liver shows the so, called normal arrangement, remaining $2/3^{rd}$ presence with variations from this and carries direct surgical importance.

In present study the arrangement of structures was observed to be the same as mentioned by Hollinshead except in 2% of the cases in which the common bile duct lies anterior and to the right in the actual edge of hepatoduodenal ligament. The hepatic artery lies anterior just to the left of common bile duct. The portal vein lies behind the duct and artery and to the right of duct.

Mcgreger gave the surgical importance of structures in hepatoduodenal ligament. He described it as “Pringles manoevre”. The vessels in the free border of the lesser omentum may be controlled by compression between the thumb and index finger of the left hand. This measure is an emergency procedure, which may be useful in cases of injury to one of the large vessels in the area or in hepatic injuries. It is safer for 30 minutes if blood pressure is normal.

V. Variations in ductal system:

The variations in the extra hepatic ductal system were observed under following headings.

1. Presence of accessory ducts
2. Mode of termination of accessory ducts

1. Presence of accessory ducts

Schachner (1916) studied 76 specimens in that he noted, double cystic duct in 2 cases, and absence of common bile duct in one case.

In the present study accessory cystic duct was noted in 2 specimens.

Flint (1922 –23) described about 29 (14.5%) accessory bile ducts by dissecting 200 specimens. All was accessory right hepatic ducts.

Gray (1936) stated that accessory hepatic ducts are more common from right lobe of liver.

Lurje (1937) reported by studying 194 cadavers in which 2.8% of accessory hepatic ducts are emerged from right side of liver.

Edward H.Daseler (1947) worked on 500 cases and visualized, accessory right hepatic duct in 8 cases (1.6%).

In this study, I observed 10% (5 cases) accessory hepatic ducts arising from the right side of liver. The present study coincides with that of Flint and Gray regarding the presence of accessory right hepatic duct.

2. Mode of termination of duct:

Flint (1922 –23) dissected 200 specimens. He classified 29 accessory hepatic duct on the basis of termination as:

	Flint study	**present study**
Junction occurs in upper 1/2 of common hepatic 5duct (or) in right hepatic duct- High union	4.5%	4%
Junction occurs in lower 1/2 of common hepatic duct	4.5%	4%
Junction at the union of cystic and common hepatic duct	5%	NIL

The present study coincides with the above study except in the termination at the union of cystic and common hepatic duct, but I have also noted accessory right hepatic duct draining in the middle of common hepatic in 2% of cases.

dward H.Daseler (1947) in his work on 500 cases showed.

	Daseler study	present study
accessory right hepatic duct entered common hepatic duct	0.2%	10%
accessory right hepatic duct entered cystic duct	0.6%	Nil
small accessory right hepatic duct draining into gall bladder	0.4%	Nil

On comparing the above study, it correlates with that of Edward H.Daseler study but, the occurrence is more in the present study and it disagree with the finding that accessory right hepatic duct draining into cystic duct and gall bladder.

Clinical importance:

Particularly, all the injuries to the ducts occur mostly during operation of cholecystectomy. Hence it is necessary for the surgeons to make him familiar with both the normal and variations of these parts.

VI. Variations in arterial system related to ductal system:

The two main arteries related to extrahepatic duct system are cystic artery and right hepatic artery. These are discussed under the following headings.

1) Origin of the artery
2) Relation of the artery to common hepatic duct

1a. Origin of cystic artery

E.R.Flint (1922–23) dissected 200 specimens and found the origin of cystic artery from right hepatic artery in 98% cases, from left hepatic artery in 1.5% cases and from gastro duodenal in 0.5%.

In present study, I have noticed cystic artery arising from right hepatic artery in 94%. The present study coincides with Flint's study except for the cystic artery origin from left hepatic artery and gastro duodenal artery.

Edward H. Dasler M.D., (1947) from a study of 500 specimens, classified the various origin of cystic artery into 12 types. This study coincides with my study in the following,

Type I: Cystic artery arising from right hepatic artery in 58.6%. In present study it was 94%.

Type II: Cystic artery from the proximal portion of the right hepatic artery in 13.1% cases. In present study it was 4%.

Type III: Cystic artery from an aberrant right hepatic artery derived from superior mesenteric artery in 11.9% cases. In present study it was 0%.

Type IV: Cystic artery from left hepatic artery in 6.2%, which was not noted in present study.

Type V: Cystic artery from a branch of common hepatic artery in 2.8%. In present study it was 2%.

The remaining type was not found in present study.

Type VI: Cystic artery from gastroduodenal artery in 2.6%.

Type VII: Cystic artery from a branch of celiac axis in 0.4%.

Type VIII: In 0.6% cases cystic artery derived from a replacing or from an accessory type of hepatic artery.

Type IX: Long slender cystic artery derived from first portion of superior mesenteric artery in 0.2%.

Type X: Cystic artery arising from superior pancreaticoduodenal artery (0.2 %).

Type XI: cystic artery originated as a direct branch from aorta (0%).

Type XII: cystic artery arising branch of right gastroepiploic artery (0%).

Hollinshead (1954) also described that cystic artery arises from right hepatic artery. He also added it may also arise from left hepatic artery and common hepatic artery. In latest edition of Gray's anatomy (2005) it's mentioned that cystic artery arising from right hepatic artery. He also stated that cystic artery may arise sometimes from common hepatic artery, left hepatic artery and gastro duodenal artery.

On comparing all the study including the present study, cystic artery arising from right hepatic artery is noted to be the commonest one. In the present study, cystic artery arising from the right hepatic artery is noted in 94% specimens.

b. Accessory cystic artery:

Edward H. Dasler M.D., (1947) from a study of 580 lab specimens noted 65 specimens of accessory cystic artery. In this, in 76.9% cases it arises from right hepatic artery, 6.15% cases from common hepatic artery and 3% cases from accessory right hepatic branch of superior mesenteric artery.

Gray’s anatomy (2005) also mentioned that accessory cystic artery from common hepatic artery.

In present study, I observed accessory cystic artery arising from common hepatic artery. I have not noted other origins of accessory cystic artery as mentioned by above references.

c. Double cystic artery:

The presence of double cystic artery was observed in one specimen. Flint (1922 – 23) noted 15%; Edward H. Dasler noted 14% in their study. The occurrence of double cystic artery was found to be less in incidence when compared to the other workers in the present study.

d. Origin of right hepatic artery:

Flint (1922 – 23) from his work on 200 specimens showed, right hepatic artery arising from

	Flint study	Present study
main right hepatic artery	79%	100%
from the superior mesenteric artery	21%	0%
presence of 2 right hepatic arteries one from hepatic proper and other from superior mesenteric artery	3.5%	0%

Edward H. Dasler (1947) dissected 500 specimens and reported, right hepatic artery arising from hepatic artery proper in 83.2%.

Hence on comparing all above studies including the present study, I observed right hepatic artery arising from hepatic proper is the commonest one.

2. Relationship of arteries to common hepatic duct :

a. Cystic artery in relation to common hepatic duct:

Eisendrath (1918) studied in 100 specimens. He described cystic artery passing dorsal to common hepatic duct was 73% and ventral to common hepatic duct was 27%.

Flint (1922 – 23) dissected 200 specimens and stated, cystic artery passing dorsal to common hepatic duct 84% and cystic artery passing venral to common hepatic duct was 16%.

In present study cystic artery passing dorsal to common hepatic duct was 94% and cystic artery passing ventral to common hepatic duct was 6%. In all studies artery passing dorsal to common hepatic duct is found to be high in number.

Gray’s anatomy (2005) also mentioned that cystic artery can either passes anterior or posterior to common hepatic duct.

b. Right hepatic artery in relationship to common hepatic duct :

Flint (1922 – 23) dissected 200 specimens and stated, that right hepatic artery passing posterior to common hepatic duct 68% and right hepatic artery passing anterior to common hepatic duct was 12.5%.

Nicholas A. Michels (1951) estimated statistically in 200 bodies and mentioned that right hepatic artery passing posterior to common hepatic duct 88% and right hepatic artery passing anterior to common hepatic duct was 12%.

In the present study right hepatic artery passing posterior to common hepatic duct was 98% and right hepatic artery passing anterior to common hepatic duct was 2%. On comparing the above studies, the posterior relationship of right hepatic artery to the common hepatic duct is found to be more in occurrence. Hence present study coincides with Flint and Nicholas in this aspect.

Surgical importance

The degree of variations in the vascular pattern encountered in this area is of vital importance. The increasing number of operations performed for obstructive jaundice and biliary fistula calls for a more detailed knowledge of the blood vessels in gastro hepatic region. Hence identifications of major structures in this area before surgery is attempted.

The course of cystic artery is so variable and the occurrence of double cystic artery, aberrant cystic artery replacing cystic arteries is so common hence careful ligations of the artery are essential. The more frequent damage is that ligation of cystic duct and cystic artery in a single tie leading to severe hemorrhage and necrosis.

Jackson (1938) stated that the major cause of injury to the duct is hemorrhage from a divided cystic artery or anomalous arterial stump. The frequency in which the right hepatic artery lies in close approximation to the cystic duct is particularly vulnerable to injury during cholecystectomy. Injuries may result in troublesome hemorrhage and subsequent injury to common bile ducts or even in advertent ligation of right hepatic artery, common hepatic artery resulting in hepatic infarction and necrosis.

Moreover the vessels passing anterior to the duct are more important because bile ducts may be injured in efforts to stop hemorrhage from these vessels since they are more prone to include in the clamp along with the ducts, which leads to severe hemorrhage.

VII. Calot's triangle

Moosman (1948), elaborated the area originally described by calot and now defined as "Moosman's area" in which the following structure lie namely, cystic artery 90%, right hepatic artery 82%, accessory right hepatic artery 95% and 23 accessory bile ducts in 91%.

Stremple (1986) estimated that 85% of all variations in the hepatic pedicle are found in this area and 50% of these variations are a potential hazard during cholecystectomy.

In the anatomical basis of clinical practice (2005), it is mentioned that the near triangular space formed between the cystic duct, common hepatic duct and inferior surface of segment V of liver is commonly referred to as calot's triangle. This space usually contains cystic artery, one or two cystic veins. He also added that it might contain any accessory ducts, which drain into the gall bladder from liver.

In the present study the boundaries of calot's triangle was normal in 49 (98 %) specimens and in one specimen the boundaries altered as cystic duct on the left side, common hepatic duct on the right side and hilum of liver above without situs inversus. Moreover in present study, in 90% of cases cystic artery and right hepatic artery are the two main contents, in 10% of cases accessory hepatic ducts were noted in addition to its normal content.

The present study was supported by Gray's anatomy in the presence of accessory bile ducts.

Nicholas (1951) mentioned about double cystic artery with in the calot's triangle in 14.5% of cases in a total of 2.5% of double cystic artery.

In present study, I noted 2% of cases of double cystic artery, which agrees with Nichole's study though less in occurrence.

Clinical importance:

To avoid misidentification of ducts, identification of cystic duct, cystic artery and the structures to be divided in cholecystectomy both open or laproscopic cholecystectomy, calot's triangle must be dissected and studied. Moreover, failure to define the normal anatomy and difficult to dissect the calot's triangle results in increase incidence of iatrogenic injury to biliary and portal structures. Biliary leak after cholecystectomy can be avoided by revisiting the biliary anatomy and structures in calot's triangle.

CONCLUSION

- After studying 50 specimens' of extrahepatic biliary apparatus, I have come to the following conclusion as follows.
- A single gall bladder, extra hepatic, lodged in the fossa for the gall bladder, covered with peritoneum only on the posterior surface, with rugae in the interior was observed, in all the cases. Supernumerary gall bladder, intra hepatic gallbladder, left sided gall bladder, floating gall bladder, diverticula of gall bladder, phyrgian cap and septate gall bladder, although occasionally reported earlier was not noted in present study.
- Hartman's pouch was found in 4% in this study as a variation in the shape.
- Extrahepatic union of right and left hepatic ducts to form the common hepatic duct was noted in 64% of cases, which appeared to be more common than intrahepatic union.
- Cystic duct joins the common hepatic duct as an angular type in 80% cases.
- Cystic duct joins the common hepatic duct at a point in which it makes common hepatic duct shorter and common bile duct longer. This is consider as normal level of union.
- The average length of the ducts observed in the study are cystic duct 2 to 4 cms, common hepatic duct 1.5 to 3.5 cms and common bile duct 5.5 to 8 cms.

- ❖ The arrangement of structures in hepatoduodenal ligament was that, common bile duct lies anterior and to the right of the ligament, hepatic artery lies anterior and to the left of duct system and portal vein larger and posterior to these structures.
- ❖ The frequency of occurrence of accessory ducts was 14%.
- ❖ The most commonly occurring ductal variations are presence of accessory right hepatic ducts terminating anywhere in common hepatic duct.
- ❖ Cystic artery arising from the right hepatic artery is seen inside the calot's triangle dividing into superficial and deep branches to supply the respective surfaces of gall bladder is noted to be the commonest arrangement.
- ❖ Right hepatic artery arises from hepatic proper and seen to the left side of duct system.
- ❖ Both cystic and right hepatic arteries passing posterior to the common hepatic duct to reach the calot's triangle is seen to be more common.

Hence many variations have found in this study, I believe the understanding of these variations is important not only for the anatomists, but definitely useful for operating surgeons and radiologist.

CHART - 1

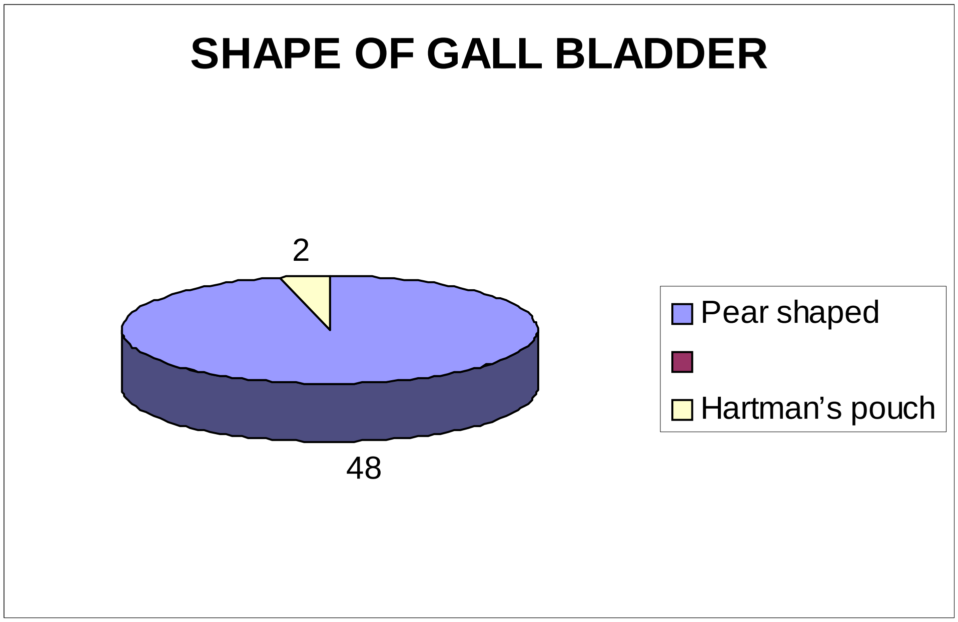


CHART –2

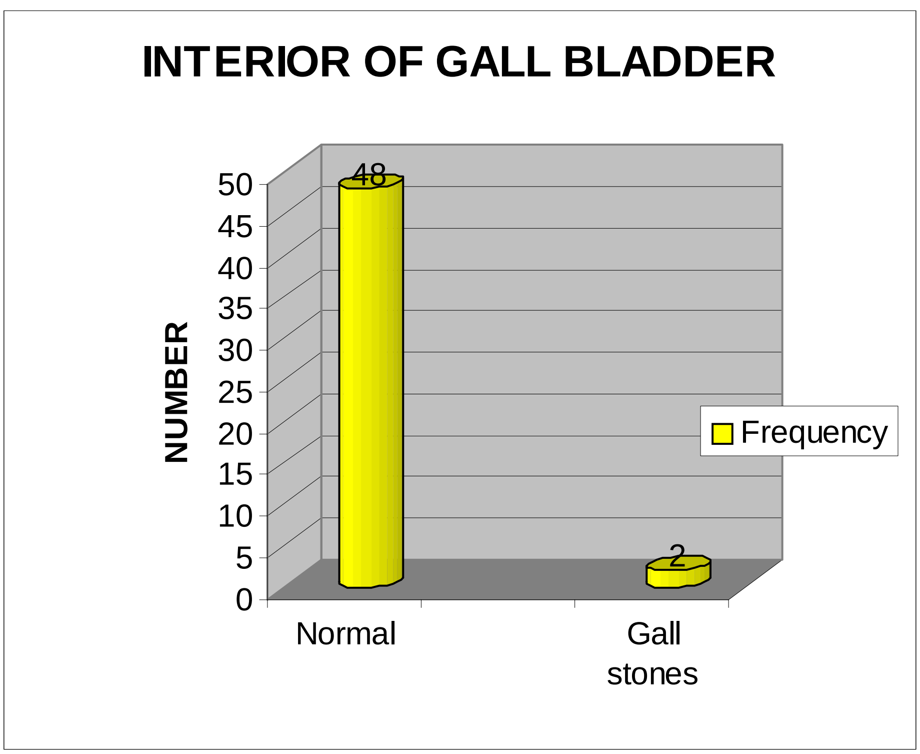
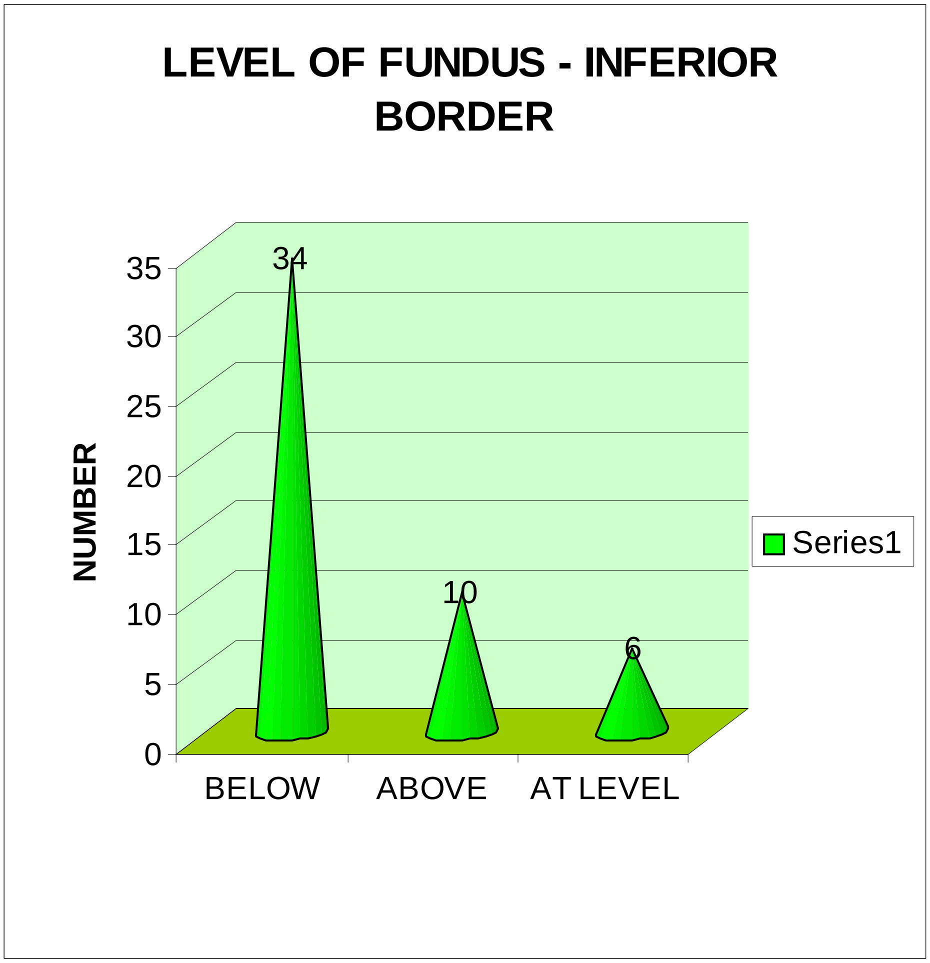


CHART – 5



LEVEL OF FUNDUS - INFERIOR BORDER
NUMBER
35
30
25
20
15
10
5
0
34
10
6
BELOW
ABOVE
AT LEVEL
Series1

CHART – 3

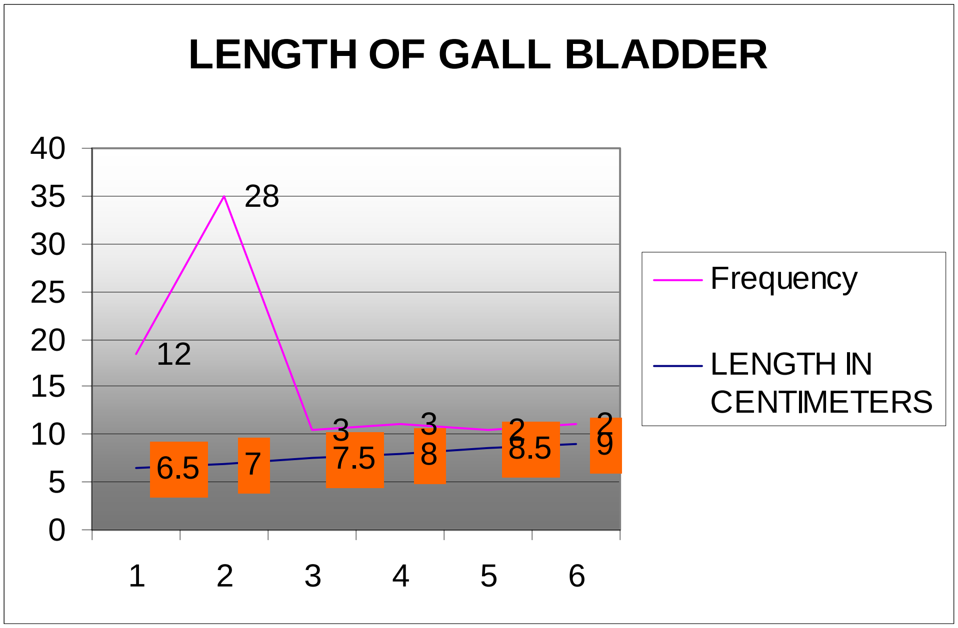


CHART – 4

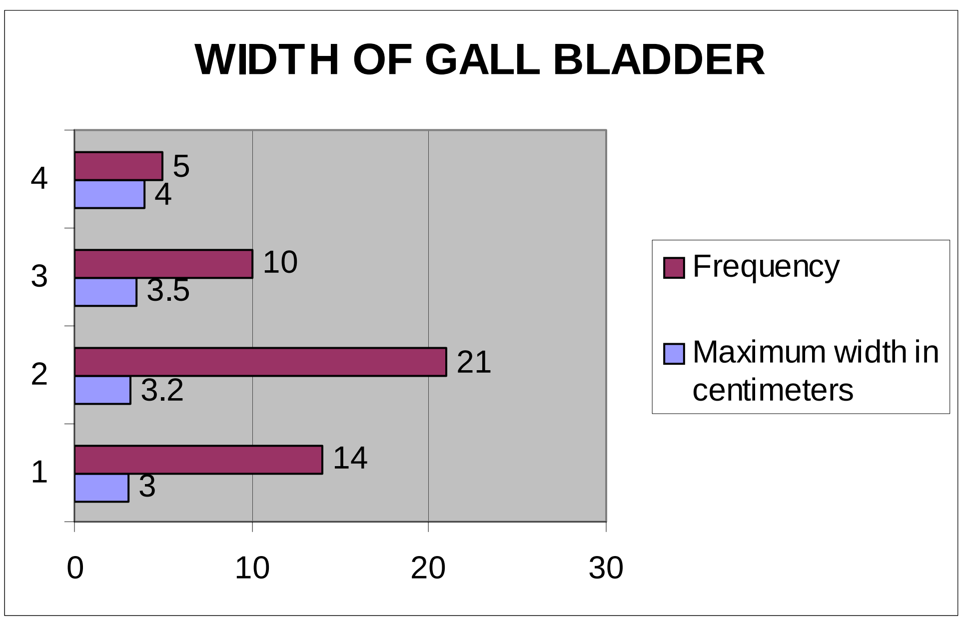


CHART – 6

Cystic Duct Length

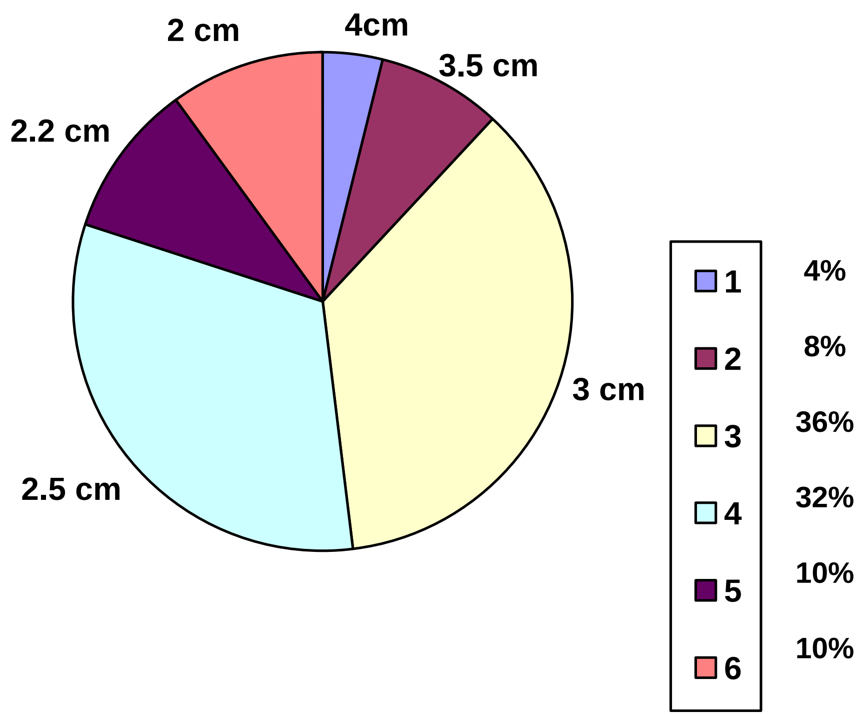
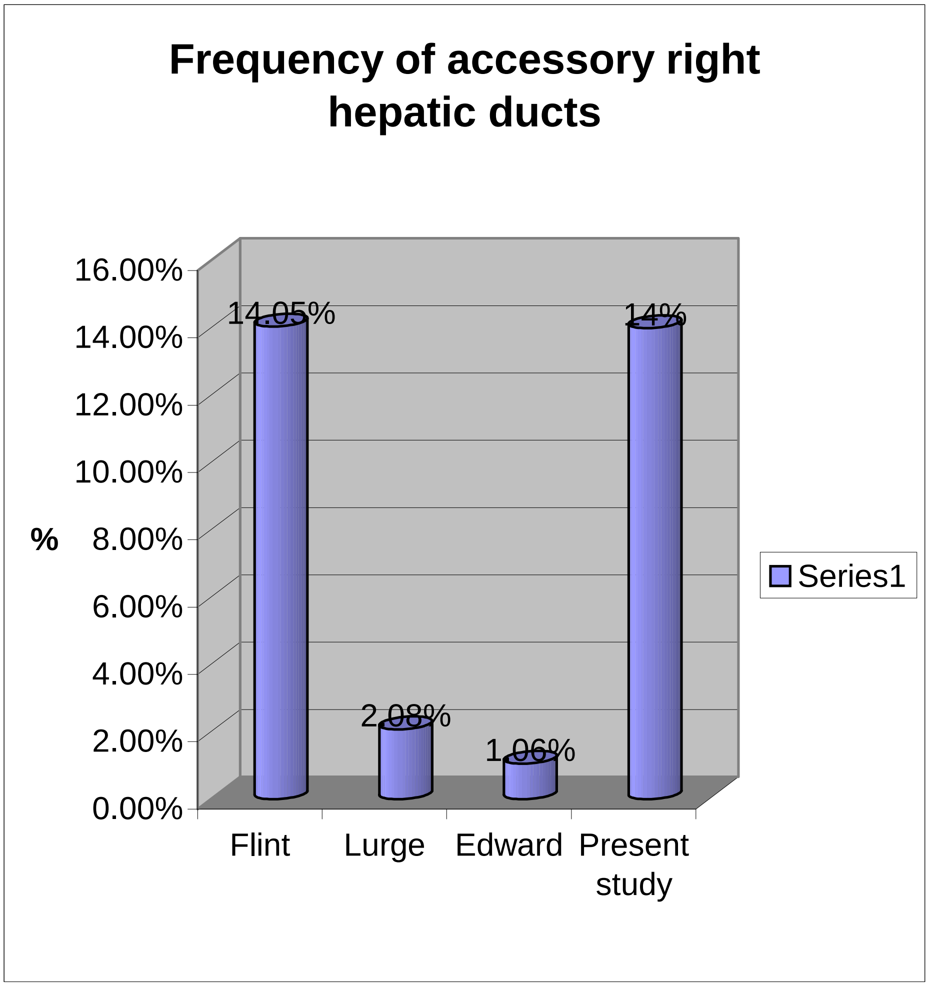
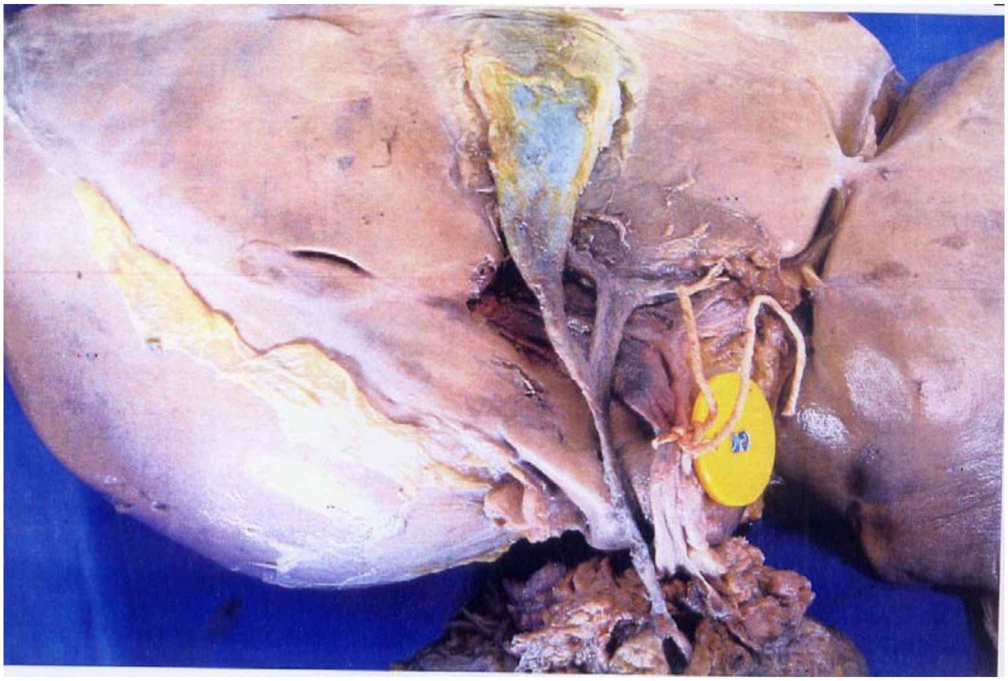


CHART – 7

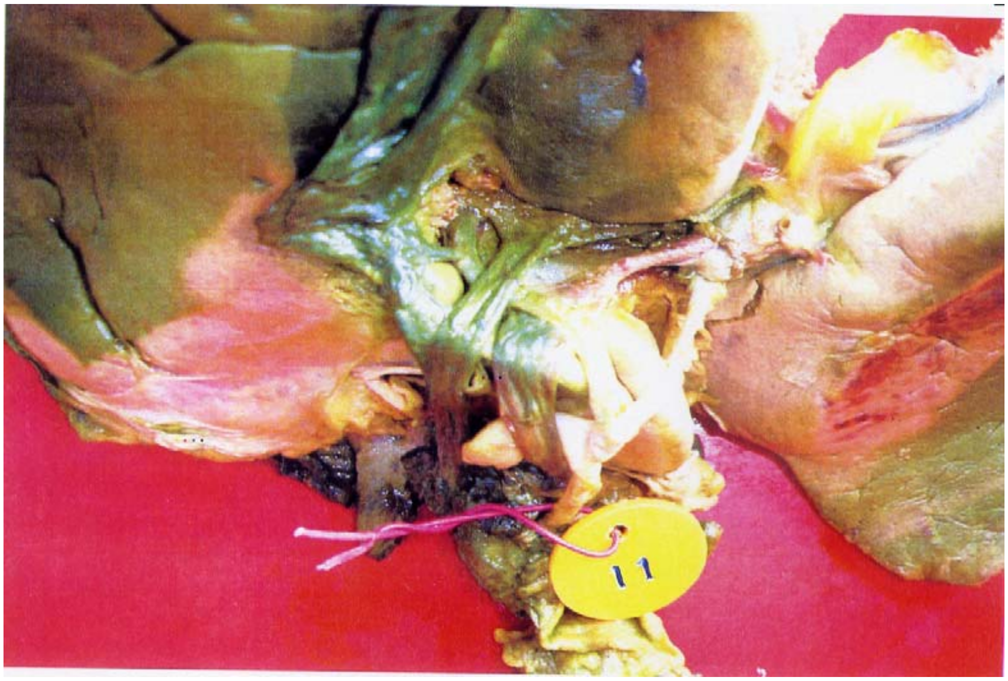


Frequency of accessory right hepatic ducts
16.00%
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
%
14.05%
2.08%
1.06%
14%
Flint
Lurge
Edward
Present study
Series1



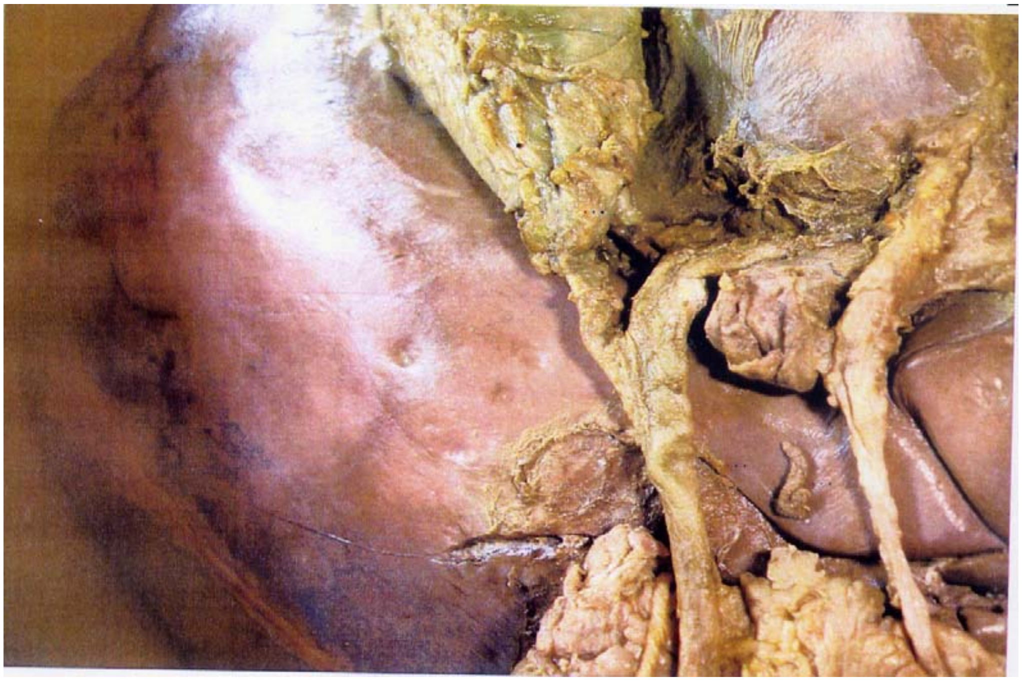
Pic.6: Extrahepatic union of right and left hepatic ducts

Pic. 7: Intrahepatic union of right and left hepatic ducts with an accessory cystic duct



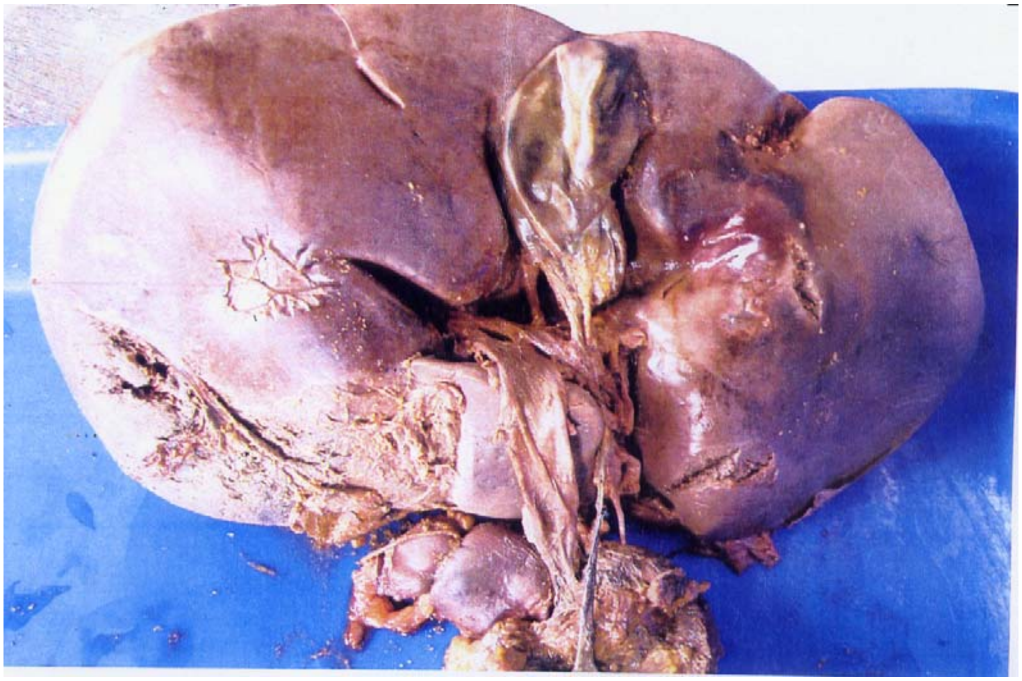
Pic. 8 : Angular type

Pic. 9 : Parallel type of union of cystic duct with common hepatic duct with an aberrant replacing cystic artery

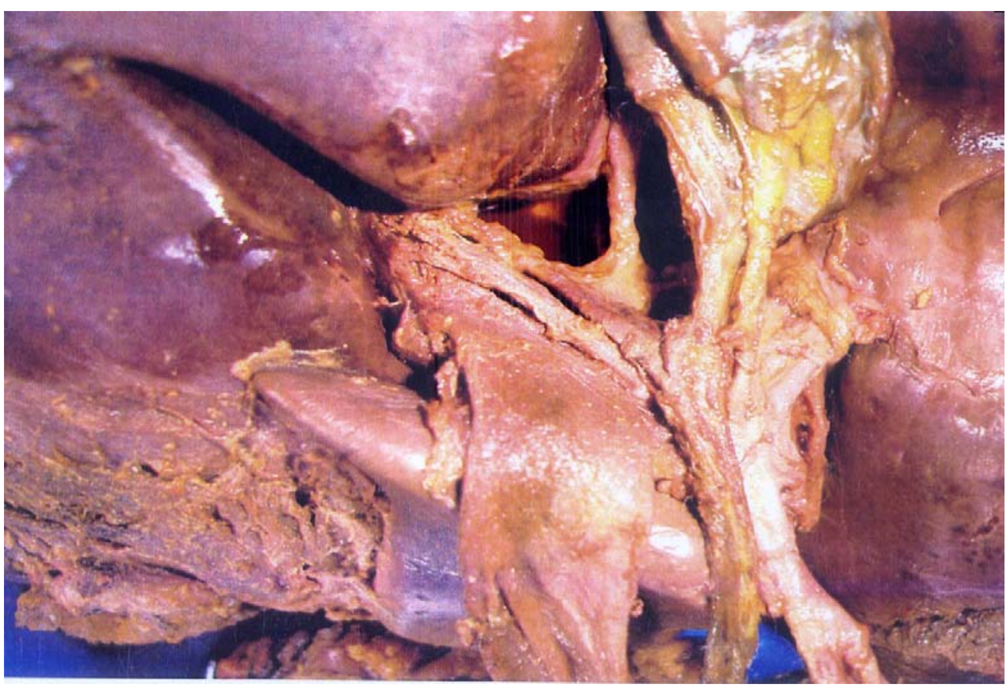


Pic. 10 : High level of union

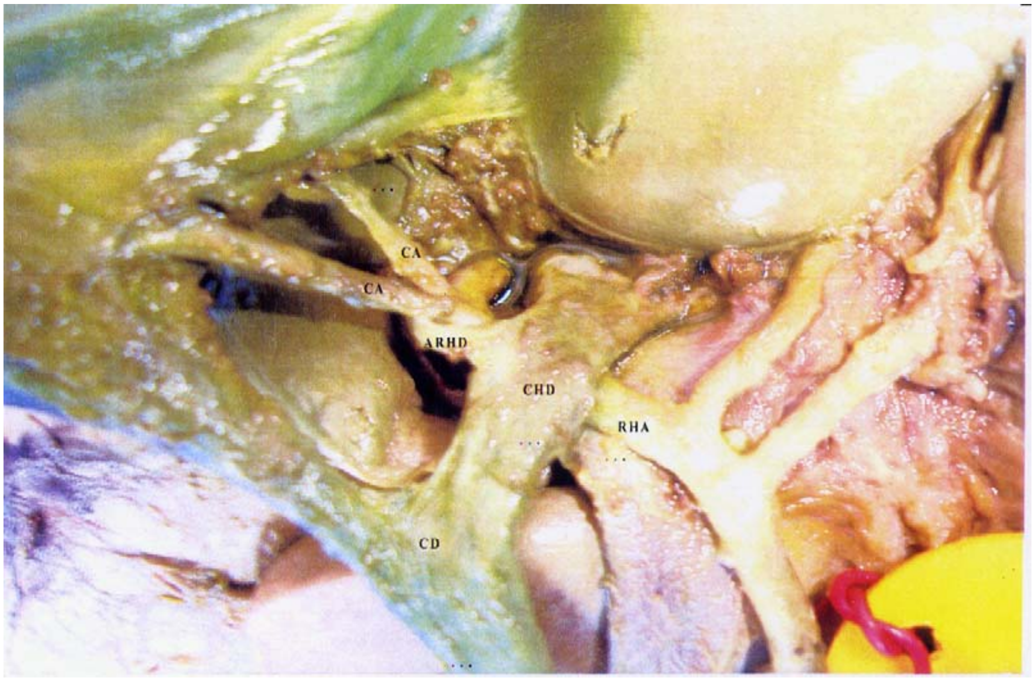
Pic. 12 : Accessory right hepatic duct



Pic. 11: Variations in hepatoduodenal ligament



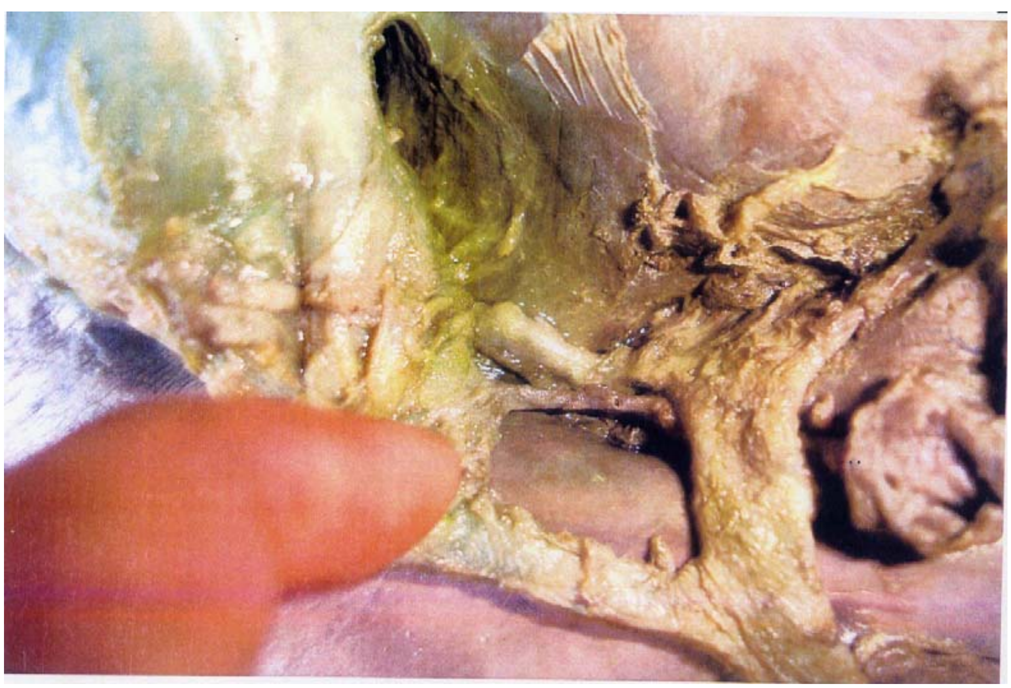
Pic. 11a : Variations in hepatoduodenal ligament



Pic.13: Accessory right hepatic duct

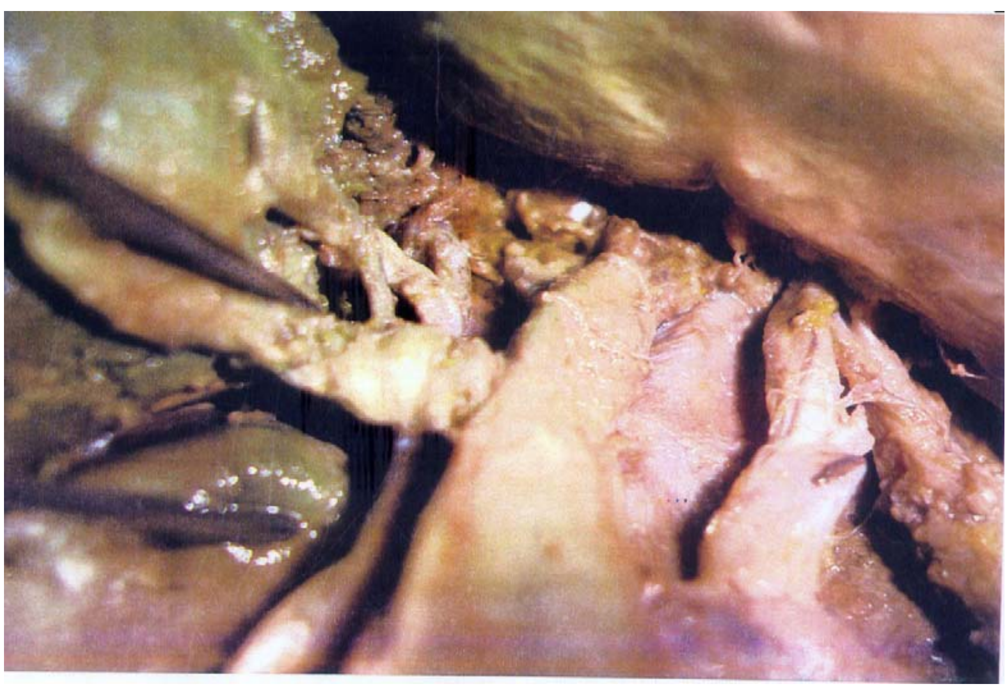
Pic. 14: Accessory right hepatic duct with and accessory cystic artery

Pic. 15: Accessory right hepatic duct



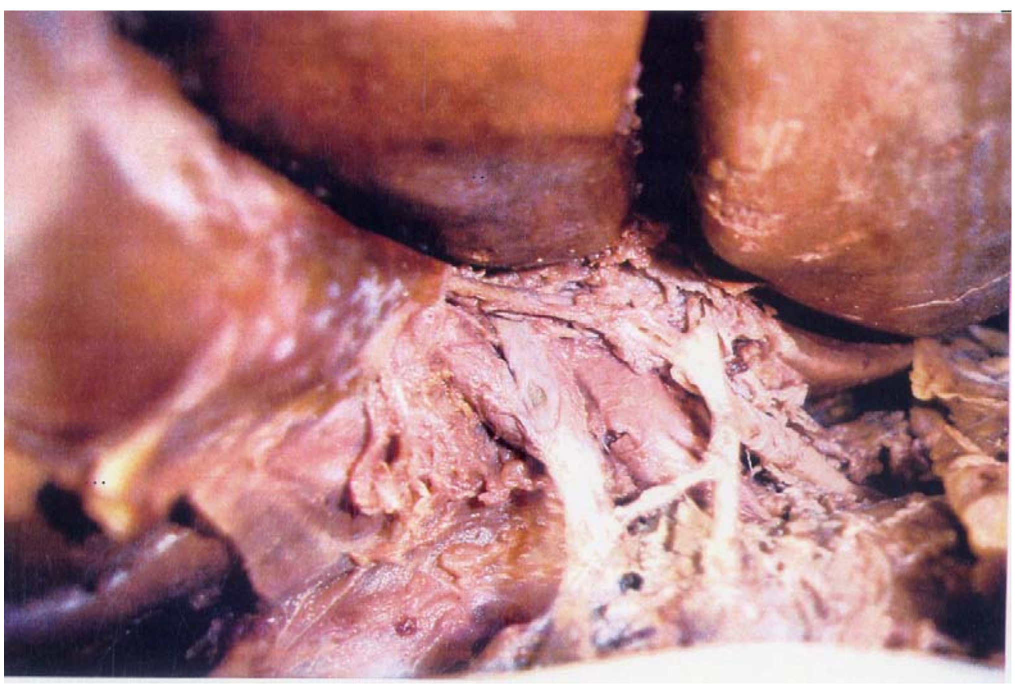
Pic. 16: Accessory right hepatic duct

Pic. 19: Accessory cystic duct



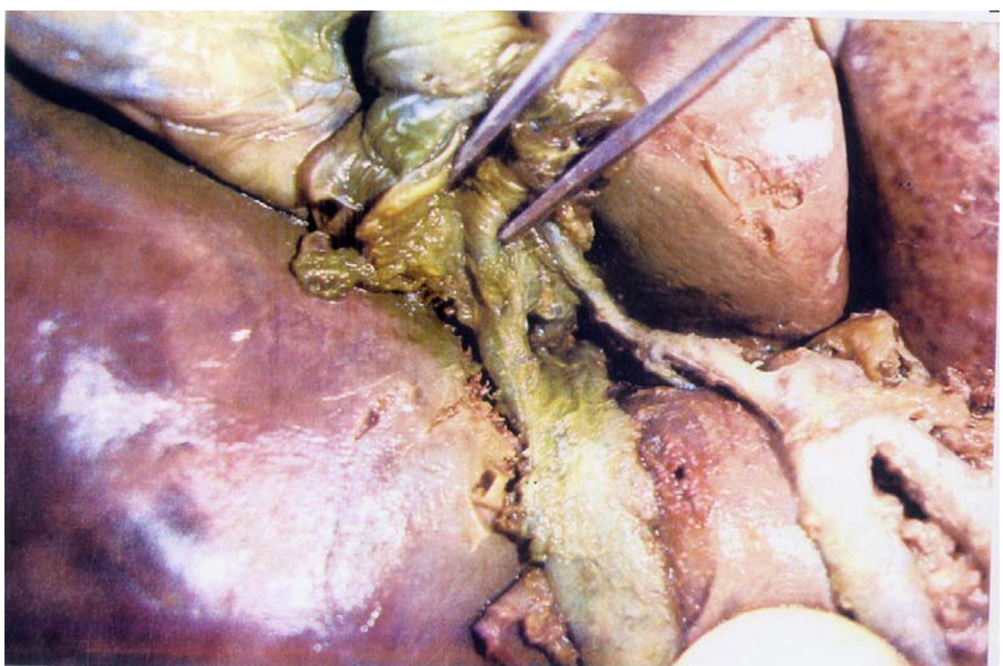
Pic. 19a : Same specimen with aberrant replacing cystic artery

Pic. 20: Double cystic artery



Pic. 21: Cystic artery passing ventral to common hepatic duct

Pic. 22: Cystic artery passing ventral to common hepatic duct



Pic. 23: High division of cystic and right hepatic artery also showing cystic artery passing ventral to common hepatic duct

Pic . 24 : Accessory cystic duct

Pic . 25 : Cystic artery ventral to common hepatic duct

Pic . 17 : High level of union

Pic . 18 : Low level of union

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Gall bladder | Cystic duct | Common Hepatic duct | Common Bile duct

Specimen No.	Status (P/A)	Position (N/O)	Mesentry (P/A)	Shape (N/O)	*Fundus*		Neck (N/O)	*Interior*			*Dimensions (in cms)*			*Cystic Duct*			*Common Hepatic duct*			Content of Calot's triangle (N/O)	*Common Bile duct*	
					N/O	*Distance from inferior border of liver in cms*		*Mucosa Normal/ Ironed out*	*Stones*	*Divert P/A*	*Length*	*Width in the middle*	*Max. width*	*Num ber*	*Length (cms)*	*Mode of termination (N/O)*	*Num ber*	*Length*	*Accesso ry right hepatic duct*		*Num ber*	*Length (cms)*
1.	P	N	A	N	N	B	N	N	A	A	7	2.5	3.5	ONE	4	N	ONE	3	A	N	ONE	7
2.	P	N	A	N	N	B	N	N	A	A	7	2.5	3	ONE	2.5	N	ONE	3	P	N	ONE	6.5
3.	P	N	A	N	N	B	N	N	A	A	6.5	2.5	3.2	ONE	3	N	ONE	2.8	P	N	ONE	6.5
4.	P	N	A	N	N	A	N	N	A	A	6.5	2.5	3.2	ONE	3.5	N	ONE	2.5	A	V	ONE	7.5
5.	P	N	A	N	N	B	N	N	A	A	7	2.5	3.2	ONE	3	N	ONE	2.5	A	N	ONE	7.5
6.	P	N	A	N	N	B	N	N	A	A	7	2.5	4	ONE	2.5	N	ONE	3	A	N	ONE	7
7.	P	N	A	N	N	B	N	N	A	A	6.5	2	3.5	ONE	2.2	N	ONE	2.5	A	N	ONE	7.5
8.	P	N	A	N	N	L	N	N	A	A	75	2	3	ONE	3	N	ONE	3	A	V	ONE	7.5
9.	P	N	A	N	N	B	N	N	A	A	7	2	3.2	ONE	3.5	N	ONE	2.5	A	N	ONE	6
10.	P	N	A	H	N	A	H	N	P	A	7	2	3.2	TWO	3	N	ONE	2	P	N	ONE	7.5
11.	P	N	A	N	N	B	N	N	A	A	8	2.5	3	ONE	2.5	N	ONE	3.5	A	N	ONE	7
12.	P	N	A	N	N	A	N	N	A	A	7	2	3.5	TWO	3	N	ONE	3.5	A	N	ONE	6
13.	P	N	A	N	N	B	N	N	A	A	7	2	3	ONE	2.2	H	ONE	2	A	N	ONE	8
14.	P	N	A	N	N	L	N	N	A	A	6.5	2	3.2	ONE	2.5	N	ONE	2.5	A	N	ONE	6.5
15	P	N	A	N	N	B	N	N	A	A	7	2.5	3	ONE	3	N	ONE	3	A	N	ONE	7.5
16.	P	N	A	N	N	A	N	N	A	A	7	2.0	3.2	ONE	3	N	ONE	2	A	N	ONE	7
17.	P	N	A	N	N	B	N	N	A	A	7	2	4	ONE	2	N	ONE	2	A	N	ONE	7.5
18.	P	N	A	N	N	B	N	N	A	A	7	2.5	3.5	ONE	2.5	N	ONE	2.5	A	N	ONE	6.5
19.	P	N	A	N	N	A	N	N	A	A	9	2.5	3	ONE	2	N	ONE	2.5	A	N	ONE	7
20.	P	N	A	N	N	B	N	N	A	A	7	2	3.2	ONE	2.5	N	ONE	2.5	P	N	ONE	7.5
21.	P	N	A	N	N	B	N	N	A	A	7	2.5	3.2	ONE	2.3	N	ONE	2	A	N	ONE	7.5
22.	P	N	A	N	N	L	N	N	A	A	7	2.5	3	ONE	2.4	H	ONE	2	A	V	ONE	8

Gall bladder **Cystic duct** **Common Hepatic duct** **Common Bile duct**

Specimen No.	Status (P/A)	Position (N/O)	Mesentry (P/A)	Shape (N/O)	*Fundus*		Neck (N/O)	*Interior*			*Dimensions (in cms)*			*Cystic Duct*			*Common Hepatic duct*			Content of Calot's triangle (N/O)	*Common Bile duct*	
					N/O	Distance from inferior border of liver in cms		Mucosa Normal/ Ironed out	Stones	Divert P/A	Length	Width in the middle	Max. width	Num ber	Length (cms)	Mode of termination (N/O)	Num ber	Length	Accesso ry right hepatic duct		Num ber	Length (cms)
23	P	N	A	N	N	B	N	N	A	A	6.5	2.5	3.5	ONE	4	H	ONE	1.5	A	N	ONE	8
24	P	N	A	N	N	B	N	N	A	A	6.5	2.5	3.5	ONE	2.5	L	ONE	3.5	A	N	ONE	5.5
25	P	N	A	N	N	A	N	N	A	A	7	2	3	TWO	3	N	ONE	2	A	N	ONE	7.5
26	P	N	A	N	N	B	N	N	A	A	7	2	3.5	ONE	3.5	N	ONE	3	A	N	ONE	7
27	P	N	A	N	N	A	N	N	A	A	6.5	2	4	ONE	3	N	ONE	2.5	A	N	ONE	6.5
28	P	N	A	N	N	B	N	N	A	A	75	2.5	3.5	ONE	2.	H	ONE	2.5	A	N	ONE	8
29	P	N	A	N	N	B	N	N	A	A	7	2	3	TWO	2.2	N	ONE	2	A	N	ONE	6
30	P	N	A	N	N	L	N	N	A	A	7	2.5	3	ONE	3	N	ONE	3	A	N	ONE	6.5
31	P	N	A	N	N	A	N	N	A	A	8	2.5	3.2	ONE	3.5	N	ONE	2.5	A	N	ONE	7
32	P	N	A	N	N	B	N	N	A	A	7	2.5	3.2	ONE	3	N	ONE	3	A	N	ONE	7.5
33	P	N	A	N	N	B	N	N	A	A	7	2.5	3.5	ONE	2.5	N	ONE	2	A	N	ONE	7.5
34	P	N	A	N	N	B	N	N	A	A	6.5	2	3	ONE	3	N	ONE	2	A	N	ONE	6
35	P	N	A	N	N	B	N	N	A	A	7	2	3.2	ONE	2.8	H	ONE	1.5	A	V	ONE	8
36	P	N	A	N	N	B	N	N	A	A	7	2	3.2	ONE	2.5	N	ONE	2	A	N	ONE	6.5
37	P	N	A	N	N	B	N	N	A	A	7	2.5	3.2	ONE	3	N	ONE	2.5	A	N	ONE	7
38	P	N	A	N	N	B	N	N	A	A	7	2	3.2	ONE	3	H	ONE	2	A	N	ONE	8
39	P	N	A	N	N	B	N	N	A	A	8.5	2.5	3	ONE	2	H	ONE	2	A	V	ONE	8.5
40	P	N	A	N	N	B	N	N	A	A	6.5	2.5	3.2	ONE	2.5	N	ONE	2	P	N	ONE	7.5
41	P	N	A	N	N	L	N	N	A	A	7	2.5	3.2	ONE	2	N	ONE	3.	A	N	ONE	7.5
42	P	N	A	N	N	B	N	N	A	A	7	2	3	ONE	2.5	N	ONE	3	A	N	ONE	7.5
43	P	N	A	N	N	A	N	N	A	A	8.5	2.5	3.5	ONE	3	N	ONE	2	A	N	ONE	7
44	P	N	A	N	N	B	N	N	A	A	7	3	3.2	ONE	2.8	N	ONE	3	A	N	ONE	6

Gall bladder															Cystic duct			Common Hepatic duct				Common Bile duct	
					Fundus			***Interior***			***Dimensions (in cms)***				***Cystic Duct***			***Common Hepatic duct***				***Common Bile duct***	
Specimen No.	***Status (P/A)***	***Position (N/O)***	***Mesentry (P/A)***	***Shape (N/O)***	***N/O***	***Distance from inferior border of liver in cms***	***Neck (N/O)***	***Mucosa Normal/ Ironed out***	***Stones***	***Divert P/A***	***Length***	***Width in the middle***	***Max. width***	***Num ber***	***Length (cms)***	***Mode of termination (N/O)***	***Num ber***	***Length***	***Accesso ry right hepatic duct***	***Content of Calot's triangle (N/O)***	***Num ber***	***Length (cms)***
45	P	N	A	N	N	L	N	N	A	A	6.5	2.5	3.3	ONE	2.5	N	ONE	2.5	A	N	ONE	7.5
46	P	N	A	H	N	B	H	N	2	A	6.5	2.5	3	ONE	2.2	H	ONE	1.5	A	N	ONE	8
47	P	N	A	N	N	A	N	N	A	A	7	2.8	3.5	ONE	2.5	N	ONE	2	A	N	ONE	7
48	P	N	A	N	N	B	N	N	A	A	7.5	3	3	ONE	2.8	N	ONE	2.5	A	N	ONE	7.5
49	P	N	A	N	N	A	N	N	A	A	8	2	3.2	ONE	3	N	ONE	2.8	A	N	ONE	7
50	P	N	A	N	N	B	N	N	A	A	7.5	2.5	3	ONE	2.5	N	ONE	3	A	N	ONE	7.5

Key to master chart

P – Present

Fundus A – Above the level B – Below the level L – At the level

A – Absent

N – Normal

Mode of termination N – Normal union H – High union L – Low union

H – Hartman's pouch