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Anatomical Variations of Extrahepatic Biliary System

Lutfi G. Awazli *DGS, HDLM, FICMS*

Laser Institute for Postgraduate Studies, University of Baghdad, Baghdad, Iraq

Abstract

Background Variations in the anatomy of gallbladder, bile ducts and the arteries that supply them are important to the surgeon during cholecystectomy, because failure to recognize them may lead to inadvertent iatrogenic injuries.

Objective To evaluate the type and frequency of anatomical variations of extra hepatic biliary system encountered during cholecystectomy.

Methods One hundred and fifty patients with gallstones underwent cholecystectomy at Baghdad Teaching Hospital. There comprised 112 females and 38 males with age range between 20-80 years. Open (33 cases) and laparoscopic (117 cases) cholecystectomies were done. Extra hepatic biliary tree was carefully dissected to study the variations in the anatomy of the gallbladder, bile ducts, and the arteries that supply them.

Results There were only three important vascular and four important ductal anomalies while gallbladder anomalies were rare. The total numbers of the extrahepatic biliary anomalies were 81 cases (incidence 54%), and included vascular anomalies (60 cases = 40%); ductal anomalies (18 cases = 12%); gallbladder anomalies (3 cases = 2%); mostly occurred as Phrygian cap (2 cases = 1.3%). The higher incidence of anatomical abnormalities was found in females 80% (65 cases) while in males 20% (16 cases).

Conclusion Anomalies of the vascular and ductal components of the extra hepatic biliary tree are relatively common (the former occurring much more frequently than the latter). Failure to recognize them during biliary surgery leads to iatrogenic injuries and can increase morbidity and mortality.

Key Words Extra hepatic biliary tract; biliary anomalies, cholecystectomy.

Introduction

The biliary tract is the site of great variation and even gross anomalies and their clinical significance is variable [1,2]. These anomalies can represent a major challenge especially to unprepared and unaware surgeons for failure to recognize them at operation may lead to disaster [3,4].

The anatomy of the biliary system has been the subject of extended research for many years largely because of their surgical importance in cholecystectomy, and interest has been centered on the extrahepatic biliary tree because it is frequently abnormal [5]. Many studies have attempted to determine a standard length, diameter, and thickness of various portions of the ductal system but significant normal variability in duct size and length may be encountered [6].

There is a wide difference of opinion which still exists regarding basic detail of extrahepatic biliary anatomy, and it is pertinent at this point to consider why these discrepancies occur, there are probably a number of reasons [5]:

1. It is not possible to compare the results derived from different methods (e.g. radiological and dissection) [5].
2. One cannot necessarily expect, using the same investigative technique to produce identical measurements and observation on different basic materials (i.e., cadaver and operative specimens) [5].
3. The operative field allows less scope for the dissection of the anatomical details which are best demonstrated on resin-cast material [5].
4. Various radiological techniques, i.e., intravenous cholangiography, per-operative cholangiography, post-operative T-tube cholangiography, ERCP (Endoscopic retrograde cholangio-pancreatograghy), PTC (Percutaneous transhepatic cholangiograghy), do not necessarily produces exactly the same measurable results in the same patient [4].

Many studies reported that the incidence of biliary anomalies varies from 15 to 66 percent [1,3,5,7-11]. This study aims at describing some anatomical variations of the extra hepatic biliary system that face the surgeon during cholecystectomy and determine the type and frequency of each anomaly.

Methods

This is an observational study of one hundred and fifty consecutive patients with calculi of the biliary system operated on as elective cholecystectomies, all of them done in Baghdad Teaching Hospital for a period of one year (from 1st October 1999 to 1st October 2000). There were 112 females and 38 males, with age range of 20-80 years and a mean age of 46 years. In general, the clinical presentation of patients was attacks of upper abdominal pain, vomiting, with or without jaundice. Preoperative investigations included abdominal ultrasound and liver function tests, which indicate the presence of gallstones or bile duct stones. Operative technique included laparoscopic method (117 cases = 78%) while conventional open method (33 cases = 22%) with or without common bile duct (CBD) exploration, 24 cases (16%) by right subcostal, and 9 cases (6%) by right paramedian incision.

At the time of operation, a detailed sketch was made by the surgeon, by elevation of the anterior margin of the right lobe of the liver with retraction of the stomach, duodenum, and colon to expose the gallbladder (GB), then by careful blunt dissection of the hepatoduodenal ligament and the Calot’s triangle which is necessary in order to identify the structures in or around this region and avoid any accidental injury to the extrahepatic biliary ducts and blood vessels, and also to show the main anatomical features, and in particular the relations of the common hepatic, common bile, and cystic ducts, and the course and relations of the right hepatic and cystic arteries, and also to determine the type and frequency of each anomaly and its surgical significance.

Results

The total series of 150 cholecystectomies have been done in this study, included 112 females (74.7%) and 38 males (25.3%) with a peak incidence in the fifth decade of life and a mean age of 46 years, as shown in (Table 1).

Table 1. Age and Sex distribution

Age (Yr.)	20-29	30-39	40-49	50-59	60-69	70-80	Total (%)
Male	2	5	12	8	6	5	38 (25.3)
Female	7	22	36	23	18	6	112 (74.7)
Total	9	27	48	31	24	11	150 (100)

*Female: Male ratio = (112/38) = 3:1

The total number of extrahepatic biliary anomalies were 81 out of 150 cases (incidence 54%), and these divided into vascular (40%), ductal (12%), and GB anomalies (2%), (Table2).

Vascular anomalies

The incidence of vascular anomaly is high (40%), The commonest was the accessory cystic artery (18%), though not much less common is the anterior transposition of the cystic artery, or the right hepatic artery (16%), while the incidence of the caterpillar hump right hepatic artery was much less (6%).

Ductal anomalies

The incidence of ductal anomalies was much less than that of arterial anomalies (18 cases = 12%), The commonest is a long cystic duct with or without low fusion with common hepatic duct (CHD) occurring in 8 cases (5.3%), while other ductal anomalies like short cystic duct, high fusion of cystic duct with CHD or right hepatic duct (RHD), and accessory hepatic ducts were found in (3 cases = 2%), (3 cases = 2%), and (4 cases = 2.7%) of patients respectively.

Regarding the accessory hepatic ducts, all of them arose from the right lobe of the liver and drained either into the neck of GB (one case) or the CHD (3 cases). The length and diameter of these ducts were extremely variable.

Gallbladder anomalies

In this study, there were only three cases (2%), and these included Phrygian cap (2 cases), and the other interesting case which is not reported in textbooks or other studies, in this case the GB fundus passed through the liver substances from the inferior (visceral) surface to protrude out at the anterior surface, making a hole in the liver (Table 2).

Table 2. Extrahepatic biliary anomalies in cholecystectomies and its several subtypes

Anomalies		No. (%)	Total
Vascular anomalies	Accessory cystic artery Anterior cystic artery or anterior right hepatic artery Caterpillar hump right hepatic artery	27 (18) 24 (16) 9 (6)	60 (40)
Ductal anomalies	Long cystic duct Short cystic duct High fusion of cystic duct with common hepatic duct Accessory hepatic ducts	8 (5.3) 3 (2) 3 (2) 4 (2.7)	18 (12)
Gallbladder anomalies	Phrygian cap Gall bladder fundus pass through the liver	2 (1.3) 1 (0.7)	3 (2)
Total		81 (54)	

Associated anomalies

The number of patients in whom vascular, ductal, and GB anomalies actually coexist is small, only 5 cases (3.3%).

Relation of the cystic artery with the Calot's triangle

The cystic artery was found inside the Calot's triangle in 144 cases (96%), while in 6 cases (4%) outside and in these cases they were found inferior to the cystic duct.

Operative technique

Included laparoscopic cholecystectomy were successfully done in 117 cases out of the total 150 cases of cholecystectomy (78%), while the rest 33 cases (22%) done by conventional open cholecystectomy.

The number of the anomalies recognized by laparoscopic cholecystectomy was 64 out of total 81 anomalies, while other 17 cases recognized by conventional open cholecystectomy.

Only 4 cases of laparoscopic cholecystectomy converted to open method due to extensive adhesions with unclear anatomy (3 cases), and uncontrolled bleeding (1 case), and this gives a conversion rate (3.3%).

Table 3. Comparison between this study and other studies regarding vascular anomalies

Studies	Anterior cystic or anterior RHA (%)	Accessory cystic artery (%)
Our study (2000)	16	18
Khamiso (2010) [8]	2.67	1
Gupta (2003) [15]	-	15
Bhanasali (2003) [16]	-	20
Adkins (2000) [3]	-	12
Shwartz (1999) [13]	15	25
Stremple (1986) [14]	20	25
Benson (1976) [5]	20.7	26.4
Moosman (1951) [17]	19.6	25.2

Discussion

Many studies reported that the incidence of biliary anomalies varies from 15 to 66 percent. [1,3,5,7-11] In this study the incidence of anatomical abnormality in the disposition and relations of the extrahepatic bile ducts and arteries is (54%), so it is within the range reported by others, thus the surgeon will meet some anomaly in every other case upon which he operates. This in keeping with the statement made by Hand (1973) [6] “It is difficult to know what is normal and what is abnormal”. Although the incidence of anomalies is high, there are in fact a relatively few surgical important ones (three vascular and four ductal) and all these were readily recognized at operation.

Vascular anomalies

Vascular anomalies (40%) were more common than ductal anomalies (12%). Commonly the cystic artery passes superior and medial to the cystic duct within the Calot’s triangle [3] as in this study (96%), while it is found outside in 6 cases only (4%), inferior to cystic duct especially when there is high insertion of this duct. So it is important to be aware of the situation when no artery is seen in Calot’s triangle, because various abnormalities in position may exist and overlooking them result in sever hemorrhage [12].

The commonest vascular anomalies are:

I. Accessory cystic artery (18%):

This high incidence was also reported in many studies (no statistical significant difference between our study and other studies: $P > 0.05$), as shown in (Table 2) [3,13-17]. Therefore, after carefully ligating or clipping one artery, the surgeon must search carefully for the possibility of another supply which may have any source of origin, and if not identified this may be torn and bleeding may obscure the operative field and hurried blind clamping may produce a disaster [14].

II. Anterior transposition of the cystic artery or the right hepatic artery (RHA) anterior to the CHD or CBD:

This anomaly was found in (16%), which was also reported by other studies as shown in (Table 3), again there is no statistical significant difference between our study and other studies: $P > 0.05$. It is clinically important to note especially when doing an exploration of CBD, and when the anterior cystic artery being ligated there is always a possible risk of direct injury to either CBD or CHD, depending on where the anterior cystic artery runs, how closely it is related to the ductal structure and how far proximally the ligation is placed [14].

III. Caterpillar hump right hepatic artery: The incidence of this variation was 6% in this study. It is within the range reported by other studies (1-12.9%) [8,17-20]. In this case the right hepatic artery replaces the cystic artery within the Calot's triangle, and it is tortuous and projects forwards to the right of the CHD. It is a dangerous anomaly because it may be mistaken for the cystic artery so ligation can lead to fatal complication in the presence of impaired liver functions [21, 22].

Ductal anomalies

The incidence of significant anomalies of the extrahepatic bile ducts ranges from 10 to 28 percent in autopsy series [23-27]. The cystic duct varies in length as well as in the level and pattern of conjunction with the common hepatic duct [23].

The commonest ductal anomalies are:

1. Long cystic duct with abnormal low fusion with the CHD. In this study it was found in (5.3%) of cases. Under this circumstance the cystic duct is invariably longer than normal. It runs alongside and parallel with the CHD, before joining it. In this case a variable length of the cystic duct is tightly bound to the CHD before they actually fuse [16]. Thus, extensive dissection of the distal portion of the cystic duct can produce devascularization of a segment of CBD, subsequently ischemia, fibrosis and stricture at the level of junction of cystic duct with the CHD [10].

2. Short cystic duct: This anomaly was found in 3 cases (2%). In this condition, the cystic duct is very short (less than 0.5 cm in length). The main danger of this anomaly when the surgeon try to visualize the cystic duct by vigorous traction on the GB, so producing marked angulation and tenting of the CHD or CBD which may then be caught in a clamp or clip [3].

3. High fusion of the cystic duct with CHD or RHD: It was found in 3 cases (2%). In this condition the cystic duct enters the confluence of the right and left hepatic ducts making trifurcation, so the right or left hepatic ducts may be damaged during cystic duct ligation or clipping, furthermore any tenting produced by traction could compromise the lumen at the confluence if a tie was applied [3].

4. Accessory hepatic (bile) ducts: It is the most interesting abnormality of the ducts, because there is a wide variation in its incidence between literatures and quoted as varying from 0.67 to 31 percent (as shown in table 4) [8,13,17,27-29], in addition that he risk of injury to an accessory duct without knowledge that it has been torn or avulsed is present in every case of cholecystectomy [28], because they are infrequently seen and difficult to recognized due to their unusual position and commonly so narrow in caliber in addition that bile flow during anesthesia is commonly decreased [25], or acute and chronic cholecystitis produces enough inflammatory changes which obscure the ductal structures. The incidence of accessory bile ducts in our study is less than that reported in literatures, (the difference is statistically significant: $P < 0.05$), as shown in table 4. The explanation is that, the high incidence occurs in studies who dissect resin- casts in cadaver [17,27,29] with more meticulous dissection technique might be responsible for the result. Other explanation is that, some surgeons might not be aware of the possibility of the presence of accessory bile ducts and certainly is not in the habit of looking for them at operation, and also the in availability of pre- and peroperative cholangiogram in this study.

Table 4. Comparison between this study and other studies regarding accessory hepatic ducts

Studies	Accessory hepatic ducts (%)
Our study (2000)	2.7
Khamiso AH(2010) [8]	0.67
Shwartz (1999) [13]	15
Lichtenstein and Nicosia (1970) [28]	10
Healey and Schroy (1953) [27]	28
Johnston and Anson (1952) [29]	31
Moosman (1951) [17]	16

Biliary tract injury

These injuries are frequently related to surgical inexperience and biliary tract anatomical variations which may be difficult to identify during laparoscopic surgery. Moossa et al. (1992) [30], emphasized that the presence of bile duct aberrations does not excuse bile duct injury and that intraoperative diagnosis of anatomical variations of the biliary tract contributes greatly to the safety of cholecystectomy. Many of the biliary injuries following cholecystectomy are not recorded in the reports, so it is difficult to know their true incidence [30-33]. In many studies it was found that injuries to the CBD have been reported in up to 0.5 percent (usually 0.2- 0.3%) of patient underwent open chole-cystectomy [34,35], while in laparoscopic cholecystectomy the initial studies was approximately 1% [36,37], but recently, the overall incidence of laparoscopic bile duct injury was 0.6% (range 0.1-2.9%) [38]. In this study, laparoscopic cholecystectomy has been associated with bile duct injuries in two cases (1.7%) while none in conventional open method and these injuries are acceptable because they are within the range reported by other studies as mentioned in the previous paragraph.

In conclusion, anomalies of the vascular and ductal components of the extrahepatic biliary tree are common; the former occurring much more frequently than the latter. Inexperience of the surgeon with the anatomical variations and the in availability of the pre- and per- operative cholangiogram were noted as common factors in most of iatrogenic biliary injuries during cholecystectomy. Laparoscopic cholecystectomy was performed in the majority of this patients with acceptable rate of injury (1.7%) because it is within the range reported by other studies (0.1- 2.9%). Open cholecystectomy continues to be a safe and effective means of treating anatomical variations of the extra hepatic biliary tree.

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E-mail: lutfigh@yahoo.com
Mobile: + 964 7701500758
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