VOLUME - 15, ISSUE - 03, MARCH - 2026 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

General Surgery

WHEN ANATOMY DEVIATES, SURGEONS HESITATE : MAPPING VARIATIONS IN BILIARY TREE

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ABSTRACT

Introduction: Anatomical variations are not uncommon. A surgeon should be consciously aware about the possibility of encountering them during the procedure. The aim of this study to identify the variations of the biliary system during laparoscopic cholecystectomy. **Methods:** An observational study of 135 patients conducted in Department of General Surgery at GMC Patiala undergoing standard 4 port laparoscopic cholecystectomy (LC) for identification of gall bladder (GB), ductal and vascular anomalies of Extra Hepatic Biliary Tree (EHBT). **Results:** 113 females and 22 males were included in this study where 54 cases reported anomalies. Out of these, 34 cases reported vascular anomalies where accessory cystic artery (CA) was the commonest anomaly noted in 17 cases, 14 cases showed ductal variations where short cystic duct (CD) seen in 6(4.4%) cases and 6 cases of gall bladder anomalies (4 of buried GB and 2 of Phrygian Cap) were observed. **Conclusion:** Anatomical Variations of Biliary Tree are uncommon although not rare. A mere suspicion of congenital anomaly should make a surgeon exercise surgical prudence and ligation of structures to be done after clear picture is formed after meticulous dissection. It Is important to keep a lookout of these anomalies to avoid injuries to bile duct and severe hemorrhage.

KEYWORDS : Biliary Tree, Variations, Ductal, Vascular

INTRODUCTION

It is important to have knowledge of basic embryology and anatomy of the biliary tree which will further help us to understand the variations and anomalies which are encountered during surgery.[1] Failure to recognize these variations may inadvertently lead to ductal ligation, biliary leakage. Hepatic Diverticulum arises from ventral part of primitive gut which further develops into two small buds.[2-4] Cranial bud develops into liver and extrahepatic biliary tree. Caudal bud divides into superior bud (develops into gall bladder and cystic duct) and inferior bud (develops into right and left pancreas). The whole of the biliary tree develops completely by 5th week of intrauterine life.[2,5]

The extra-hepatic biliary duct system comprises of four parts – cystic duct and gall bladder, right and left hepatic ducts, common hepatic and bile duct including its supra-duodenal and retro-duodenal parts, the pancreatic and intra-duodenal portions.[6]

Incidence of anomalies of extra-hepatic biliary system varies from 15 to 66%[1,7-13] where a study done by Awazli et al[14] reported an incidence as high as 54%. Ductal variations commonly encountered are accessory cystic duct, accessory hepatic duct, low medial insertion of cystic duct etc. Vascular anomalies include double cystic artery, Moynihan's hump, transposition of artery etc.

The aim of this study was to identify the frequency of variations of the EHBT and its vascularisation during laparoscopic cholecystectomy which will help in minimizing the incidence of inadvertent mistakes that might take place without proper knowledge of these variations during surgery.

MATERIALS AND METHODS

This observational study was conducted on 135 patients who presented to Surgery Out Patient Department (OPD) in Rajindra Hospital Patiala with symptomatic cholelithiasis during the period from January 2024 to June 2024. All these patients underwent Laparoscopic Cholecystectomy under general anesthesia after routine hematological investigations, ultrasound abdomen and preanesthetic check up. patients with acute cholecystitis, empyema, gall bladder, pancreatitis, obstructive jaundice and carcinoma of gall bladder were excluded from study. No other Pre-op specific radiological investigation was done for diagnosing extra hepatic biliary tree anomalies.

LC was performed using the standard 4 port technique. Pneumoperitoneum was created via veress needle. A 30° high definition (HD) camera was utilized for adequate visualization. Careful dissection of the hepatocystic triangle and the Calot's triangle was carried out to identify the main anatomical structures , and in particular the relations of the common hepatic, common bile duct, cystic ducts, the course and relations of the right hepatic and cystic arteries. All the variations (ductal as well as vascular) were duly noted.

OBSERVATIONS AND RESULTS

A total of 135 LC's were observed in this study for presence of any anatomical variations. Out of these 135 patients, 113 (83.7%) were females and 22 (16.3%) patients were of the male gender.

Table 1: Age and Sex Distribution

AGE(yrs.)	20-29	30-39	40-49	50-59	60-69	TOTAL(%)
MALE	0	5	6	7	4	22(16.3%)
FEMALE	13	32	40	18	10	113(83.7%)
TOTAL	13	37	46	25	14	135

The maximum number of patients belonged to the age group of 40-49 years where 40 patients were females out of the total 46 patients (Table 1). This corroborates with the fact that cholelithiasis as a disease is fairly common in fertile females over the age of 40 with obesity being an added factor.

Ductal Anomalies

A total of 14 (10.3 %) cases in our study showed ductal anomalies. Short CD was the commonest ductal anomaly seen in 6 (4.4 %) cases, followed by presence of long CD with or without low insertion into the CHD in 3 (2.2%) cases.

High fusion of cystic duct into the CHD was seen in 2 (1.5%) cases with similar number of patients showing cystic duct insertion into the right hepatic duct 1.e 2 (1.5%) cases.

Accessory hepatic ducts arising from right lobe of liver and draining directly into the gall bladder was observed in 1(0.7%) case.

Gall Bladder Anomalies

Two types of gallbladder anomalies were identified in our patient population. Phrygian cap was seen in 2 (1.5%) cases. Intrahepatic GB is one of those situations which makes the removal of the specimen complex and risky for the surgeon. This was encountered in 2 (1.5%) cases.

Vascular Anomalies

The incidence of vascular anomalies was comparatively more as compared to ductal anomalies in our study (34[25.2%] vs 14[10.3%]). Out of the 34 cases, 17 cases showed presence of an accessory CA followed by anterior transposition of CA in 10 cases. Short cystic artery was encountered in 5 cases. The caterpillar or Moynihan's hump was the least encountered vascular anomaly in our study. (2[1.5%] cases)

Table 2. Summary of Observations of the Present Study.

Anomaly		No. of patients (%)	Total
DUCTAL ANOMALIES	Short cystic duct	6(4.4)	14(10.3)
	Long cystic duct with or without low insertion into CHD	3(2.2)	
	High insertion of cystic duct with common hepatic duct	2(1.5)	
	Accessory hepatic ducts	1(0.7)	
	Cystic duct inserting into RHD	2(1.5)	
GALL BLADDER ANOMALIES	Phrygian cap	2(1.5)	6(4.4)
	Buried gall bladder	4(2.9)	
VASCULAR ANOMALIES	Accessory cystic artery	17(12.6)	34(25.2)
	Aberrant cystic artery/ low lying cystic artery anterior to bile duct	10(7.4)	
	Short cystic artery	5(3.7)	
	Moynihan's hump anomaly	2(1.5)	

DISCUSSION

Prevalence of gallstones increases with age and is associated with metabolic derangements such as dyslipidaemia and diabetes as a result of which it is much more common in females who are obese and diabetic. Moreover, women of reproductive age group whom are having high estrogen levels or are on estrogen rich birth control pills have higher incidence of cholelithiasis.[15] In our study, 113 (83.7%) females out of 135 patients presented with gallstones. Studies done by Talpur et al (85%)[11], Gupta et al (59%)[16] and Dharmendra et al (75%)[17] showed similar results.

Variations result from aberrations during embryological development and are not uncommon to encounter during surgery. In modern times, the advent of high resolution laparoscopic camera provides a magnified image of the biliary system which further helps in recognizing and identifying variations avoiding inadvertent injuries and complications. A total of 54 cases (40%) had one or the other variation in the present study. Awazli et al[14] and Dharmendra et al[17] reported higher incidence of vascular anomalies whereas Talpur et al[11] observed ductal and GB anomalies on the higher side. Gupta et al[16] found similar incidence in both categories. In our study, vascular anomalies were on the greater side (34 vs 20 cases).

Ductal Anomalies

Having a thorough knowledge of the normal anatomy and its variations help achieve higher success rates in surgery. One should be familiar with these as sometimes they are difficult to diagnose preoperatively.[18] Most of the ductal anomalies encountered during surgeries revolve around cystic duct in terms of its length or its insertion into CHD. Identification of cystic duct in the Calot's triangle and awareness of its variations is of ultra importance as misidentification may lead to morbid injuries to the biliary tree leading to complications. A total of 14 cases presented with variations in our study where short cystic duct was the most common ductal abnormality observed in 6 (4.4%) cases. Studies conducted by Talpur et al (2.67%)[11] and Khan et al (2.3%)[19] found short CD as the most common anomaly whereas Awazli et al (5.3%)[14] found Long CD as the most common anomaly in his study which was only 1%(3 cases) in our study. In such cases, one has to take care to avoid extensive dissection of CD as it may lead to segmental devascularisation of adjoining CBD resulting in ischemia and stricture formation. The following table (Table 3) depicts the comparison of findings of various studies in regards to ductal anomalies noted :

Table 3 : Comparison of Various Studies Regarding Ductal Anomalies

Study	Short CD	Long CD	High Insertion of CD	Accessory Hepatic Duct	CD insertion into RHD
Talpur et al (2010)[11] (n = 300)	8 (2.67%)	3 (1 %)	-	2 (0.67%)	-
Cacheiro et al (2012)[20] (n = 41)	-	-	1 (2.45%)		1 (2.45%)
Awazli et al (2013)[14] (n = 150)	3 (2%)	8 (5.3%)	3 (2%)	4 (2.67%)	-
Khan et al (2012)[19] (n = 300)	7 (2.3%)	5 (1.67%)	-	4 (1.34%)	5 (1.67%)
Kullmann et al (1996)[21] (n = 513)	-	-	16 (3.1%)	-	1 (0.2%)
Devi T et al (2013)[22] (n = 50)	-	-	-	5 (10%)	-
Taourel P et al (1996)[23]	-	11/126 (9 %)	-	12/171 (9 %)	-
Uchiyama et al (2006)[24] (n = 1041)	-	-	-	30 (2.9%)	-
De Fillipo et al (2008)[25] (n = 350)	-	16 (4.5%)	-	-	9 (2.7%)
Jung Ta-Kao et al (2011)[26] (n = 3546)	-	191 (5.4%)	-	-	-
Suhocki PV et al (1999)[27] (n = 82)	-	-	-	12 (15%)	-
Khayat et al (2014)[28] (n = 120)	24 (20%)	-	-	4 (3.3%)	2 (1.67%)
Present Study	6 (4.4%)	3 (2.2%)	2 (1,5%)	1 (0.7%)	2 (1.5%)

Gall Bladder Anomalies

Isolated anomalies of the GB are rare as they are usually associated with ductal or vascular anomalies. Phrygian Cap

or Folded fundus is one of the most common gall bladder anomalies that may be encountered during cholecystectomy (2 cases in our study). It is of no pathological significance but it might simulate as a gall bladder mass on imaging.[29] Intrahepatic or buried gall bladder is another anomaly observed in patients undergoing cholecystectomy (3% or 4 cases in the present study).

Table 4 : Comparison of Various Studies Regarding Gall Bladder Anomalies

Study	Phrygian Cap	Buried Gall Bladder
Talpur et al (2010)[11] (n = 300)	1 (0.33%)	3 (1%)
Dharmendra et al (2017)[17] (n = 100)	1 (1%)	2 (2%)
Gupta et al (2023)[16] (n = 298)	2 (0.7%)	9 (3%)
Present Study	2 (1.5%)	4 (3%)

Vascular Anomalies

Identification of vascular anomalies is of prime importance as misdiagnosis can lead to severe haemorrhage and non-visualisation of operative field, blind controlling of which may lead to serious injuries and post operative complications increasing the morbidity in patients. Anterior Transposition of CA is one of the most common anomaly studied as ligation of this artery poses a risk of injury to CBD or CHD. 10 (7.4%) cases reported this anomaly in our study which is concurrent with other studies as shown in the table below. The presence of an accessory CA was the most common anomaly visualized in our study (17 cases). Surgeons should look out for this anomaly during careful dissection as non-identification may lead to severe hemmorhage leading to high conversion rates. Caterpiilar/Moynihan's hump is the most dangerous anomaly where right hepatic artery replaces CA in Calot's triangle, ligation of which results in impaired liver function having devastating effects.[30-31] 2 (1.5%) cases reported this anomaly in the present study whereas Awazli et al[14] reported it as high as 6 % in their study.

Table 5 : Comparison of Various Studies Regarding Vascular Anomalies

Study	Artery anterior to CD/CHD	Short CA	Accessory CA	Moynihan's Hump
Devi T et al (2013)[22] (n = 50)	5 (10%)	-	-	-
Awazli et al (2013)[14] (n = 150)	24 (16%)	-	27 (18%)	9 (6%)
Talpur et al (2010)[11] (n = 300)	8 (2.67%)	5 (1.67%)	-	8 (2.67%)
Saidi H et al (2007)[32] (n = 102)	46 (45.15%)	-	-	-
Gupta et al (2023)[16] (n = 298)	32 (10.7%)	-	-	3 (1%)
Dharmendra et al (2017)[17] (n = 100)	3 (3%)	-	-	2 (2%)
Present Study	10 (7.4%)	5 (3.7%)	17 (12.6%)	2 (1.5%)

CONCLUSION

Anomalies of the biliary system are not uncommon and can be of clinical importance while performing laparoscopic or open cholecystectomy. Awareness of these variations prevents the surgeon from causing any inadvertent injuries subsequently decreasing the conversion or re-exploration rates.

Limitations

A large sample size is required to extrapolate the findings of this study to the general population. Observer bias cannot be ruled out as different surgeons would definitely have different perceptions of the anatomical variations encountered during the procedure. The use of radiological imaging intraoperatively could have definitely helped in identifying these variations more accurately and precisely.

Conflicts of Interest

The authors declare that they have no financial conflict of interest with regard to the content of this study.

Source of Funding

None

REFERENCES

1. Mortelé, K. J., Rocha, T. C., Streeter, J. L., & Taylor, A. J. (2006). Multimodality imaging of pancreatic and biliary congenital anomalies. Radiographics, 26(3), 715-731.
2. Bremer, J. L. (1906). Description of a 4.mm. human embryo. American journal of anatomy, 5(4), 459-480.
3. Kanagasuntheram, R. (1960). Some observations on the development of the human duodenum. Journal of anatomy, 94(Pt 2), 231.
4. Jona, J. Z., & Belin, R. P. (1976). Duodenal anomalies and the ampulla of Vater. Surgery, gynecology & obstetrics, 143(4), 565-569.
5. Lindner, H. H., & Green, R. B. (1964). Embryology and surgical anatomy of the extrahepatic biliary tract. Surgical clinics of north America, 44(5), 1273-1285.
6. Chen, W. J., Ying, D. J., Liu, Z. J., & He, Z. P. (1999). Analysis of the arterial supply of the extrahepatic bile ducts and its clinical significance. Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the British Association of Clinical Anatomists, 12(4), 245-249.
7. Al-Sayigh, H. A. (2010). The incidence of cystic artery variation during laparoscopic surgery. Med J Babylon, 7(4), 389-403.
8. Adkins, R. B., Chapman, W. C., & Reddy, V. S. (2000). Embryology, anatomy, and surgical applications of the extrahepatic biliary system. Surgical Clinics, 80(1), 363-379.
9. Benson, E. A., & Page, R. E. (1976). A practical reappraisal of the anatomy of the extrahepatic bile ducts and arteries. British Journal of Surgery, 63(11), 853-860.
10. Hamza, M. U., Jaffar, A. A., Hassan, H. A., & Jasim, Z. M. (2008). Vascular and gallbladder variations in laparoscopic cholecystectomy. Med J Babylon, 5(1), 119-34.
11. Talpur, K. A. H., Laghari, A. A., Yousfani, S. A., Malik, A. M., Memon, A. I., & Khan, S. A. (2010). Anatomical variations and congenital anomalies of extra hepatic biliary system encountered during laparoscopic cholecystectomy. JPMA. The Journal of the Pakistan Medical Association, 60(2), 89.
12. Bayraktar, Y., Balaban, H. Y., Arslan, S., & Balkanci, F. (2006). Agenesis of gallbladder and multiple anomalies of the biliary tree in a patient with portal thrombosis: a case report. Turkish Journal of Gastroenterology, 17(3), 212-215.
13. Russell ROG, Williams NS, Bulstrode CjK. Bailey and Love's: Short practice of surgery.Vol. 2. 23rded.New York:Arnold;2000.p. 965-86.
14. Awazli, L. G. (2013). Anatomical variations of extrahepatic biliary system. Iraqi Journal of Medical Sciences, 11(3).
15. Shabanzadeh, D. M. (2018). New determinants for gallstone disease. Dan Med J, 65(2), B5438.
16. Gupta, R., Kumar, A., Hariprasad, C. P., & Kumar, M. (2023). Anatomical variations of cystic artery, cystic duct, and gall bladder and their associated intraoperative and postoperative complications: an observational study. Annals of Medicine and Surgery, 85(8), 3880-3886.
17. Kumar, D., & Shahil, P. (2017). Anatomical variations of gall bladder & its association with post operative outcome. IOSR Journal of Dental and Medical Science, 16(5), 53-55.
18. Carbajo, M. A., del Omo, J. C. M., Blanco, J. I., Cuesta, C., Martin, F., Toledano, M., ... & Vaquero, C. (1999). Congenital malformations of the gallbladder and cystic duct diagnosed by laparoscopy: high surgical risk. JSLS: Journal of the Society of Laparoendoscopic Surgeons, 3(4), 319.
19. Khan, A. S., Paracha, S. A., Shah, Z., Tahir, M., & Wahab, K. (2012). Anatomical variations of cystic duct encountered during open cholecystectomy. Khyber Medical University Journal, 4(1), 19-22.
20. Cachoeira, E., Rivas, A., & Gabrielli, C. (2012). Anatomic variations of extrahepatic bile ducts and evaluation of the length of ducts composing the cystohepatic triangle. Int J Morphol, 30(1), 279-83.
21. Kullman, E., Borch, K., Lindstrom, E., Svanvik, J., & Anderberg, B. (1996). Value of routine intraoperative cholangiography in detecting aberrant bile ducts and bile duct injuries during laparoscopic cholecystectomy. British journal of surgery, 83(2), 171-175.
22. Devi, T., & Krishna, P. (2013). The study of variations of extra hepatic biliary apparatus. IOSR-JDMS, 5(5), 25-31.
23. Taourel, P., Bret, P. M., Reinhold, C., Barkun, A. N., & Atri, M. (1996). Anatomic variants of the biliary tree: diagnosis with MR cholangiopancreatography. Radiology, 199(2), 521-527.
24. Uchiyama, K., Tani, M., Kawai, M., Ueno, M., Hama, T., & Yamaue, H. (2006). Preoperative evaluation of the extrahepatic bile duct structure for laparoscopic cholecystectomy. Surgical Endoscopy and Other Interventional Techniques, 20(7), 1119-1123.
25. De Filippo, M., Calabrese, M., Quinto, S., Rastelli, A., Bertellini, A., Martora, R., ... & Zompatori, M. (2008). Congenital anomalies and variations of the bile and pancreatic ducts: magnetic resonance cholangiopancreatography findings, epidemiology and clinical significance. La radiologia medica, 113(6), 841-859.

26. Kao, J. T., Kuo, C. M., Chiu, Y. C., Changchien, C. S., & Kuo, C. H. (2011). Congenital anomaly of low insertion of cystic duct: endoscopic retrograde cholangiopancreatography findings and clinical significance. Journal of clinical gastroenterology, 45(7), 626-629.
27. Suhocki, P. V., & Meyers, W. C. (1999). Injury to aberrant bile ducts during cholecystectomy: a common cause of diagnostic error and treatment delay. AJR. American journal of roentgenology, 172(4), 955-959.
28. Khayat, M. F., Al-Amoodi, M. S., Aldaqal, S. M., & Sibiany, A. (2014). Abnormal anatomical variations of extra-hepatic biliary tract, and their relation to biliary tract injuries and stones formation. Gastroenterology research, 7(1), 12.
29. Lamah, M., & Dickson, G. H. (1999). Congenital anatomical abnormalities of the extrahepatic biliary duct: a personal audit. Surgical and Radiologic Anatomy, 21(5), 325-327.
30. Rocko, J. M., & Di Gioia, J. M. (1981). Calot's triangle revisited. Surgery, gynecology & obstetrics, 153(3), 410-414.
31. Goor, D. A., & Ebert, P. A. (1972). Anomalies of the biliary tree: report of a repair of an accessory bile duct and review of the literature. Archives of Surgery, 104(3), 302-309.
32. Saidi, H., Karanja, T. M., & Ogengo, J. A. (2007). Variant anatomy of the cystic artery in adult Kenyans. Clinical Anatomy, 20(8), 943-945.