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Original Research Article

Studying Prevalence of Anatomical Variations of Extra Hepatic Biliary Tree and Vasculature Encountered During Laparoscopic Cholecystectomy

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Abstract:

Background: The anatomy of the extra-hepatic biliary tree (EHBT) is crucial for surgeons, as it is a common site for both anatomical variations and surgical procedures**.** This study aimed to find the prevalence of anatomical variations of extrahepatic biliary system in patients undergoing laparoscopic cholecystectomy.

Methods: This cross-sectional observational study was conducted in patients of either gender and >18yrs of ages, with USG finding of cholelithiasis and was treated by laparoscopic cholecystectomy. Patients of gall bladder perforation, biliary peritonitis and who refused to participate were excluded out. Structures mainly asses during laparoscopic cholecystectomy for gall bladder, cystic duct, common bile duct, cystic artery and hepatic artery and was recorded in proforma.

Results: The vast majority of participants, 173 out of 198 (87.4%), have no anatomical variations in their gallbladder. Intrahepatic gallbladders were found in 20 (10.1%) individuals. Only one individual (0.5%) has a cystic duct that enters the right hepatic duct, a rare variation. Three participants (1.5%) have a cystic duct that inserts along the medial aspect of the common bile duct. A small percentage of cases exhibited variations. Specifically, "Moynihan's Hump" was found in 3 (1.5%) cases. One individual (0.5%) has double cystic arteries, one case (0.5%) has cystic artery originating anterior to cystic duct and the one case (0.5%) has where cystic artery originated from accessory right hepatic artery. Only 1 (0.5%) of the cases, displayed a pre duodenal portal vein variation. There was no incidence of injury to biliary tree or episode of abnormal bleeding from hepatobiliary vasculature.

Conclusion: This study contributes valuable insights into the demographics, conditions, and anatomical variations associated with gallbladder diseases. While it reflects established trends and provides useful data for clinical practice.

Keywords: Anatomical Variations, Extra Hepatic, Common Bile Duct, Cholecystectomy.

Introduction

The variations in anatomy of the bile ducts has long been known. Variations arise from aberrations in embryological development [1]. Couinaud has been describing them since 1957. Huang proposed a classification of biliary variations in China based on endoscopic retrograde cholangiopancreatography (ERCP).

Subsequently, additional classifications were created, each with an increasingly intricate anatomy, to meet the needs of contemporary surgery [2]. Many studies reported that the incidence of biliary anomalies varies from 15 % to 66 % [3]. According to reports, as much as 47% of extra-hepatic biliary tree (EHBT) anatomical variations occur [4]. These variations include accessory hepatic ducts, aberrant ducts that connect the liver directly to the gallbladder (accessory cysticohepatic ducts) or ducts of Luschka, low insertion of the cystic duct, insertion of the cystic duct into the right hepatic duct or left hepatic duct, and insertion of the cystic duct on the left side of the common hepatic duct or left cystic duct insertion.

Additional variations include a short cystic duct, long cystic duct, and double cystic duct [5]. The anatomy of the extra-hepatic biliary tree (EHBT) is crucial for surgeons, as it is a common site for both anatomical variations and surgical procedures. Anatomical variations in extra-hepatic biliary tree and vasculature are among the most frequent causes of such iatrogenic injuries.

Therefore, the laparoscopic surgeon should have knowledge of the anatomical variations of arterial and biliary tree. Incorrect surgery can lead to cystic artery bleeding, injury to the extrahepatic bile duct or intra-abdominal organs needing conversion to open surgery and further morbidity.

Although many imaging and pre-operative diagnostic tools are available to assess the hepatobiliary anatomy, these both are unreliable and too expensive for most of the population of our country [6]. This study aimed to find the prevalence of anatomical variations of extrahepatic biliary system in patients undergoing laparoscopic cholecystectomy.

Materials and Methods

This cross-sectional observational study was conducted in the General Surgery and Gastro surgery department, at tertiary care teaching hospital of Rajasthan from October 2022 to June 2024 after approval from institutional ethical committee.

Patients of either gender and >18yrs of ages, with USG finding of cholelithiasis and was treated by laparoscopic cholecystectomy in General Surgery and Gastro surgery department was included.

Patients of gall bladder perforation, biliary peritonitis and who refused to participate were excluded out.

Methodology:

After admission of the patient to general surgery department and gastro surgery department, a written and informed consent was obtained by the patient prior to surgery. A detailed history was taken followed by clinical examination and ancillary investigations including complete blood count, urine routine examination, liver function tests, random blood sugar levels, and ultrasonography. Structures mainly asses during laparoscopic cholecystectomy for gall bladder, cystic duct, common bile duct, cystic artery and hepatic artery and was recorded in proforma.

Sample Size: Sample size was 62 using following formula; $n=(Z_{\alpha} + Z_{1-\beta})^2 .P(1-P)/E^2$, Where n = sample size, P= 4% prevalence [7], Z_{α}= 1.96 at 95%confidence level, $Z_{1-\beta}$ =0.84 at 80%power of study, E = 7% be absolute error

Statistical Analysis: All the data entered into a computer and analysis was done using SPSS version 23. Descriptive statistics include mean, median, and range for continuous variables and absolute numbers with percentages for categorical variables.

Results

The age of all 198 patients ranged from a minimum of 19 years to a maximum of 87 years in the study. The mean age of the participants was approximately 48.43 years. Majority of the participants were female, with 134 females making up 67.7% of the total population. In contrast, there were 64 male participants, accounting for 32.3% of the total. (Table 1)

Table 1: Demographic details and operative findings of all the patients

	N(%) or Mean±SD
Age (Years)	48.43±16.10
Gender	
Male	64(32.3%)
Female	134(67.7%)
Operative findings	
Contracted GB	4(2%)
Edematous GB	14(7%)
Adhesions	6(3%)
Inflamed GB with Multiple Calculi	44(22.2)
GB Containing Multiple Calculi	124(62.6%)
Mucocele of GB	2(1%)
Stone Impacted at Neck of GB	2(1%)
Thick Walled GB	2(1%)

The most prevalent finding was "GB Containing Multiple Calculi," which was recorded in 124 cases, accounting for 62.6% of the total. "Inflamed GB with Multiple Calculi" was the second most common, seen in 44 cases or 22.2% of the study population. Other notable findings included "Edematous GB" in 14 cases (7.0%) and "Adhesions" in 6 cases (3.0%). (Table 1)

Table 2: Distribution of Anatomical Variation in gall bladder, cystic duct, hepatic artery, cystic artery and portal vein

	Number	Percentage
Anatomical Variation in GB		
None	173	87.4
Intrahepatic GB	20	10.1
Left sided GB	5	2.5
Anatomical Variation in Cystic Duct		
None	179	90.5
Cystic duct entering to right hepatic duct	1	.5
Cystic duct insert along the medial aspect of CBD	3	1.5
Long	11	5.5
Short	4	2.0
Anatomical Variation in Hepatic Artery		
None	191	96.5
Moynihan's Hump	3	1.5
Right accessory hepatic artery arising from SMA & anterior to cystic duct	4	2.0
Anatomical Variation in Portal Vein		
None	197	99.5
Pre duodenal portal vein	1	.5

The vast majority of participants, 173 out of 198 (87.4%), have no anatomical variations in their gallbladder. Intrahepatic gallbladders, where the gallbladder is located within the liver, were found in 20 individuals, accounting for 10.1% of the participants. The majority, 179 participants (90.5%), have no anatomical variations in their cystic duct, indicating a typical anatomical structure is most common in this population. Only one individual (0.5%) has a cystic duct that enters the right hepatic duct, a rare variation. Three participants (1.5%) have a cystic duct that inserts along the medial aspect of the CBD.

Additionally, 11 individuals (5.5%) have a long cystic duct, while 4 individuals (2.0%) have a short cystic duct. The majority of the cases, 191 or 96.5%, displayed no anatomical variation in the hepatic artery. In contrast, a small percentage of cases exhibited variations. Specifically, "Moynihan's Hump" was found in 3 cases, representing 1.5% of the total. Another variation, the "Right accessory hepatic artery arising from the superior mesenteric artery (SMA) and anterior to the cystic duct," was noted in 4 cases, or 2.0%. The overwhelming majority, 195 participants (98.5%), exhibit no variations in their cystic artery.

There were, however, a few cases with notable variations. One individual (0.5%) has double cystic arteries: one case (0.5%) has cystic artery originating anterior to cystic duct and the one case (0.5%) has where cystic artery originated from accessory right hepatic artery.

The majority of cases, 99.5%, exhibited no variation in portal vein, with 197 out of 198 individuals showing a standard anatomical pattern. Only 0.5% of the cases, or 1 individual, displayed a pre duodenal portal vein variation. (Table 2) There was no incidence of injury to biliary tree or episode of abnormal bleeding from hepatobiliary vasculature.

Discussion

In this study mean age of patients was 48.43±16.10 years. Other studies also found the similar results; like Bansal et al study where they reported mean age of 43.56 years of the patients [8]. In another study by Pandey et al involving 64 newly diagnosed cases of gallbladder cancer and 101 cases of cholelithiasis; the mean age of the patients with GB cancer was 51±1.2 years and it was 40.9±1.12 years for the patients with gallstones. Over two-thirds (68.7%) of cancer patients and 90% of gallstones patients were females, which were similar to our study [9].

In present study 67.7% of participants being female and 32.3% male. Comparative studies show similar trends [8-10]; like Bansal et al, in their study and find out that, 35% male, and 65% female [8].

This disparity aligns with the generally observed higher prevalence of gallbladder diseases in females. This gender imbalance could be attributed to hormonal factors, particularly estrogen, which has been linked to gallbladder disease risk [11-12]. Acute calculus cholecystitis and chronic calculus cholecystitis also show higher prevalence in females. This gender disparity is consistent with findings from similar studies, such as those by Rajan et al which report a higher incidence of gallbladder pathology in females. The increased incidence in females may be linked to factors like pregnancy, obesity, and estrogen levels, which have been associated with a higher risk of gallbladder diseases [13].

In the reproductive years, there is a strong correlation between gallstone disease and female gender. Stone formation is nearly twice as common in women as in men; men start to catch up after menopause, when the difference starts to close [14].

The operating findings in present study revealed that "GB Containing Multiple Calculi" was the most common condition, observed in 62.6% of cases, followed by "Inflamed GB with Multiple Calculi" at 22.2%. These findings underscore the prominence of calculous and inflammatory conditions in the study sample, which was corroborated by other research, such as Bansal et al study [8].

Since EHBT is one of the most frequently used locations for surgical procedures in addition to being a common site for anatomical variations, its anatomy is extremely important to surgeons. The prevalence of aberrant anatomy in EHBT varies; as much as 47% has been documented by Dundaraddey et al study [15]. 19% of the patients in a study by Kullman et al had EHBT anatomical variations [16] whereas Philippo et al [17] and Cochoeira et al [18] found lower incidences 8.8% and 7.3%, respectively.

Anatomical variations in the gallbladder were observed in 12.6% of cases, with intrahepatic gallbladders and left-sided gallbladders being the most noted variations. Surgeons would be able to perform safe procedures with little to no damage if they could correctly identify the EHBT anatomy and any potential abnormalities. The surgeons believe it is critical to understand the most prevalent abnormalities. In our study, Anatomical variations in the cystic duct were present in 9.5% of cases, with variations in length (short or long cystic duct) and insertion points being recorded. Similar results were also obtained in other studies like a study by Khayat et al, the most common EHBT abnormality found in 20% of the patients was short CD [19]. This result was in line with research by Khan et al [20] and Talpur et al [7] which found that short CD was the most frequent abnormality. However, the most prevalent EHBT abnormalities, according to studies by Kullman et al [16] and Devi et al [21] were accessory hepatic ducts. Only 3.33% of the participants in this study had accessory hepatic ducts visible.

For the hepatic artery and cystic artery, variations were rare, occurring in 3.5% and 1.5% of cases, respectively in our study. The right hepatic artery is normally the source of the cystic artery, but it can also arise abnormally from other branches of the celiac axis. In 385 of 6898 (5.58%) cases, it originated from an aberrant (replaced or accessory) right hepatic artery; in 143 of 6898 (2.07%) cases, it originated from the left hepatic artery; and in 134 of 6898 (1.94%) cases, it originated from the gastroduodenal artery as documented by Andall et al [22]. An even rarer occurrence is when the cystic artery originated from the superior pancreaticoduodenal artery, superior mesentery artery, proper hepatic bifurcation, celiac artery, or another origin.

Ding et al study listed instances in which the cystic arteries were found both inside and outside of the hepatobiliary triangle. According to their study, only 3 out of 600 (0.5%) Chinese patients had an accessory artery that approached the gallbladder outside of the hepatobiliary triangle, passing through the triangle superficially to the cystic duct, as did our patient [23].

Of the 244 Japanese patients treated in Suzuki et al study, 13 (5.3%) showed the same pattern; in general, 27 cases (11.1%) showed the occurrence of a double cystic artery [24]. According to Zubair et al study 54.66% of the 220 Pakistani patients who had laparoscopic cholecystectomy were identified as having this type. However, the most frequent variation was the double cystic artery passing through the hepatobiliary triangle, which was observed in 26 (11.8%) cases [25].

The portal vein variation was found in only 0.5% of cases. These findings are consistent with the literature, such as that by Polguj et al study which document similar rates of anatomical variations [26]. Understanding these variations is crucial for surgical planning and reducing complications.

Limitations: The study's focus on a specific geographic region may limit the applicability of the findings to other populations with potentially different prevalence rates or risk factors. The cross-sectional nature of the study provides a snapshot in time but does not account for changes in conditions or outcomes over time.

Conclusion

This study reinforced the established findings of gallbladder diseases which are more common among women. Anatomical variations were relatively rare but noteworthy. These findings underscore the importance of understanding anatomical variations for effective surgical planning and minimizing complications. In conclusion, this study contributes valuable insights into the demographics, conditions, and anatomical variations associated with gallbladder diseases. While it reflects established trends and provides useful data for clinical practice, addressing its limitations and expanding research efforts will further enhance our understanding and management of these conditions.

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