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Original Article

Surgery Section

Evaluation of Variation in the Calot's Triangle at a Tertiary Care Hospital in Northern Uttar Pradesh, India: A Cross-sectional Study

POOJA PANDEY[1], ABHISHEK RANJAN[2], IRFAN KHAN[3], SHYAMENDRA PRATAP SHARMA[4]

ABSTRACT

Introduction: Cholelithiasis is the most common disease worldwide, and laparoscopic cholecystectomy is the standard treatment of choice. To perform laparoscopic cholecystectomy, it is essential to understand the critical view of safety, which primarily involves the dissection of Calot's triangle. Anatomical variations in Calot's triangle exist, and understanding them is crucial to avoid unintended situations during surgery. Mirizzi syndrome, a rare complication in Calot's triangle, can significantly increase mortality and morbidity rates.

Aim: To evaluate the anatomical variations in the Calot's triangle.

Materials and Methods: A cross-sectional study was conducted at Mayo Institute of Medical Sciences, Department of General Surgery, from October 2021 to September 2022. The total sample size included 100 patients with gallstone disease who underwent surgical intervention. Intraoperative findings, such as variations in the cystic artery and cystic duct, as well as Mirizzi syndrome grading, were recorded in an Excel sheet and tabulated. The results were expressed in terms of frequency and percentage.

Results: The average age of the patients was 39.42±12.11 years, with females outnumbering males. Among them, 28% had a cystic artery lying outside of Calot's triangle, and 96% had a cystic artery originating from the right hepatic artery. The remaining 2% originated from an aberrant right hepatic artery, 1% from the left hepatic artery, and 1% from the gastroduodenal artery. Cystic duct variations were found in 5% of cases. Of these, 2% had a short cystic duct (<2 cm), 1% had a long cystic duct (approximately 5 cm), one patient had an absent cystic duct, and one had a low insertion into the common hepatic duct. Mirizzi syndrome Grade-I and Grade-II patients accounted for 4% and 2% respectively, while Grade-III, Grade-IV, and Grade-V each contributed to 1%.

Conclusion: Knowledge of Calot's triangle variations is crucial, especially for aspiring surgeons, as it helps them make decisions promptly when encountering difficulties during surgery. Understanding the Calot's region ensures the safety not only of patients but also of surgeons.

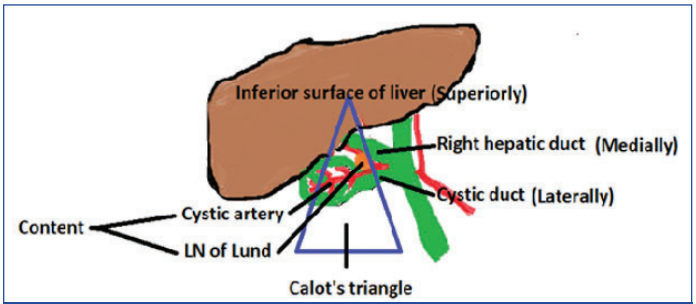
Keywords: Cystic artery, Cystic duct, Mirizzi syndrome, Right hepatic artery

INTRODUCTION

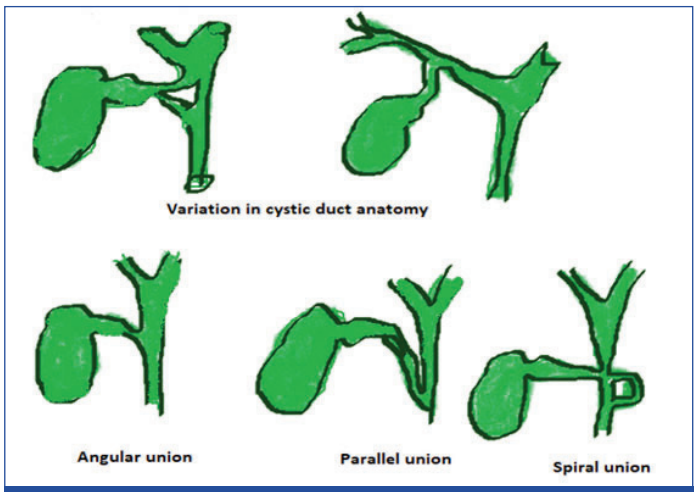
The gallbladder, a pear-shaped organ, exhibits various variations, particularly in its ductal system and vascular supply. Cholecystectomy is a common surgical procedure performed worldwide, both through laparoscopic and open approaches. One major concern for the operating surgeon in both types of cholecystectomy is the incidence of bile duct injuries and arterial injuries [1]. To prevent such mishaps during surgery, Calot introduced the concept of Calot's triangle in 1891, which was later modified in 1981 by Rocko and DiGioia. According to the modified concept, the triangle is medially bounded by the hepatic duct, laterally by the cystic duct, and superiorly by the inferior surface of the liver. Its contents include the cystic artery and the Lund lymph node [Table/Fig-1] [2].

The risk of iatrogenic injury is highest when anatomical variations are present [Table/Fig-2,3]. The cystic artery can exhibit variations such as being double, resembling a caterpillar, passing anteriorly to the hepatic duct, and originating from both the gastroduodenal artery and the hepatic artery. Knowledge of cystic artery variations is crucial as injury to it can result in troublesome bleeding [3]. Similarly, the cystic duct can present with variations such as absence, duplication, short/long length, and high or low insertion at the hepatic duct (right or left).

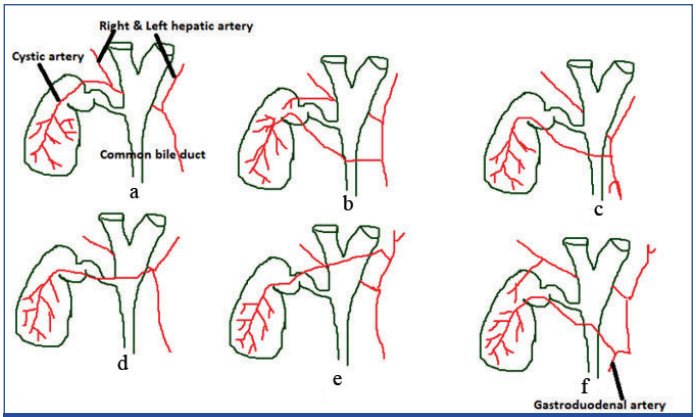
In addition to these variations, the distortion of Calot's triangle due to Mirizzi syndrome poses a significant challenge for surgeons. Mirizzi syndrome is a rare condition caused by external compression from one or multiple large impacted gallstones on the common bile duct or common hepatic duct, leading to the formation of fistulae. It is observed in 0.06-5.7% of cholecystectomy patients [4]. Risk factors for developing Mirizzi syndrome include long and short



[Table/Fig-1]: A pictorial representation showing the boundary of Modified Calot's triangle with its content [2].



[Table/Fig-2]: Variations in cystic duct.



[Table/Fig-3]: Variations in cystic artery a) most common anatomy, b) double cystic artery, c) cystic artery originating from proper hepatic artery and lying anterior to the bile duct, d) cysric artery from right hepatic artery coursing anteriorly, e) cystic artery from left hepatic artery and anterior to the bile duct, f) cystic artery originating from gastroduodenal artery.

cystic ducts, as well as a parallel running cystic duct that intersects with the common bile duct at a low insertion point. Various grading systems are available for Mirizzi syndrome, ranging from Grade-I, which involves external compression of the common bile duct due to an impacted stone at the neck of the gallbladder, to Grade-V, which includes cholecystocholedochoenteric fistula with or without gallstone ileus [5].

Preoperative diagnosis of Mirizzi syndrome is challenging, making intraoperative findings crucial in determining the appropriate surgical approach. Previously, open surgery was the preferred treatment, but with advancements in technology and surgical skills, laparoscopic techniques can now be used [6]. The present study aimed to identify the anatomical variations in Calot's triangle.

MATERIALS AND METHODS

A cross-sectional study was conducted in the Department of General Surgery at MIMS from October 2021 to September 2022. The study was approved by Institutional Ethical Committee (IEC) with IEC number 313. The study included a total of 100 patients with gallstone disease who underwent surgical intervention.

Inclusion criteria: Both males and females aged >18 years and <75 years were included. Patients with ultrasound-confirmed gallstone disease, including those with intrahepatic gallbladder, previous history of acute cholecystitis, and who provided consent for surgery, were included.

Exclusion criteria: Patients with disseminated vascular coagulopathy, Hepatitis B, Hepatitis C, human immunodeficiency virus, and those who had previously undergone cholecystectomy were excluded from the study.

The variables studied included variations in the cystic duct, such as absence, length (long or short), variations in insertion, spiral union, parallel union, and double cystic duct. Variations in the cystic artery, including double cystic artery, proximal or distal to the right hepatic artery, caterpillar turn, and origination from the gastroduodenal artery, were also assessed. Mirizzi syndrome grading was noted according to the following criteria [7]: Grade-IA (presence of cystic duct), Grade-IB (obliteration of cystic duct), Grade-II (<1/3rd compression of the common hepatic duct diameter), Grade-III (>1/3rd compression of the common hepatic duct diameter), and Grade-IV (>1/2 compression of the common hepatic duct diameter). Grade-I is not associated with fistula formation, while Grade-II, III, and IV are associated with fistula formation.

STATISTICAL ANALYSIS

Statistical analysis was performed using an Excel sheet, and the results were expressed in terms of frequency and percentages.

RESULTS

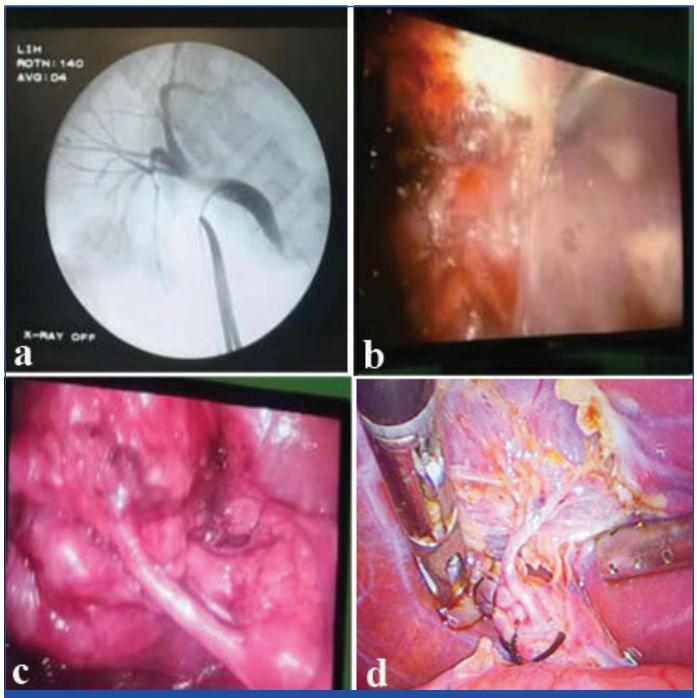
Among the study subjects, the majority 36 (36%) belonged to the 30-39 years age group. The mean age of the study cases was 39.42±12.11 years [Table/Fig-4]. Females constituted 84% of the participants, while males accounted for 16%.

Age (years)	n (%)
20-29	21 (21.0)
30-39	36 (36.0)
40-49	23 (23.0)
50-59	15 (15.0)
>=60	5 (5.0)
Mean±SD	39.42±12.11

[Table/Fig-4]: Age distribution of study cases.

Surgical intervention: Regarding surgical intervention, laparoscopic cholecystectomy was attempted in all patients, and it was successfully performed in 95% of cases. Conversion to the open method was required in five cases due to reasons such as excessive bleeding caused by injury to an aberrant hepatic artery, absence of the cystic duct (confirmed with intraoperative cholangiogram [Table/Fig-5a]), and Type-IV Mirizzi syndrome, for which a hepaticoduodenostomy was performed.

Variation of Calot's triangle: In 72% of cases, the cystic artery was present and located within the triangle as its content, while in 28% of cases, it was adjacent to the cystic duct [Table/Fig-5c,6]. Two cases exhibited Moynihan's hump configuration [Table/Fig-5b,d].



[Table/Fig-5]: (a) Intraoperative cholangiogram in an absent cystic duct; (b) Moynihan's hump; (c) Dilated and thickened cystic artery anterior to the cystic duct; (d) Caterpillar turn.

Total number of cases	Inside the Calot's	Outside the Calot's
100	72	28

[Table/Fig-6]: Cystic artery in relation to Calot's triangle.

Typically, the cystic artery arises from the terminal branch of the right hepatic artery, followed by the right hepatic proper and the left hepatic artery [Table/Fig-7].

In 1% of cases, the cystic duct was found to be absent, as confirmed by intraoperative cholangiogram, leading to conversion to an open cholecystectomy [Table/Fig-8].

Variations	%
Right hepatic artery	96
Left hepatic artery	1
Gastroduodenal artery	1
Aberrant right hepatic artery	2
Absent cystic artery	0
Double cystic artery	0

[Table/Fig-7]: Cystic artery variations.

Variations	%
Absent cystic duct	1
Double cystic duct	0
Short cystic duct <2 cm	2
Long cystic duct≈5 cm	1
Low insertion into common hepatic duct	1
High insertion into hepatic duct (right/left)	0

[Table/Fig-8]: Cystic duct variations.

Mirizzi syndrome was encountered in 9% of the patients, with one patient having a cholecystocholedochoenteric fistula that was referred to the hepatobiliary surgeon [Table/Fig-9].

Grading of Mirizzi syndrome	n	Surgery performed
I	4	Cholecystectomy
II	2	Cholecystectomy+T-tube repair
III	1	Cholecystectomy+T-tube repair
IV	1	Hepaticoduodenostomy
V	1	Refer to hepatobiliary surgery

[Table/Fig-9]: Frequency of cases of Mirizzi syndrome.

DISCUSSION

In present study, 28% of the participants had a cystic artery located outside of Calot's triangle, while 96% of them had a cystic artery originating from the right hepatic artery. Cystic duct variations were observed in 5% of cases.

A retrospective study involving 600 patients reported that 85.5% of patients had a normal Calot's triangle, and 13% had a cystic artery located outside of the triangle [3]. In a cadaver dissection study involving 100 specimens, it was found that 65% had a cystic artery within Calot's triangle, while 35% had a cystic artery located outside of the triangle. Additionally, 92% of the participants had cystic arteries originating from the right hepatic artery, 4% had an abnormal right hepatic artery, 1% had a gastroduodenal artery, and 1% had a left hepatic artery [8].

In the literature, the prevalence of anatomical variations of the cystic duct ranges between 8.2% and 24% [9]. The normal length of the cystic duct is typically 2-4 cm, and it usually inserts into the middle third of the common bile duct, mostly towards the right side [10]. Short cystic ducts have been reported in 1.3-2.6% of cases, while absent and double cystic ducts are extremely rare, with reported incidences of 0.3-0.4% [11]. Aberrant cystic ducts have also been reported in a small percentage of cases [11]. In present study, absent cystic duct was found in 1% of cases, short cystic duct in 2%, long cystic duct in 1%, and low insertion into the common bile duct in 1%, but no double cystic duct was observed.

Mirizzi syndrome is a rare condition, seen in only 0.1% of cases, where an impacted stone compresses the common bile duct [11,12]. The incidence of Mirizzi syndrome in patients undergoing cholecystectomies ranges from 0.7-25% [11]. In present study, 9% of cases were diagnosed with Mirizzi syndrome.

Knowledge about anatomical variations is crucial to prevent inadvertent complications. Bile is a chemical irritant, so it is important to be cautious about postoperative bile leakage. Additionally, bleeding due to injury to the cystic artery can lead to liver necrosis, potentially requiring hepatectomy. Therefore, achieving a critical view of safety before clipping or ligating, and ensuring that the structures being cut are not the hepatic artery or common bile duct, is essential to minimise morbidity and mortality rates [12].

Mirizzi syndrome can mimic gallbladder carcinoma, so thorough radiological investigations such as abdominal ultrasound, Computed Tomography (CT) of the abdomen, Magnetic Resonance Cholangiopancreatography (MRCP), and endoscopic retrograde cholangiopancreatography are necessary for accurate diagnosis. The standard treatment approach described in the literature is laparoscopic cholecystectomy, which was performed in present study [12].

Limitation(s)

The study had limitations including a small sample size and being conducted at a single centre. Conducting a multicentre study with a larger sample size would provide a more comprehensive understanding of the topic and contribute to the reevaluation of the area as a region.

CONCLUSION(S)

The laparoscopic method provides a wide field of vision, making it easier to identify structures in Calot's triangle. With this improved visualisation, the anatomical variations and rare conditions like Mirizzi syndrome can be identified and addressed promptly, potentially saving the patient's life and improving their quality of life.

Photographs [Table/Fig-2,3] were created by Dr. Pooja Pandey using Microsoft Paint, with references taken from standard textbooks. Photographs [Table/Fig-4a-c] were captured from recorded videos during the surgical procedures.

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PARTICULARS OF CONTRIBUTORS:
1. Junior Resident 3rd Year, Department of General Surgery, MIMS, Barabanki, Uttar Pradesh, India.
2. Junior Resident 2nd Year, Department of General Surgery, MIMS, Barabanki, Uttar Pradesh, India.
3. Assistant Professor, Department of General Surgery, MIMS, Barabanki, Uttar Pradesh, India.
4. Assistant Professor, Department of General Surgery, MIMS, Barabanki, Uttar Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Shyamendra Pratap Sharma,
Assistant Professor, Department of General Surgery, Mayo Institute of Medical Sciences, Gadia, Barabanki-225001, Uttar Pradesh, India.
E-mail: remembermepooja@gmail.com

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