STUDY OF VARIATIONS IN ORIGIN AND COURSE OF CYSTIC ARTERY IN RELATION TO CALOT'S TRIANGLE

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ABSTRACT

Calot's triangle is an anatomical space and also known as "triangle of cholecystectomy". It is bounded medially by Common hepatic duct, laterally by cystic duct, and superiorly by the under surface of liver and its main contain is Cystic artery. The variation in the origin and course of the cystic artery can cause serious problems resulting, severe arterial bleeding during any surgical procedures. Hence, variations in the Calot's triangle are very important for the surgeons. An observational cross sectional study was carried out in Department of Anatomy of two Medical Colleges in Kathmandu, Nepal. A total of 30 embalmed human cadavers were dissected, in 27 cases (90.0%), cystic artery arose from right hepatic arteries, the mean length was 11.47 mm. One (3.3%) cystic artery arose from proper hepatic artery, one (3.3%) from superior mesenteric artery and one (3.3%) from accessory hepatic artery and the length of the cystic arteries were found to be measured as 15.88 mm, 27.49 mm and 24.17 mm respectively. The cystic artery was also found to be lying inside and outside the Calot's triangle in 96.7% and 3.3% respectively. In 26 cases (86.7%) cystic arteries were observed as passing posterior to the common hepatic duct. Further in 2 cases (6.7%) cystic arteries were found to be lying anterior to the common hepatic duct. Result also showed as in 1 case (3.3%) it was running anterior to the bile duct and in 1 case (3.3%) between right and left hepatic ducts. In conclusion the variations in the origin and course of the cystic artery are essential in performing cholecystectomy (open or laparoscopic).

KEYWORDS

Calots triangle, cystic artery, hepatic artery, common hepatic duct, bile duct, cholecystectomy

***Received on**: January 20, 2022*
***Accepted for publication**: April 22, 2022*

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DOI: https://doi.org/10.3126/nmcj.v24i2.46028

INTRODUCTION

The anatomy of this region has been described for more than a century in the form of well-known "triangles" namely, "triangle of Calot" (CT) and "triangle of cholecystectomy". In its original description by Calot in 1891, the triangle was described to be bounded medially by hepatic duct (HD), laterally by cystic duct (CD), and superiorly by cystic artery (CA).[1]

A triangle was described, bounded medially by HD, laterally by CD, and superiorly by the under surface of liver in 1981 and named it as "triangle of cholecystectomy" (Fig. 1). These triangles are said to contain cystic artery.[2,3] The variation in the origins and course of the cystic artery can cause serious problems resulting, severe arterial bleeding during any surgical procedures. Therefore, a complete knowledge of these calot's triangle with its boundaries and contents both normal and its variations are very important for the surgeons.[3]

The cystic artery is the main source of blood supply of the cystic duct and gallbladder.[4-6] The cystic artery always remained the center of attraction, as complications were centered on the key step of ligating and dividing the cystic artery.[6,7] Over a century, open cholecystectomies were performed for cholelithiasis, which has been revolutionized by laparoscopic techniques.[6-8] The various origins of the cystic artery and its course with respect to Calot's triangle thus requires the attention of surgeons in order to avoid iatrogenic injury of the bile ducts and vessels.[6,9] The cystic artery usually arises from the right hepatic artery being lying right side of the common hepatic duct in Calot's triangle.[6,7] When the cystic artery originates being outside of Calot's triangle, it crosses anterior to the common hepatic duct. This condition may create complications during surgery.[5,6]

Common afflictions of the gallbladder include acute inflammations, ascending cholangitis, gallstone and pancreatitis. Treatment of these conditions may need surgical intervention in the region of Calot's triangle.[10] Injury to Bile duct, hepatic artery and cystic artery are not uncommon during cholecystectomy. As reported by Ahmad and Sylvia[11] 9% of all patients who were taken for laparoscopic cholecystectomy, were converted to standard open cholecystectomy and the main cause for this was found to be the variant anatomy of this region.[10] Thus it is crucial to become well aware about the variations which can exist within the Calot's triangle so as to minimize all possible intra and postoperative risks.[12]

MATERIALS AND METHODS

The present study was observational , cross-sectional study. In which 30 embalmed human cadavers were dissected at the Department of Anatomy of the Nepal Medical College and Kist Medical College of Kathmandu Valley, evaluated over a period of 1 year from NOV 2020 - NOV 2021, in the course of teaching and learning activities of undergraduate students. Investigator had collected the Ethical clearance letter and written application from Head of the Department of Anatomy for taking permission and for doing dissection in Kist Medical College. The peritoneal cavity were opened and explored. The lesser omentum was dissected and the subhepatic regions of the abdomen were exposed. The fundus of the gall bladder was held with a hand and pulled in a cephalic, lateral and anterior direction. After this, epiploic foramen was identified and the artery forceps was placed through the opening as a guide. The peritoneum covering the Calot`s Triangle were carefully opened, exposing the cystic duct, cystic artery and hepatic duct. The boundaries of calot's triangle were observed. The cystic artery was then followed to its origin. The origin, length, and course of the cystic artery along with its position with reference to Calot's triangle were noted recorded and photographed. Length was measured using a Vernier Caliper.[13] Data were entered and analyzed using SPSS-16.

List of abbreviations used in our study:

RHA - Right hepatic artery, PHA – Proper hepatic artery, GDA- Gastroduodenal artery, SMA- Superior mesenteric artery, AHA-Accessory hepatic artery, CA-Cystic artery , CHD- Common hepatic duct, BD- Bile duct, CD- Cystic duct, RHD- Right hepatic duct and LHD- Left hepatic duct

RESULTS

The boundary of the Calot's triangle was observed as an area bounded by the common hepatic duct medially, cystic duct laterally and liver superiorly (Fig. 1).

Out of 30 cadavers, in 27 (90.0%) cystic artery arose from right hepatic arteries (Fig. 1), one (3.3%) from proper hepatic artery (Fig. 2), one (3.3%) from superior mesenteric artery (Fig. 3) and one (3.3%) case from accessory hepatic artery (Fig. 4). Variations in the origin of cystic artery compared with other studies (Table 1).

Table 1: Variation in the origin of cystic artery compared with other studies

n	Studies	No. of Cadavers	Origin of Cystic A						
			RHA %	LHA %	PHA %	GDA %	CMA %	SMA %	ARHA%
1	Kankhare[5] 2016	40	70.0	50	7.5	1.0		5.0	
2.	Dandekar & danben[7] 2016	82	79.3	1.2	3.7	00	2.5	00	
3.	Flisinski [9] 2004	34	82.3	5.9	0.0	3.0	0.0	0.0	
4	Ombe I[13] 2019	32	87.5	31.0	9.4				
5	Chen TH[14] 2000	72	76.6	0.0	0.0	0.0	0.0	0.0	
6	Futara [15] 2001	110	75.5	4.5	0.0	7.3			
7	Saidi H [16] 2007	102	92.2	0.0	7.8	0.0			
8	Khalim [17] 2008	60	90.0	3.0	2.0	2.0	2.0		
9	Bakheit [18] 2009	160	78.0	2.0		3.0	17.0		
10	Puspathala[19] 2010	50	54.0	0.0	22.0	8.0	12.0	4.0	
11	Tejaswiet [21] 2013	100	92.0	1.0	0.0	1.0	0.0	0.0	
12	Aristol [22] 2014	40	95.0	0.0	5.0		2.5		
13	Desila and fed[23] 2014	50	96.0				4.0		
14	Abeysaiya[25] 2016	200	100.0	0.0	0.0	0.0			
15	Present study	30	90.0		3.3			3.3	3.3

LHA- Left hepatic artery, GDA- Gastroduodenal artery and CHA- Common hepatic artery

Out of 30 cadavers, the cystic artery was passing within Calot's triangle in 29 specimens (96.7%) but in 1 specimen (3.3%) the cystic artery was outside the Calot's triangle. Comparison of the course of cystic artery to the calot's triangle with other studies were also mentioned (Table 2).

Out of 30 cadavers, in 26 cases (86.7%) cystic arteries were observed as passing posterior to the common hepatic duct (Fig. 1). Out of 26 cases, in 25 cases (83.3%) cystic arteries arose from RHA and 1 (3.3%) cystic artery arose from SMA (Fig. 3). Further in 2 cases (6.7%) cystic arteries were found anterior to the common hepatic duct and among them in 1 case (3.3%) it was arising from PHA (Fig. 2) and 1 case (3.3%) was found to be from the ARHA (Fig. 4).

Result also showed as in 1 case (3.3%) cystic artery was found anterior to the bile duct arising from RHA lying outside the calot's triangle, (Fig. 5). In 1 case (3.3%) between right and left hepatic duct arising from RHA (Fig. 6). Comparison of different studies concerning the course of cystic artery with regard to hepatobiliary ducts were shown in Table 3.

Fig. 1: Boundaries of the Calot's triangle. Bounded by the common hepatic duct medially, cystic duct laterally and liver superiorly and CA and RHA lying posterior to the common hepatic duct. CA arising from the right hepatic artery.

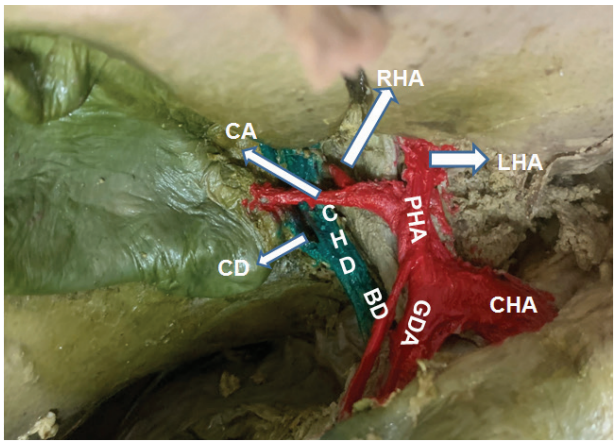

Fig. 2: Cystic artery arising from the Proper hepatic artery, lying anterior to the Common hepatic duct within the calots triangle.

Table 2: Comparison of the course of cystic artery to the Calot's triangle with other studies.

n	Studies	Number of cadavers	Relationship to the Calot's triangle	
			Inside %	Outside %
1.	Kankhare[5] 2016	40	95.0	5.0
2.	Dandekha and dander[7] 2016	82	96.4	3.6
3.	Flisinki[9] 2004	34	65.0	35.0
4.	Ombe I[13] 2019	32	84.3	9.4
5.	Chen TH[14] 2000	72	86.1	13.9
6.	Futura[15] 2001	110	81.0	190
7.	Bakheit[18] 2009	160	32.0	68.0
8	Rahman K[20] 2012	60	96.6	3.3
9	de Silva[23] 2014	50	100.0	0.0
10	Rasid A[24] 2015	176	76.4	23.9
11	Abeysaiya[25] 2016	200	89.0	21.0
12	Present study 2021	30	96.7	3.3

Table 3: Comparison of different studies concerning the course of cystic artery with hepatobiliary duct.

Authors	Number of samples studied	Relation of cystic artery with hepatobiliary ducts		
			Anterior (%)	Posterior (%)
Kankhare[5] *et al* 2016	40	Common hepatic duct Cystic duct	10.0	90.0
Dandekar and Dandekar[7] 2016	82	Common hepatic duct Bile duct	26.8 1.2	6.1 3.7
Flinsinski *et al*[9] 2004	34	Common hepatic duct	29.4	67.7
Chen[14] 2000	72	Common Hepatic duct	27.3	72.7
Bakheit[18] 2009	160	Common hepatic duct Cystic duct bile duct	7.0 53.0 2.0	25.0 13.0
Saidi[16] *et al* 2007	102	Common hepatic duct	45.1	46.1
Abeysuriya[25] *et al* 2016	200	Common hepatic duct Cystic duct	5.0 1.0	89.0
Our study	30	Common hepatic duct Bile duct In between right and left hepatic duct.	6.7 3.3 3.3	86.7*
*Out of 86.7%, 83.3% cystic artery arose from RHA and 3.3% cystic artery arose from SMA.				

In our study the mean length of cystic artery was 11.47 mm and ranged between 4.41 mm to 17.80 mm, in 27 cases (90.0%) which were arose from RHA. The length of the cystic arteries one in each cases were found to be measured as 15.88 mm, 27.49 mm and 24.17 mm respectively which were arising from AHA, PHA and SMA. Length of the cystic arteries with respect to their origin demonstrated in Table 4.

Table 4: Length of the cystic artery with respect to origin.					
Source of origin	**No of cases**	**Mean length (mm)**	**Minimum length (mm)**	**Maximum length (mm)**	**SD**
RHA	27	11.47	4.41	17.80	3.641
ARHA	1	15.88	15.88	15.88	-
PHA	1	27.49	27.49	27.49	-
SMA	1	24.17	24.17	24.17	-

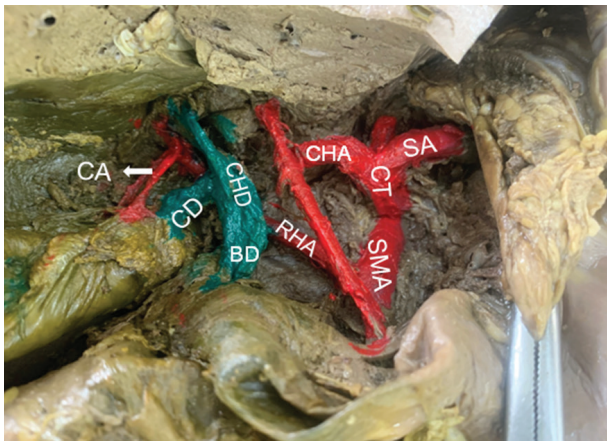

Fig. 3: Cystic artery arising from superior mesenteric artery lying, anterior to the common hepatic duct and within the calots triangle.

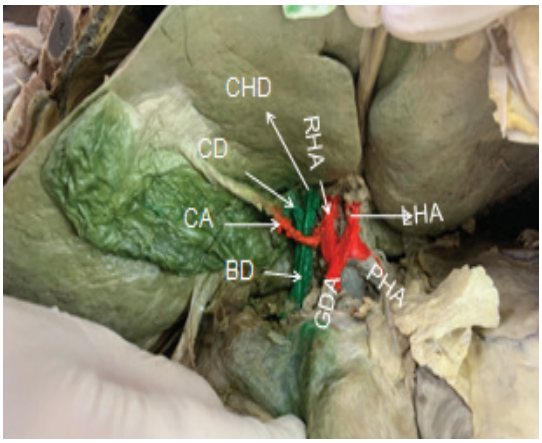

Fig. 5: Cystic artery arising from right hepatic artery and lying outside the calots triangle and running anterior to the bile duct .

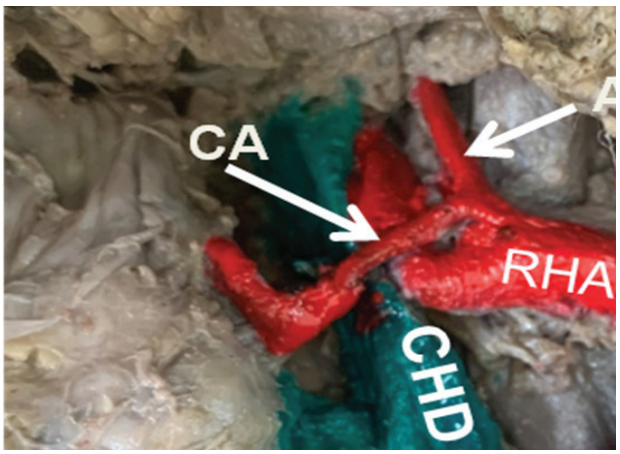

Fig. 4: Cystic artery arising from accessory hepatic artery and lying anterior to the common hepatic duct within the calot's triangle.

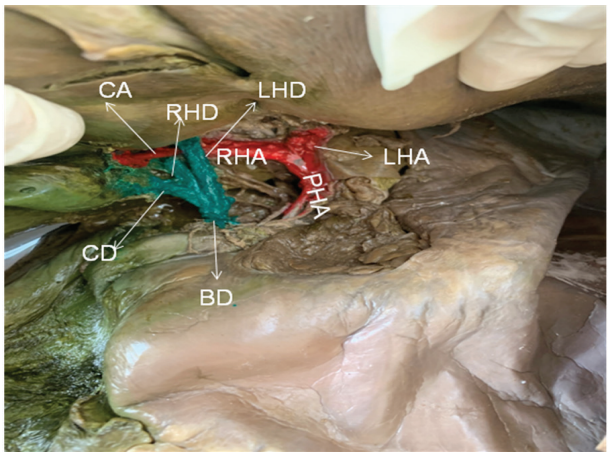

Fig. 6: Cystic artery arising from right hepatic artery and running between right and left hepatic artery.

DISCUSSION

There are various variations observed related to course of cystic artery in relation to calots triangle as recorded from different literature reviews. In literature reviews it was observe most common source of origin of cystic artery are 100.0% , 96.0%, 95.0% and 92.0%, originating from right hepatic artery,[21-23,25] respectively.

In the present study the origin of cystic artery found to be 90.0% from RHA. Thus result of the present study is similar to that of study conducted by Abeyasaia,[25] de Silva[23] but our result is different from the study reported from India.[19] They found the origin of the cystic artery from RHA only in 54.0%.

Other literature review showed that the origin of the cystic artery from ARHA in 3.3%,[11]

4.0%,[21] and the least common sources observed were from the LHA in 1.0%.[21] In the present study source of origin of the cystic artery from ARHA in 3.3% and 3.3% From the PHA.

In our study the origin of the cystic artery from gastroduodenal artery was not found where as reported by Kankhare,[5] Flisinski,[9] Ahmed M,[11] Future,[15] Puspathala,[19] Tejaswi,[21] it was found to be 1.0%, 2.94%, 1.7%, 7.3%, 8.0% and 1.0% respectively (Table 1).

During the course of review , it was also noted that cystic arteries arising from RHA was running posterior to common hepatic duct in 72.7%[14] and 63.3%[11] and in our study 83.33% cystic artery arose from RHA running posterior to common hepatic duct.

The CA traveled anterior to the CHD to supply the GB in 13.3%[11] and 27.3%[14] respectively. In our study also in 2cases (6.7%) cystic artery were found anterior to the common hepatic duct. Nagral[10] mentioned that usually CA's which originate from sources other than the RHA, tend to pass anteriorly to ductal structures and are thus more prone to injury.

As per literature review the cystic artery was found anterior to the bile duct 1.2%[7] and 2.0%[18] respectively whereas in present study 3.3% cystic artery was found lying anterior to the bile duct (Table 3).

Cystic artery originating from accessory RHA (from SMA) was observed entering to the gallbladder along the posterior surface of the CHD In 13.3%[7] and 1 case[10] as observed by various authors whereas in our study, 3.3% cystic artery which was originated from Accessory right hepatic artery, was noted to be originating directly from SMA was found lying posterior to the bile duct.

The cystic artery was found inside the calots triangle ranging from 65.0% to 100.0% [5,7,13,14,20,21,23,25] as noted by different investigator where as result of the present study that is 96.67% and it is found to be similar to studies of Desliva[23] and Rahman.[20]

As per study of previous authors, the cystic artery was found outside the calot's triangle ranging from 0.0% to 35.0%[7,13,14,20,21,25] as described where as in the present study we recorded as 3.3% (in 1 case).

The mean length of the cystic artery originating from RHA was 17.6 mm[21] and ranging between 3.7 mm to 42[21] mm, out of the 100 dissected specimens were studied in the literatures but in our study the mean length of cystic artery was 11.46 mm and ranging between 4.41mm to 17.80 mm, in 27 specimens arising from RHA.

Thus with the established information and result of the Present study adds to the existing knowledge about the anatomical variations associated with the arterial supply of gall bladder. In conclusion the, knowledge of variations in the origin and course of the cystic artery is essential in performing cholecystectomy (open or laparoscopic). Hence, it is important for the biliary and minimally invasive surgeons to appreciate the basic anatomical facts and to have a sound knowledge of anatomical variations of the cystic artery thereby minimizing the chances of complications during surgical procedure.

Conflict of interest: None

Source of research fund: None

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