Original Article

DOI: 10.7860/IJARS/2023/59640.2875

Anatomy Section

Variations of Cystic Artery Supplying the Gallbladder and its Surgical Importance: A Cadaveric Study from Tamil Nadu, India

K SANGAMESWARAN

ABSTRACT

Introduction: Symptomatic cholelithiasis is usually treated by cholecystectomy. Cystic Artery (CA) should be ligated prior to removal of gallbladder during cholecystectomy. CA arises from Right Hepatic Artery (RHA) posterolateral to common hepatic duct inside Calot's triangle but variations of CA are very common. If surgeons fail to identify these variations during cholecystectomy, this artery is more prone to iatrogenic injury leading the profuse bleeding.

Aim: To study the variations of CA in terms of its origin, number, length, course and its relation with the biliary ductal system and Calot's triangle.

Materials and Methods: The present cross-sectional study was conducted in the department of Anatomy, Government Tiruvannamalai Medical College, Tamil Nadu, India from August 2019 to July 2022. Forty adult cadaveric liver specimens with intact vasculature of gallbladder were dissected and the variations of CA were noted. Length of CA was measured by using Vernier caliper, and it's descriptive statistics like range, mean, Standard Deviation (SD) were evaluated by using Microsoft excel 2019 software.

Results: The CA arose from RHA in 33 (82.5%), from replaced RHA in 2 (5%), from Left Hepatic Artery (LHA) in 2 (5%), from Proper Hepatic Artery (PHA) in 2 (5%), and from Common Hepatic Artery (CHA) in 1 (2.5%) specimens. Its mean length ±SD was 2.6±0.35 cm. CA was single in 39 specimens (97.5%) (38 single CA inside Calot's triangle, one single CA was outside of Calot's triangle). Double cystic arteries were seen in only one specimen (2.5%) and forming compound type of relation with Calot's triangle (one CA was outside of Calot's triangle and the other one was inside of that triangle) in it. CA was superomedial to Cystic Duct (CD) in 34 (85%) specimens. This artery was passing anterior and posterior to common hepatic duct in 6 (15%) and 2 (5%) specimens, respectively.

Conclusion: The overall prevalence of variations in different parameters of CA in the present study was found to be high as 35%.

Keywords: Calot's triangle, Cholecystectomy, Hepatic artery, Prevalence

INTRODUCTION

Gallbladder and biliary ductal system form the extrahepatic biliary apparatus. Gallbladder stores the bile and concentrates it to about ten times [1]. Gallbladder stones (cholelithiasis) are one of the commonest clinical problems encountered now-a-days, and it affects approximately 10-15% of the population [2]. Symptomatic cholelithiasis is usually treated by cholecystectomy (surgical removal of gallbladder). Laparoscopic cholecystectomy is preferred over open cholecystectomy because of its advantages like shorter period of hospitalisation and faster recovery [3]. But in any form of cholecystectomy, the most important step is clamping CA and CD prior to removal of gallbladder [1]. So, adequate knowledge about anatomy of CA and CD is very important for surgeons.

The CA gives blood supply to gallbladder. Usually, after reaching superior aspect of neck of gallbladder, CA divides into superficial and deep terminal branches. There is no corresponding parallel vein to CA [4]. CA arises as a branch of RHA inside cystohepatic (Calot's) triangle. Calot originally described CA itself as the superior boundary of this triangle in 1891 [5]. In the modern surgical era, this triangle is bounded superiorly by inferior border of liver, medially by common hepatic duct and inferiorly by CD [6]. Usually RHA, CA and the cystic lymph node of lung are the contents of this triangle [1].

As anatomical variations in and around of cystohepatic triangle are frequent, careful dissection of Calot's triangle is necessary for both conventional and laparoscopic cholecystectomy [7]. Variations in the vascular supply of the extrahepatic biliary tree are more common than the ductal variations [8]. CA shows the second most common arterial variations of hepatic pedicle next to the RHA [9] and commonly variant origins are found such as it can originate from any artery in the vicinity of the biliary apparatus, but usually arises from RHA [10]. In addition, CA shows many variations in its number, course, and its relations with the biliary ducts [10]. Prevalence of the findings of CA differed between different Indian studies as well as foreign studies [7,9,10]. Thus, it is difficult to predict the exact prevalence of anatomical variations of CA both within and outside India. So, careful vigilance is needed by the surgeons all over the world when they approach Calot's triangle during cholecystectomy to avoid any iatrogenic injury to CA and biliary ducts.

Hence, the present study was conducted to study the variations of CA in terms of its origin, number, length, course and it's relation with the bile ducts and Calot's triangle.

MATERIALS AND METHODS

The present cross-sectional study was conducted in the Department of Anatomy, Government Tiruvannamalai Medical College, Tamil Nadu, India from August 2019 to July 2022. This study was done in donated cadaveric liver specimens only (not involving any patients and animals), and hence, ethical clearance exemption was given to this study by Ethical Committee of the Institution (Proposal No.IEC- 01/2022 GTVMMC&H/IEC-EC/NEW/ INST/2020/491 dated 27.01.2022).

Inclusion criteria: Forty adult liver specimens with intact vasculature of gallbladder were included.

Exclusion criteria: Structurally damaged specimens and paediatric specimens were excluded from the study.

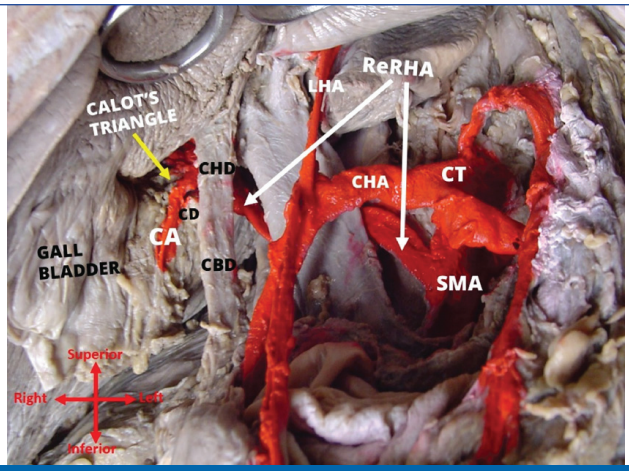
Study Procedure

The 40 specimens were dissected from 40 adult cadavers (22 male and 18 female cadavers) of Tamil Nadu. The age of these cadavers was

ranging from 42 to 77 years, and these cadavers were donated to the Institution for the study and research purposes. Meticulous dissection was done as per the method given in Cunningham's manual of practical anatomy [11]. In the dissection, the peritoneal cavity was opened and explored, and the lesser omentum was dissected and the subhepatic region of the abdomen was exposed. Coeliac trunk was dissected to find out the origin and course of hepatic artery and CA. Biliary ductal system and Calot's triangle were dissected to find out the relation with the CA. Cystic arterial variations in the following parameters such as origin, length, number, course and its relations with the bile ducts and Calot's triangle were noted and photographed.

Ignjatovic D et al., described three types of CA depending upon it's relation with Calot's triangle such as type 1 (single CA in Calot's triangle), type 2 (more than one CA in Calot's triangle) and type 3 (no CA in Calot's triangle) [12]. Presence or absence of these three types of CA was explored in the present study, and the prevalence of these types was noted.

Vernier caliper was used for measuring the length of CA, and the unit of measurement in vernier caliper was in millimeters.



[Table/Fig-2]: Origin of Cystic Artery (CA) from aberrant (replaced) Right Hepatic Artery (ReRHA), the latter was coming as a branch from superior mesenteric artery. CA: Cystic artery; ReRHA: Replaced (aberrant) right hepatic artery; SMA: Superior mesenteric artery; CHA: Common hepatic artery; LHA: Left hepatic artery; CT: Coeliac trunk; CD: Cystic duct; CHD: Common hepatic duct; CBD: Common bile duct

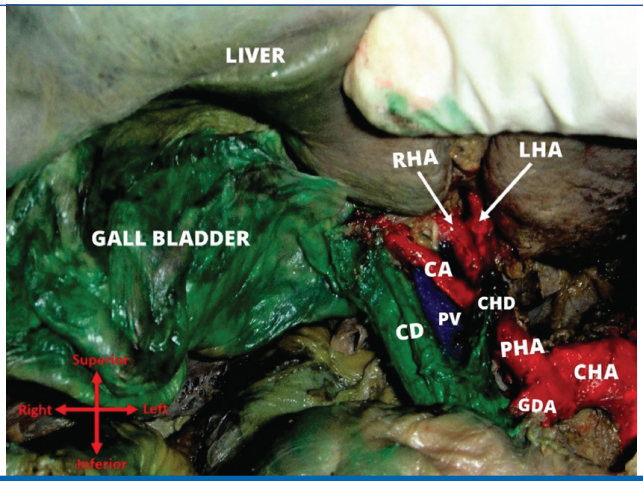
STATISTICAL ANALYSIS

The findings of the present study were statistically analysed and the results were presented as percentages. Variable (the length of CA) of all the specimens were measured, and its descriptive statistics like range, mean, SD were evaluated by using Microsoft excel 2019 software.

RESULTS

Out of 40 specimens (collected from 22 male and 18 female cadavers) of the present study, prevalence of variations in different parameters of CA was noted and the overall prevalence of all these variations of CA in the present study was found to be 35%. Female cadaveric specimens accounted for majority of these variations (20% in the overall prevalence of 35%), while male cadaveric specimens had less variations (15% in the overall prevalence of 35%). The age of the cadavers of present study was ranging from 42 to 77 years, and the mean age ±SD was 62±6.65 years.

The prevalence of variations in different parameters of CA (such as origin, number, length, the relation with bile ducts and Calot's triangle) are tabulated in [Table/Fig-1].



[Table/Fig-3]: Origin of Cystic Artery (CA) from Proper Hepatic Artery (PHA). CA: Cystic artery; PHA: Proper hepatic artery; RHA: Right hepatic artery; LHA: Left hepatic artery; CHA: Common hepatic artery; GDA: Gastroduodenal artery; CD: Cystic duct; CHD: Common hepatic duct; PV: Portal vein

Parameters	Findings of the present study				
Types of origin of CA	From RHA in 33 (82.5%) specimens	From aberrant RHA in 2 (5%) specimens	From LHA in 2 (5%) specimens	From PHA in 2 (5%) specimens	From CHA in 1 (2.5%) specimen
Number of CA	Single CA in 39 (97.5%) specimens		Double CA in 1 (2.5%) specimen		
Length of CA	Ranged between 2.2 to 2.9 cm in as majority as 34 (85%) specimens		Mean length ±SD 2.6±0.35 cm	Shortest CA 1.5 cm	Longest CA 3.7 cm
Relation of CA with CHD	CA passed anterior to CHD in 6 (15%) specimens		CA passed posterior to CHD in 2 (5%) specimens		
Relation of CA with CD	Superomedial to CD in 34 (85%) specimens	Anterior to CD in 3 (7.5%) specimens	Inferolateral to CD in 1 (2.5%) specimen	Not related with CD in 3 (7.5%) specimens	
Relation of CA with CBD	NIL				
Relation of CA with the Calot's triangle	CA present inside Calot's triangle in 38 (95%) specimens		CA present outside of Calot's triangle in 1 (2.5%) specimen	CA forms compound type of relation with Calot's triangle in 1 (2.5%) specimen	

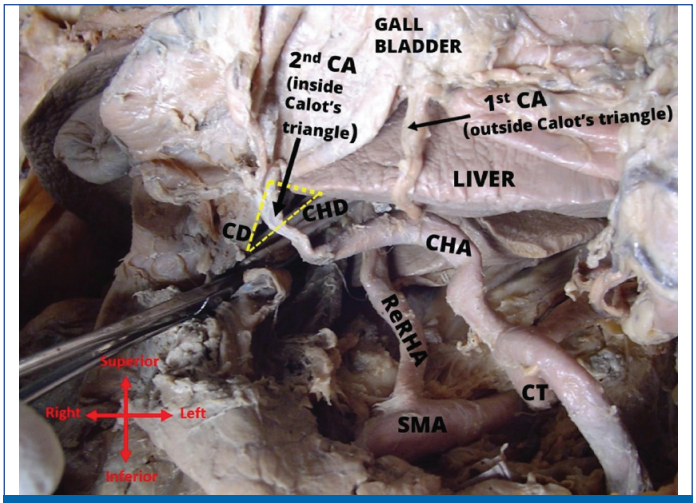
[Table/Fig-1]: Findings of the present study. CA: Cystic artery; RHA: Right hepatic artery; Aberrant RHA: Aberrant right hepatic artery; LHA: Left hepatic artery; PHA: Proper hepatic artery; CHA: Common hepatic artery; CHD: Common hepatic duct; CD: Cystic duct; CBD: Common bile duct

In the present study, out of total 40 specimens, origin of CA from RHA was found in 33 (82.5%) specimens, from aberrant (replaced) RHA in 2 (5%) specimens [Table/Fig-2], from PHA in 2 (5%) specimens [Table/Fig-3], from LHA in 2 (5%) specimens, and from CHA was found in 1 (2.5%) specimen. Which 1 (2.5%) specimen in which CA was arising from CHA, had double CA, and in that specimen both CA were arising from CHA only [Table/Fig-4]. Remaining 39 (97.5%) specimens had single CA only.

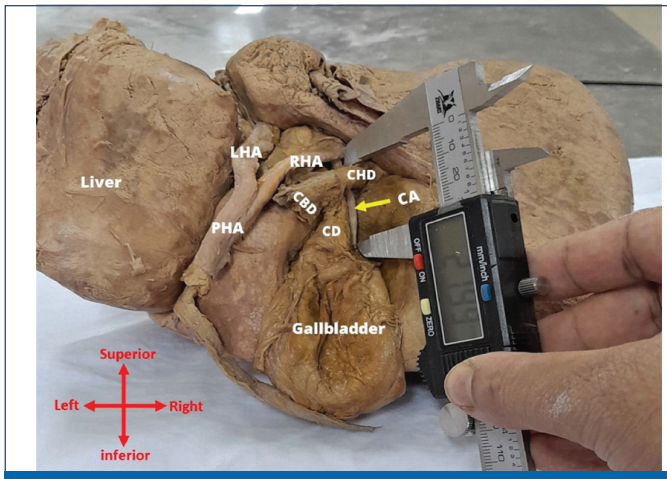
The length of CA was ranging from 1.5 to 3.7 cm in this study of 40 specimens, with majority (n=34) between 2.2 to 2.9 cm. Mean length of CA was 2.6±0.35 cm [Table/Fig-5].

According to the Ignjatovic D et al., classification of three types of CA, type 1 (single CA in Calot's triangle) was found in 39 (97.5%) specimens of the present study while type 3 (no CA in Calot's triangle) was present in the remaining 1 (2.5%) specimen [Table/Fig-6] of the present study [12]. Type 2 (more than one CA in Calot's triangle) was absent in the present study.

In 1 (2.5%) specimen of single CA neither origin nor course of CA was present inside Calot's triangle [Table/Fig-6]. Single CA travelled through Calot's triangle in 38 (95%) specimens of the present study. Thus, CA was present inside Calot's triangle in these 38 specimens. But in 8 (20%) of these 38 specimens, it was noted as

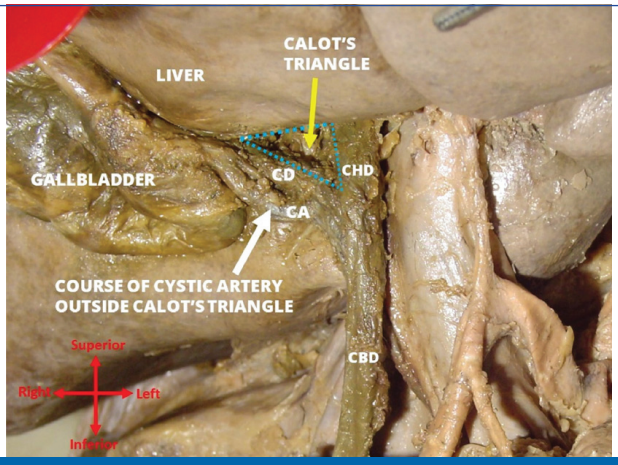


[Table/Fig-4]: Origin of double cystic arteries from CHA. Compound type of relation with Calot's triangle {1st Cystic Artery (CA) travels outside of Calot's triangle and 2nd Cystic Artery (CA) travels through Calot's triangle}.
1st CA: 1st cystic artery; 2nd CA: 2nd cystic artery; CHA: Common hepatic artery; CT: Coeliac trunk; SMA: Superior mesenteric artery; CHD: Common hepatic duct; CD: Cystic duct; ReRHA: Replaced right hepatic artery

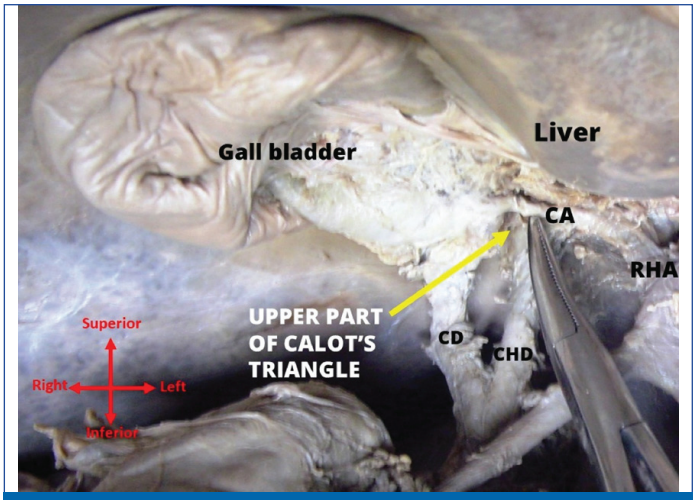


[Table/Fig-5]: Measuring the length of cystic artery in millimeters by using Vernier caliper.
CA: Cystic artery; PHA: Proper hepatic artery; RHA: Right hepatic artery; LHA: Left hepatic artery; CD: Cystic duct; CHD: Common hepatic duct; CBD: Common bile duct

after originating outside of Calot's triangle CA entered into Calot's triangle by passing either anterior to CHD as in 6 (15%) specimens [Table/Fig-7] or posterior to CHD in 2 (5%) specimens. In the remaining 30 (75%), of these 38 specimens both origin and course of CA was seen inside Calot's triangle only [Table/Fig-2,3]. In one specimen with double cystic arteries, compound type of relation of CA with Calot's triangle (i.e., 1st CA travelled outside Calot's triangle throughout its course, but 2nd CA entered inside this triangle.



[Table/Fig-6]: Presence of Cystic Artery (CA) outside of Calot's triangle. Here Cystic Artery (CA) travels inferolateral to Cystic Duct (CD).
CA: Cystic artery; CD: Cystic duct; CHD: Common hepatic duct; CBD: Common bile duct



[Table/Fig-7]: Cystic artery travels in the upper part of Calot's triangle (after crossing anterior to common hepatic duct), but Cystic artery is not related with cystic duct.
RHA: Right hepatic artery; CD: Cystic duct; CHD: Common hepatic duct

The CA was located superomedial to CD in 34 (85%) specimens [Table/Fig-2,3], anterior to CD in 3 (7.5%) specimens which included 2nd CA of double cystic arteries also and inferolateral to CD in 1 specimen (2.5%) [Table/Fig-6]. But CA was not related with CD in 3 specimens (7.5%) [Table/Fig-7] which included 1st CA of double cystic arteries also.

DISCUSSION

The CA shows many variations in its origin, number, length, and it's relation with the biliary ducts and Calot's triangle. Failure to notice these variations of CA by the surgeons during laparoscopic cholecystectomy may result in accidental iatrogenic damage to CA and profuse bleeding. This bleeding may reduce overall visibility in the surgically approached area, and may lead to iatrogenic injury to biliary ducts. The resulting bile leakage may urge the situation to convert it from laparoscopic cholecystectomy into open cholecystectomy [13].

Although latest techniques like laparoscopic ultrasonography, laparoscopic doppler and tactile sensor probe can identify biliary ductal and arterial anatomy peroperatively, these techniques are costly and currently not available everywhere. So there is certainly no alternative to meticulous dissection and clear definition of anatomy [14].

Usually, CA arises as a branch from RHA in most of the cases. Sometimes CA may arise from other arteries such as aberrant RHA, CHA, PHA, LHA, gastroduodenal artery and superior mesenteric artery [7,15-19]. During development, the extrahepatic biliary system arises from an intestinal diverticulum, which carries a rich supply of vessels from aorta, coeliac trunk and superior mesenteric artery. Later most of these vessels are degenerated, leaving in place the mature vascular system. As the pattern of degeneration is highly variable, it is not unusual for CA to derive from any artery other than RHA in the vicinity [20]. So the surgeons have to check thoroughly the neighbour arteries of hepatobiliary region to rule out the possibility of aberrant origin of CA from those arteries. Incidence of different types of origin of CA in the present study had been compared with the other studies [7,15-19] conducted inside and outside India in [Table/Fig-8].

Usually CA is single in number. Rarely, it may be double. These double CA may arise from a single artery [18,21] or sometimes from two different arteries [22,23]. If surgeons fail to identify this extra artery of gallbladder during surgery, dangerous bleeding may be the unwelcome outcome when removing the gallbladder. High incidence of double CA was observed as 28% in a study by Dandekar U and Dandekar K and 13.3% by Gawali RA [7,24]. But 2.5% incidence of double CA present study is almost similar to incidence of 4% by Ramakrishna R and Tiwari S and 3% in study by Tejaswi HL et al., [10,15].

S. no	Authors name (year and place of study)	Samples size	Origin of CA from coeliacal RHA	Origin of CA from aberrant RHA (ReRHA)	Origin of CA from LHA	Origin of CA from PHA	Origin of CA from CHA	Origin of CA from GDA	Origin of CA from CT	Origin of CA from SMA
1	Tejaswi HL et al., [15] (2013, Mysore, Karnataka, India)	100	92%	4%	1%	2%	0%	1%	0%	0%
2	Dandekar U and Dandekar K [7] (2016, Dhamangaon, Maharashtra, India)	82	79.3%	12.1%	1.2%	3.7%	2.5%	0%	0%	0%
3	Kumari R et al., study [16] (2016, Ranchi and Darbhanga, India)	36	94.4%	0%	2%	2%	1.6%	0%	0%	0%
4	Khankhare Sonali B et al., study [17] (2016, Pune, India)	40	70%	0%	5%	0%	7.5%	10%	0%	5%
5	Abeysuriya V et al., [18] (2016, Srilanka)	200	100%	0%	0%	0%	0%	0%	0%	0%
6	Singombe I et al., study [19] (2019, Zambia)	32	87.5%	0%	3.1%	9.4%	0%	0%	0%	0%
7	Present study (2022, Tamil Nadu, India)	40	82.5%	5%	5%	5%	2.5%	0%	0%	0%

[Table/Fig-8]: Comparison of various studies for different origins of Cystic Artery (CA) [7,15-19].
CA: Cystic artery; RHA: Right hepatic artery; ReRHA: Replaced (aberrant) right hepatic artery; LHA: Left hepatic artery; PHA: Proper hepatic artery; CHA: Common hepatic artery; GDA: Gastroduodenal artery; CT: Coeliac trunk; SMA: Superior mesenteric artery

S. no.	Authors name (year and place of study)	Samples size	Range of length of CA	Mean length of CA
1	Tejaswi HL et al., study [15] (2013, Mysore, Karnataka, India)	100	0.37 to 4.2 cm	1.76 cm
2	Dandekar U and Dandekar K study [7] (2016, Dhamangaon, Maharashtra India)	82	0.2 to 5.5 cm	1.69 cm
3	Singombe I et al., study [19] (2019, Zambia)	32	2 to 6 cm	3.56±1.0285 cm
4	Present study (2022, Tamil Nadu, India)	40	1.5 to 3.7 cm	2.6±0.35 cm

[Table/Fig-9]: Comparison of the length of Cystic Artery (CA) of different studies [7,15,19].

Length of CA is one of the important factors playing big role in outcome of cholecystectomy, because a short CA may easily be avulsed when the surgeon apply traction to gallbladder during surgery. If RHA has caterpillar (moynihan's) hump it will come very close to gallbladder, and CA may inturn is extremely shorter in length in these patients. So surgeon may fail to notice this short CA, and may mistakenly identify RHA hump as CA and will ligate it [25]. It will lead to ischaemic damage of right functional lobe of liver. But this caterpillar hump variation of RHA with extremely short CA was not found in the present study. Length of CA has been compared with other studies in [Table/Fig-9] [7,15,19].

Careful dissection of cystohepatic (Calot's) triangle during cholecystectomy safeguards important structures of biliary system. CA usually arises inside cystohepatic triangle. But variations also are common. Ignjatovic D et al., [12] classification of CA into three types based upon it's relation with Calot's triangle, all the three types were found in Rashid A et al., study [26] but only types 1 and 3 were seen, and type 2 was absent in the present study.

Incidence of CA outside Calot's triangle was noted as 3.6% by Dandekar U and Dandekar K study, 35% by Tejaswi HL et al., 5% by Kankhare Sonali B et al., 9.4% by Singombe I et al., and 3.3% by Pradhan A et al., [7,15,17,19,27].

Ding YM et al., had classified CA into three groups such as Group 1 (CA present inside cystohepatic triangle), Group 2 (CA present outside of cystohepatic triangle), and Group 3 (Compound type) in their study [28]. Their study had been compared with Thampi S et al., study and the present study in [Table/Fig-10] [29]. So surgeons must search for the presence of CA outside Calot's triangle also during their routine exploration inside that triangle because that patient may have compound type of relation of CA with that triangle.

In Dandekar U and Dandekar K study, they noted the position of CA in upper part of cystohepatic triangle in 12.2% cases, in middle part of this triangle in 47.6% cases, and in lower part of that triangle in 36.6% cases in their study [7]. In the present study, CA was seen in the middle of cystohepatic triangle in 82.5% specimens, in upper part of this triangle in 10% specimens and in lower part of that triangle in 5% specimens.

Before dividing any structure and removing the gallbladder, surgeons should identify all three biliary ducts, as well as the cystic and hepatic arteries [6]. CA usually arises posterolateral to CHD inside of Calot's triangle. But the variations in its relation with the biliary ductal system are not uncommon. If any iatrogenic injury occurs to any of these ducts during laparoscopic cholecystectomy leads to bile leakage, which urges the situation to convert laparoscopic surgery into open surgery.

Sometimes CA originates outside Calot's triangle, and then it passes either anterior or posterior to CHD or CBD to enter this triangle. If CA passes anterior to any of these two ducts then automatically CA will be the first structure exposed while dissecting Calot's triangle during surgery. So there are more chances of accidental injury to CA during surgical exploration of cystohepatic triangle in these patients [30]. In Dandekar U and Dandekar K study, CA crossed CHD anteriorly in 26.8% and posteriorly in 6.1% cadavers [7]. In the present study, entry of CA into Calot's triangle by passing anterior to CHD (15% specimens) and posterior to CHD (5% specimens) were noted. In Dandekar U and Dandekar K study CA crossed common bile duct (CBD) anteriorly in 1.2% and posteriorly in 3.7% [7]. In Pradhan A et al., study CA passed in front of CBD in 3.3% cadavers [27]. But CA was not related with CBD in any specimen of the present study.

In study by Fateh O et al., CA was divided into four groups based on its relative position with CD such as CA superomedial to CD (90.59%), superolateral to CD (5.19%), anterior to CD (2.59%) and

S. no.	Authors name (Year & place of study)	Samples size	Group 1 (CA present inside Calot's triangle)	Group 2 (CA present outside Calot's triangle)	Group 3 (Compound type: CA present in both inside and outside of Calot's triangle)
1	Ding YM et al., study [28] (2007, China)	600	85.5%	13%	1.5%
2	Thampi S et al., [29] (2021, Kerala, India)	32	68.75%	28.13%	13%
3	Present study (2022, Tamil Nadu, India)	40	95%	2.5%	2.5%

[Table/Fig-10]: Classification of Cystic Artery (CA) based on its relation with Calot's triangle [28,29].

absence of relation of CA with CD (1.62%) [13]. In Singombe I et al., study CA was superomedial to CD in 93.7% cadavers and anterior to CD in 6.3% cadavers [19]. In the present study, also the most common position of CA was superomedial to CD (85%), but the least common position of CA was inferolateral to CD (2.5%). CA was anterior to CD in 7.5% specimens, and CA was not related with CD in 7.5% specimens in the present study.

Limitation(s)

If a study is done in living persons angiography can be done in them, and angiographic findings can be correlated with the findings seen during surgery for getting more reliable results. Since the present study was a cadaveric study this advantage was not possible. Smaller sample size was also a limitation for the present study.

CONCLUSION(S)

Overall prevalence of variations in different parameters of CA was noted as higher as 35% in the present study, and these variations of CA were common in women than men in this study. Also, a single person can have variations of CA in more than one of these parameters explored in this study. So surgeons should always expect arterial variations in and around Calot's triangle while doing cholecystectomy. For expecting more accurate results about variations of CA, the researchers can compare their findings with the radiological findings in their future studies.

REFERENCES

[1] Kulkarni NV, Clinical anatomy, 3rd Edition, Vol 2, India, Jaypee brothers medical publishers (p) ltd., 2016, pp.550-556.
[2] Satheesha NB, Soumya KV. A south Indian cadaveric study on the prevalence of gallstones. Kathmandu Univ Med J (KUMJ). 2020;18(72):340-43.
[3] Warchalowski L. The analysis of risk factors in the conversion from laparoscopic to open cholecystectomy. Int J Environmental Res Public Health. 2020;17(20):7571.
[4] Sediqi Y, Sahak T, Himmat A. Cystic vein and its clinical significance. International journal for research in biology & amp; Pharmacy (ISSN: 2208-2093). 2019;5(12):09-14.
[5] Kumar S, Joshi MK. Calot's triangle: Proposal to rename it as calot's region and the concept of 'Ducto-Arterial Plane'. Indian J Surg. 2015;77(Suppl 3):899-901.
[6] Moore KL. Clinically oriented anatomy, 8th edition, Philadelphia, Lippincott Williams & Wilkins, a Wolters Kluwer business, 2018, pp. 1203-04.
[7] Dandekar U, Dandekar K. Cystic artery: morphological study and surgical significance. Int J Anat Res. 2016;2016:7201858.
[8] Singh K, Singh R, Kaur M. Clinical reappraisal of vasculobiliary anatomy relevant to laparoscopic cholecystectomy. J Minim Access Surg. 2017;13(4):273-79.
[9] Andall RG, Matusz P, Du Plessis M, Ward R, Tubbs RS, Loukas M. The clinical anatomy of cystic artery variations: a review of over 9800 cases. Surg Radiol Anat. 2016;38(5):529-39.
[10] Ramakrishna R, Tiwari S. Cystic artery: An anatomic morphological study and its clinical significance. Natl J Clin Anat. 2019;8:10-13.
[11] Koshi R. Cunningham's manual of practical anatomy, 16th edition, Vol 2, Oxford, United Kingdom, Oxford university press, 2017.
[12] Ignjatovic D, Zivanovic V, Vasic G, Kovacevic-Mcilwainel. Cystic artery anatomy characteristics in minimally invasive surgical procedures. Acta Chir Iugosl. 2006;53(1):63-66.
[13] Fateh O, Wasi MS, Bukhari SA. Anatomical variability in the position of cystic artery during laparoscopic visualization. BMC Surgery. 2021;21(1):01-05.
[14] Zubair M, Habib L, Mirza RM, Cnanna MA, Yousuf M, Quraishy MS. Anatomical variations of cystic artery: telescopic facts. Med J Malaysia. 2012;67(5):494-96.
[15] Tejaswi HL, Dakshayani KR, Ajay N. Prevalence of anatomical variations of cystic artery in south indian cadavers. Int J Res Med Sci. 2013;1:424-28.
[16] Kumari R, Kumari S, Prasad A, Britto NJ, Nag S. Variations in origin and course of cystic artery and its relation with calot's triangle. IOSR J Dental Med Sci. 2016;15(7):24-27.
[17] Kankhare Sonali B, Patil Anjali D, Kate Sarika P. A study of an anomalous origin of cystic artery and its relation with calot's triangle - cadaveric study. Int J Cur Res Rev. 2016;8(15):39-42.
[18] Abeysuriya V, Kumarage S, Hasan R, Wijesinghe J. Morphological variations of cystic artery in triangle of calot in laparoscopic cholecystectomy: experience in tertiary care surgical unit in south Asian country. J Med Dental Sci Res. 2016;3:18-19.
[19] Singombe I, Nambule V, Mutalife F, Mutemwa S, Kafumukache E, Erzingastian K. A cadaveric study on variations of the cystic artery in the department of pathology, at the university teaching hospitals, Lusaka, Zambia. Afr J Anat. 2019;8(1):1438-43.
[20] Abebe Bekel A. Anatomical variations and clinical relevance of cystic artery: a brief review. Eur J Anat. 2020;24(1):69-74.
[21] Mazurek A, Juszczak A, Walocha JA, Pasternak A. Rare combined variations of the coeliac trunk, accessory hepatic and gastric arteries with co-occurrence of double cystic arteries. Folia Morphol (Warsz). 2021;80(2):460-66.
[22] Polguj M, Podgorski M, Hogendorf P, Topol M. Variations of the hepatobiliary vasculature including coexistence of accessory right hepatic artery with unusually arising double cystic arteries: case report and literature review. Anat Sci Int. 2014;89(3):195-98.
[23] Kavitha Kamath B. Dual cystic arteries in association with caterpillar hump of right hepatic artery- A case report and its surgical relevance. J Clin Diagn Res. 2015;9(7):AD01-02.
[24] Gawali RA. A study on variations of origin and course of cystic artery and its relation to the calot's triangle. Int J Med Pharmacol. 2014;5(3):15-19.
[25] Jansirani D, Mugunthan N, Phalgunan V, deep SS. Caterpillar hump of right hepatic artery: incidence and surgical significance. Natl J Clin Anat. 2012;1:121-24.
[26] Rashid A, Mushtaque M, Bali RS, Nazir S, Khuroo S, Ishaq S. Artery to cystic duct: a consistent branch of cystic artery seen in laparoscopic cholecystectomy. Anat Res Int. 2015;2015:847812.
[27] Pradhan A, Lama CP, Dhungel S. Study of variations in origin and course of cystic artery in relation to calot's triangle. Nepal Med Coll J. 2022;24(2):127-33.
[28] Ding YM, Wang B, Wang WX, Wang P, Yan JS. New classification of the anatomic variations of cystic artery during laparoscopic cholecystectomy. World J Gastroenterol. 2007;13(42):5629-34.
[29] Thampi S, Krishnapillai R, Murugesan R, Sarasammal SR, Govindapillai UK. Clinical significance of origin of cystic artery and its relations to calot's triangle. Natl J Clin Anat. 2021;10:35-40.
[30] Hugh TB, Kelly MD, Li B. Laparoscopic anatomy of the cystic artery. Am J Surg. 1992;163(6):593-95.

PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Anatomy, Government Tiruvannamalai Medical College, Tiruvannamalai, Tamil Nadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
K Sangameswaran,
350, Baba Veedu, Nethaji Nagar 1st North main road, Vengikkal, Tiruvannamalai, Tamilnadu, India.
E-mail: drsangames@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Aug 18, 2022
- Manual Googling: Nov 04, 2022
- iThenticate Software: Nov 07, 2022 (12%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Aug 12, 2022**
Date of Peer Review: **Sep 14, 2022**
Date of Acceptance: **Nov 08, 2022**
Date of Publishing: **Mar 01, 2023**