

## Original Research Article

# Prevalence of anatomical variations of cystic artery during laparoscopic cholecystectomy

Harpreet Singh, Navneen Kumar Singh\*, Roop Kishan Kaul, Aviral Gupta, Sunil Tiwari

Department of General Surgery, Teerthankar Mahaveer Medical College and Research Centre, Moradabad, Uttar Pradesh, India

**Received:** 17 May 2019

**Revised:** 04 September 2019

**Accepted:** 05 September 2019

**\*Correspondence:**

Dr. Navneen Kumar Singh,

E-mail: [harpreetsingh22081978@gmail.com](mailto:harpreetsingh22081978@gmail.com)

**Copyright:** © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

### ABSTRACT

**Background:** The objective of the present study was to observe prevalence of anatomical variations of cystic artery in patients with the aim of avoiding accidental damage during laparoscopic cholecystectomy.

**Methods:** Patients (n=600) who underwent elective laparoscopic cholecystectomy after written and informed consent between October 2015 to October 2018 at Teerthankar Mahaveer Medical College and Research Centre, Moradabad were followed prospectively. Laparoscopic cholecystectomies were performed with 04 port technique with patients under anesthesia. Cystic artery's anatomical variations with reference to triangle of calot in each patient undergoing the surgery was visualized through laparoscope and recorded.

**Results:** Several anatomic variations of cystic artery were seen under laparoscope. Our experience with 600 cholecystectomies revealed that in majority of patients (85.67%; n=514), cystic artery was present in the boundaries of triangle of Calot, followed by outside the triangle of Calot seen in 13.33% (n=80) patients, while compound type was found in only 1% patients (n=6).

**Conclusions:** Variations in the anatomy of cystic artery with reference to triangle of calot is seen very often. Knowledge of these variations helps in prevention of accidental hemorrhage during laparoscopic cholecystectomy. Cystic artery is present inside the triangle of calot in majority of cases. We found that classification suggested by You-Ming et al is very useful.

**Keywords:** Cystic artery, Laparoscopic cholecystectomy, Triangle of Calot

### INTRODUCTION

Laparoscopic cholecystectomy is one of the commonly done elective surgeries and is accepted as gold standard method of treatment for gall stone disease. Experience with laparoscopic cholecystectomy has evolved during last twenty years with advancements in fiber-optic technology. However, during initial days, iatrogenic injury to bile duct and hemorrhage from cystic artery was increasingly seen, as experience with the laparoscopic anatomy was lacking.<sup>1-3</sup> Rocko in 1981, described

variations in region of Calot. Boundaries of triangle of Calot are: lower surface of the liver, common hepatic duct (CHD) and cystic duct.<sup>4</sup>

Hugh proposed that triangle of Calot should be renamed as hepatobiliary triangle and branches of cystic artery supplying cystic duct should be named as Calot's arteries.<sup>5</sup>

During laparoscopic cholecystectomy, after gaining access to abdomen, identifying cystic artery is one of the

major steps during dissection of triangle of Calot. Gall bladder and its duct are chiefly supplied by cystic artery and, it has to be clipped for performing the surgery. Improper control of cystic artery leads to uncontrollable bleeding which obscures the operative field. It usually forces the surgeon to convert the laparoscopic procedure into open cholecystectomy, which often leads to morbidity. Studies have reported that due to blood vessel injuries, the incidences of conversion of laparoscopic cholecystectomy to open surgeries are up to 1.9% with 0.02% mortality.<sup>6,7</sup> This problem often arises due to variable anatomy of cystic artery in the Calot's triangle. Normally cystic artery arises from right hepatic artery. Sometimes it has variable origin and may arise from celiac plexus, gastro duodenal artery, left branch of hepatic artery, hepatic artery proper.<sup>8</sup> Knowledge of these variations help in prevention of accidental hemorrhage during laparoscopic cholecystectomy. Our study aimed to assess the prevalence of variations in the anatomy of cystic artery seen during laparoscopic cholecystectomy in Indian population and to evaluate suitable classification to be followed by the laparoscopic surgeons while performing the surgery.

## METHODS

A prospective observational study was performed after taking institutional ethical committee (IEC) clearance and due consent from patients at Teerthanker Mahaveer Medical College and Research Centre from October 2015 to October 2018.

600 patients with proven symptomatic gall stone disease on preoperative Ultrasonography, of more than 18 years of age, with normal liver function test and serum amylase and lipase levels, who consented to undergo elective laparoscopic cholecystectomy and participate in this study were included.

Exclusion criteria followed was patients who required conversion of laparoscopic procedure to open cholecystectomy, concomitant stones in common bile duct along with gall stones, gall bladder malignancy diagnosed preoperatively, >72 hours after the recent attack of acute cholecystitis and less than 6 weeks' time elapsed after the last attack of acute cholecystitis.

Laparoscopic cholecystectomy was performed with 04 port technique with patient under general anesthesia by experienced laparoscopic surgeons. Laparoscopic visualization of cystic artery was done. Position and variation in anatomy of cystic artery with regard to triangle of Calot and origin of cystic artery were noted.

We followed the classification as proposed by You-Ming et al which divides the variations in distribution of cystic artery into 3 groups. These groups are further divided into subgroups described below.<sup>9</sup>

Classification as proposed by Ding You-Ming et al is as follows:<sup>9</sup>

### Group 1

Cystic artery and its variations found inside the triangle of Calot. Cystic artery travels inside the triangle of Calot. Cystic artery can pass in front of cystic duct or behind the cystic duct or may be found in hepatoduodenal ligament

#### *Single cystic artery inside triangle of Calot*

Right branch of hepatic artery gives origin to single cystic artery (SCA). This artery travels inside the boundaries of Calot's triangle. At neck of gall bladder, it divides into 2 branches namely deep branch and superficial branch near gall bladder's neck. During laparoscopic cholecystectomy, this artery travels in a plane that is slightly deeper and immediately behind cystic duct.

#### *Double cystic artery present in triangle of Calot*

There are 2 cystic arteries (anterior and posterior) known as double cystic artery (DCA) originating from right hepatic artery. These 2 cystic arteries run in triangle of Calot. Delicate posterior cystic artery can get damaged during surgery.<sup>5</sup>

### Group 2

#### *Cystic artery and its variations found outside the triangle of Calot*

In this group, cystic artery does not travel inside the triangle of Calot, so it is not seen inside the Calot's triangle. Following 04 variants are seen under this group.

#### *Gastroduodenal artery giving rise to cystic artery*

Cystic artery travels outside the triangle of Calot. It is seen superficial to and anterior to cystic duct during laparoscopic surgery. This anatomical variant is prone to get damaged when peritoneal folds are dissected specially folds extending from Hartmann's pouch to hepatoduodenal ligament.

#### *Cystic artery arising from the variant right hepatic artery running parallel to cystic duct*

In these cases, cystic artery arises from hepatic artery which runs parallel to cystic duct and surgeon may get confused it with large cystic artery.<sup>10-12</sup>

#### *Cystic artery arising directly from parenchyma of liver*

Here, cystic artery travels in parenchyma of liver. It pierces gallbladder bed to supply gallbladder. In these cases surgeon should be careful while dissecting gall

bladder bed, especially fundus as damage to artery may lead to haemorrhage.

#### *Cystic artery originating from left hepatic artery*

In this type, cystic artery takes its origin from left hepatic artery. It pierces liver parenchyma to reach approximately midpoint of body of gall bladder and supplies gall bladder.

#### **Group 3**

Compound type (more than one blood supply to gall bladder). In this type, gall bladder has more than >1 source of blood supply. Arterial supply to gall bladder is

present both inside and outside the triangle of Calot.

#### **Statistical analysis**

The data obtained was noted in excel sheet and subjected to analysis using SPSS version 20. All the data was presented as number and percentage.

#### **RESULTS**

Out of 600 patients studied, we found 85.7% patients in Group 1, 13.33% in Group 2 and only 1% in Group 3 categories as per You-Ming et al classification of anatomical variation of cystic artery. Results in detail are presented in Table 1.<sup>9</sup>

**Table 1: Number of cases reported with anatomical variations of cystic artery in the study.**

Groups	Anatomical variations in cystic artery	No. of patients reported (out of 600 patients)	% of cases reported
<b>Group 1</b>	Cystic artery and its variations found inside the triangle of Calot	514	85.67
<b>Group 1 (a)</b>	SCA within Calot's triangle	426	71
<b>Group 1 (b)</b>	DCA within triangle of Calot	88	14.67
<b>Group 2</b>	Cystic artery and its variations found outside the triangle of Calot	80	13.33
<b>Group 2 (a)</b>	Cystic artery arising from gastroduodenal artery (low-lying cystic artery)	42	7
<b>Group 2 (b)</b>	Cystic artery arising from the variant right hepatic artery running parallel to cystic duct	28	4.66
<b>Group 2 (c)</b>	Cystic artery arising directly from the liver parenchyma (DLP)	10	1.67
<b>Group 2 (d)</b>	Cystic artery arising from the left hepatic artery (LHA)	0	-
<b>Group 3</b>	Compound type of cystic artery	6	1

#### **DISCUSSION**

There are anatomic variations inside and around the triangle of Calot which are frequently encountered (cystic artery, biliary tree), therefore Calot's triangle should be carefully dissected.<sup>13</sup> After the introduction of laparoscopic surgery, a great interest has been shown in vascularization of gall bladder.<sup>14</sup>

Surgeon dealing with laparoscopic cholecystectomy should be aware of variations in vascular supply of gall bladder especially of cystic artery. This prevents accidental damage to cystic artery and possible hemorrhage which may convert the procedure to open cholecystectomy.

Anatomy seen during laparoscopic cholecystectomy is disparate as visualized during open cholecystectomy due to following reasons as during laparoscopic cholecystectomy, sub-hepatic space gets opened up when fundus of gall bladder is pulled which moves the liver in upward direction; while performing open cholecystectomy, traction given on Hartmann's pouch is in downwards direction. This opens up anterior aspect of triangle of Calot. This is in contrast with laparoscopic

cholecystectomy where pull given on Hartmann's pouch is in upward direction which exposes posterior aspect of triangle of Calot and magnified view during laparoscopy gives better visualization of cystic artery.<sup>9</sup>

Ignjatovic et al described 3 types of cystic artery; type 1 was described as single artery in Calot's triangle; type 2 more than one artery in Calot's triangle and type 3 no artery in Calot's triangle.<sup>5</sup>

Balija et al described two groups; in group1, cystic artery, either single or double, was present in the triangle and in group 2 no artery was seen in the triangle on laparoscopic visualization.<sup>16</sup> He did not remark on cases where vessels were seen both inside and outside the Calot's triangle.

Suzuki has also pronounced the arterial anatomical variations in 3 groups. His description of vascular classification is based on laparoscopic visualization of arterial supply to the gallbladder while no comment has been made on their anatomical origin.<sup>11</sup>

We followed classification as proposed by You-Ming et al which divides variations in distribution of cystic artery in 3 groups with further sub-groups, as aforementioned.<sup>9</sup>

The present study revealed synonymous results to the study by Farooq et al with regard to the 100% presence of cystic artery while little variation in results was seen in the investigation by Hassan and Taimur et al in which the cystic artery was absent in 3% of the patients.<sup>17-19</sup>

In our study, SCA within Calot's triangle which is the most common variant seen during laparoscopic cholecystectomy was present in 426 (71%) of the patients and DCA in 88 (14.67%) of the patients, which is synonymous to the results of the study by Farooq et al, who found SCA in 92.25% patients and double in 7.75% patients.<sup>8,17,20</sup> while Talpur et al found DCA in 1% of cases.<sup>21</sup>

In the present study we found normal positioned SCA in 71% (n=426) cases and variations in arterial supply were observed in 29% of patients. These observations are consistent with the findings of Suzuki and other authors, who described variations in the range of 23 to 28%.<sup>9,11,16,22</sup> The comparison of our findings with other authors' observations is shown in Table 2.

The commonest variation in our study was that of double arteries in Calot's triangle in 14.67% patients. This

pattern has been seen in 15 to 25% of many published studies but Suzuki has described this pattern in only 2.45% of his patients.<sup>9,11,16,22</sup>

We found arteries both within and outside the Calot's triangle in 1% of patients. This pattern is seen in 7.37% of Suzuki's patients, compared to 1.5% of patients by Ding who called this pattern a compound artery.<sup>9,11</sup> Balija has not described this pattern.

Cystic artery only outside the Calot's triangle was observed in 13.33% of our patients. This pattern was described in 5 to 13% of patients in different studies.<sup>9,11,16,22</sup>

The present study indicates there is a possibility of double CAs suggesting that one should always look for DCA during surgery in this region. Michel's stated that the superficial branch of double CA arose from the RHA, LHA, MHA, gastroduodenal artery, or retroduodenalartery.

Tripling of the CA is very rare and was encountered in only case by Michels and one case by Daseler et al.<sup>23,24</sup> In our study we did not come across akin variation.

**Table 2: Comparison of results of present study with previous studies.**

Arterial anatomy	Present study (n=600)	Ding et al (n=600) <sup>9</sup>	Suzuki et al (n=244) <sup>11</sup>	Balija et al (n=200) <sup>16</sup>	Zubair et al (n=220) <sup>22</sup>
	N (%)	N (%)	N (%)	N (%)	N (%)
<b>Group 1 (artery in Calot's triangle)</b>	514 (85.67)	513 (85.5)	193 (79.09)	189 (94.5)	192 (87.27)
<b>Group 1a (single artery)</b>	426 (71)	440 (73.3)	187 (76.6)	147 (73.5)	164 (74.5)
<b>Group 1b (double artery)</b>	88 (14.67)	73 (12.2)	6 (2.45)	31 (15.5)	26 (11.8)
<b>Group 2 (artery outside triangle)</b>	80 (13.33)	78 (13)	32 (13.11)	11 (5.5)	16 (7.27)
<b>Group 2 (b) (cystic artery arising from the variant right hepatic artery running parallel to cystic duct)</b>	28 (4.66)			11 (5.5)	2 (0.9)
<b>Group 3 (artery both within and outside triangle)</b>	6 (1)	9 (1.5)	18 (7.37)		12 (5.46)

The explanation for variant CA is found in the developmental pattern of the biliary system. In the course of fetal development, the gall bladder develops from hepatic diverticulum of the foregut which is sumptuously supplied by abdominal aorta and its initial branches. This is followed by varied pattern of degeneration of these vessels to form mature vascular system, perhaps causing variations of blood supply.<sup>25</sup>

Multitude of avant-garde techniques like laparoscopic ultrasonography, laparoscopic doppler and tactile sensor probe have been introduced to identify biliary and arterial anatomy per operatively, but these techniques are expensive and not available at all the centres. There is certainly no alternative other than meticulous dissection and clear definition of anatomy.<sup>9,22</sup>

## CONCLUSION

We have found that the classification proposed by You-Ming et al, is more practical during laparoscopic cholecystectomy. To prevent accidental haemorrhage while performing laparoscopic cholecystectomy, surgeon must know about variations seen with regard to cystic artery.

*Funding: No funding sources*

*Conflict of interest: None declared*

*Ethical approval: The study was approved by the Institutional Ethics Committee*

## REFERENCES

- Gadacz TR. Update on laparoscopic cholecystectomy, including a clinical pathway. Surg Clin North Am. 2000;80:1127-49.

2. Tebala GD, Innocenti P, Ciani R, Zumbo A, Fonsi GB, Bellini P, et al. Identification of gallbladder pedicle anatomy during laparoscopic cholecystectomy. *Chir Ital.* 2004;56:389-96.
3. Hjelmqvist B. Complications of laparoscopic cholecystectomy as recorded in the Swedish laparoscopy registry. *Eur J Surg Suppl.* 2000;585:18-21.
4. Rocko JM, Di Gioia JM. Calot's triangle revisited. *Surg Gynecol Obstet.* 1981;153:410-4.
5. Hugh TB, Kelly MD, Li B. Laparoscopic anatomy of the cystic artery. *Am J Surg.* 1992;163:593-5.
6. Thompson JE, Bock R, Lowe DK, Moody WE. Vena cava injuries during laparoscopic cholecystectomy. *Surg Laparosc Endosc.* 1996;6:221-3.
7. Deziel DJ, Millikan KW, Economou SG, Doolas A, Ko ST, Airan MC. Complications of laparoscopic cholecystectomy: a national survey of 4,292 hospitals and an analysis of 77,604 cases. *Am J Surg.* 1993;165:9-14.
8. Chen TH, Shyu JF, Chen CH, Ma KH, Wu CW, Lui WY, et al. Variations of the cystic artery in Chinese adults. *Surg Laparosc Endosc Percutan Tech.* 2000;10:154-7.
9. 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.
10. Badshah M, Soames R, Nawab J, Baloch FA, Khan J, Hasnain J. The anatomical relationship of cystic artery to Calot's triangle. *J Med Sci.* 2016;24(4):199-201.
11. Suzuki M, Akaishi S, Rikiyama T, Naitoh T, Rahman MM, Matsuno S. Laparoscopic cholecystectomy, Calot's triangle, and variations in cystic arterial supply. *Surg Endosc.* 2000;14:141-4.
12. Scott-Conner CE, Hall TJ. Variant arterial anatomy in laparoscopic cholecystectomy. *Am J Surg.* 1992;163:590-2.
13. Larobina M, Nottle PD. Extrahepatic biliary anatomy at laparoscopic cholecystectomy: is aberrant anatomy important? *ANZ J Surg.* 2005;75:392-5.
14. Mlakar B, Gadzijev EM, Ravnik D, Hribernik M. Anatomical variations of the cystic artery. *Eur J Morphol.* 2003;41:31-4.
15. Ignjatovic D, Zivanovic V, Vasic G, Kovacevic-Mcilwaine I. Cystic artery anatomy characteristics in minimally invasive surgical procedures. *Acta Chir Iugosl.* 2006;53:63-6.
16. Baliija M, Huis M, Nikolic V, Stulhofer M. Laparoscopic visualization of the cystic artery anatomy. *World J Surg.* 1999;23:703-7.
17. Farooq S, Jahan N, Arshad S. Anatomical variations of cystic artery during laparoscopic cholecystectomy; an audit of 400 cases of laparoscopic surgery for gall bladder pathologies at a tertiary care unit. *APMC.* 2019;13(1):72-5.
18. Hasan MA. Control of cystic artery in laparoscopic cholecystectomy: to clip or to use monopolar electrocautery. *PJMS.* 2011;27(5):981-4.
19. Taimur M, Hasan A, Ullah S, Masood R, Imran M. Vascular variations in the Calot's triangle seen on laparoscopic cholecystectomy. *PAFMJ.* 2011;61(4):1-4.
20. Baliija M, Huis M, Stulhofer M, Nikolic V. Contribution to the nomenclature of variations of the cystic artery. *Chirurg.* 2001;72:154-8.
21. Talpur KA, Laghari AA, Yousfani SA, Malik AM, Memon AI, Khan SA. Anatomical variations and congenital anomalies of extra hepatic biliary system encountered during laparoscopic cholecystectomy. *JPMA.* 2010;60(2):89-93.
22. Zubair M, Habib L, Mirza MR, Channa MA, Yousuf M, Quraishy MS. Anatomical Variations Of Cystic Artery: Telescopic Facts. *Med J Malaysia.* 2012;6(5):494-6.
23. Michels NA. The hepatic, cystic and retroduodenal arteries and their relations to the biliary ducts: with samples of the entire celiacal blood supply. *Ann Surg.* 1951;133(4):503-24.
24. Daseler EH, Anson BJ, Hambley CW, Reiman AF. The cystic artery and constituents of the hepatic pedicle. *Surg Gynecol Obstetr.* 1947;85(1):47-63.
25. Nowak M. Variation of the cystic artery in man. *Folia Morphologica.* 1977;36(2):89-98.

**Cite this article as:** Singh H, Singh NK, Kaul RK, Gupta A, Tiwari S. Prevalence of anatomical variations of cystic artery during laparoscopic cholecystectomy. *Int Surg J* 2019;6:3781-5.