Original Research Article

# To evaluate the incidence of double cystic artery: an observational study

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**Abstract**

**Aim:** The present study was conducted to find out the prevalence of double cystic arteries. **Methods:** This was a clinical retrospectively study conducted in the Department of General Surgery, AIIMS, Patna, Bihar, India from January 2019 to February 2020. Total 425 patients with symptomatic gallstones with benign gallbladder diseases, gallbladder polyps, previously known gallbladder inflammation, patients without bleeding clotting disorder, being over the age of 18, and patients who can be given general anesthesia induction and underwent laparoscopic cholecystectomy operation were include in this study. The characteristics and complications of the patients with double cystic artery were recorded and examined. **Results:** Out of 425 laparoscopic cholecystectomy performed, 100 male and 325 Female. The average age was 23-77(53.21). The double cystic arteries were detected in the operation of 3 males (3%) and 11 female patients (3.38%). The average age of these patients was 51.4±11.97.It was discovered from ultrasound reports that the indication for operation in 2 of the 14 patients with double cystic arteries was gall bladder polyp while it was multiple stones in the gallbladder for the rest of the patients. oral anti-diabetic-regulated diabetes mellitus was detected in 2 female patient, and hypertension was detected in 1 male patient. An epigastric hernia was detected in 2 patients other than gallstones and an epigastric hernia correction was performed simultaneously laparoscopically.3 of the 14 patients (21.43%) with double cystic arteries were switched from laparoscopic to conventional cholecystectomy due to bleeding during surgery. Bile duct injury was detected postoperatively in 2 male patients with a double cystic artery. The average duration of hospital stay of patients with a double cystic artery is 5.5(4-13) days, and (2.9 days) for patients without a double cystic artery. **Conclusion:** This study is emphasis the importance of a thorough knowledge of anatomy and recognition of variations of cystic artery are essential prerequisites for safe and uneventful laparoscopic cholecystectomy and can reduce uncontrolled intraoperative hemorrhage and extrahepatic biliary injury.

**Key words:** Cystic artery, Cholecystectomy, Gallbladder.



## Introduction

The cystic artery is known to exhibit variations in its origin and branching pattern. This is attributed to the developmental changes occurring in the primitive ventral splanchnic arteries.[1] The liver and gallbladder and biliary duct system arise as a ventral outgrowthhepatic diverticulum- from the caudal or. distal part of the forgut early in the 4th week of gestation. The hepatic diverticulum enlarges rapidly and divides in to two parts as it growth between the layers of ventral mesogastrium.

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The larger cranial part of the hepatic diverticulum is the primordium of the liver. The proliferating endodermal cells give rise to interlacing cord of hepatocytes and to epithelial lining of the intrahepatic part of the biliary apparatus. The small caudal part of the hepatic diverticulum becomes the gallbladder and the stalk of the diverticulum forms the cystic duct. Initially the extrahepatic biliary apparatus is occluded with epithelial cells, but it is later canalized because of vacuolation resulting from degeneration of these cells. The stalk connecting the hepatic and cystic ducts to the duodenum becomes the bile ducts.[2] The variations in anatomy of cystic artery based on its origin position and number are well described in various studies because of its importance in avoiding inadvertent bleeding and its consequences. The reported incidence of these variations is from 25% to 50%.[3] The cystic artery usually arises from the right hepatic artery (RHA). It usually passes posterior to the common

hepatic duct and anterior to the cystic duct to reach the superior aspect of the neck of the gallbladder. It divides into superficial and deep branches. The superficial branch ramifies on the inferior aspect of the gallbladder body, the deep branch on the superior aspect. These arteries Anastomoses over the surface of the body and fundus. An accessory cystic artery may arise from the common hepatic artery or one of its branches and the cystic artery often bifurcates close to its origin, giving rise to two vessels which approach the gallbladder. Multiple fine arterial branches may arise from the parenchyma of segments IV or V of the liver and contribute to the supply of the body, particularly when the gallbladder is substantially intrahepatic. This makes the gallbladder relatively resistant to necrosis during inflammation which otherwise occludes the cystic artery. The cystic artery gives rise to multiple fine branches which supply the common and lobar hepatic ducts and upper part of the common bile duct. These fine branches form a network which anastomoses with the vessels ascending around the common bile duct and with the vessels from the liver parenchyma which descend with the right and left hepatic ducts.[4] The aim of this study was to become familiar with vascular variations in laparoscopic cholecystectomy.

## Material and Methods

This was a clinical retrospectively study conducted in the Department of General Surgery, AIIMS, Patna, Bihar, India from January 2019 to February 2020.Total 425 patients with symptomatic gallstones with benign gallbladder diseases, gallbladder polyps (size >1 cm or multiple polyps), previously known gallbladder inflammation, patients without bleeding clotting disorder, being over the age of 18, and patients who can be given general anesthesia induction and underwent laparoscopic cholecystectomy operation were include in this study.

Patients who cannot be given general anesthesia induction, patients with bleeding-clotting disorders, patients with a known malignancy or who have undergone malignancy surgery and who have been followed up in oncology, patients who have undergone hepatobiliary surgery before and under 18 years of age were exclude from study.

Hospitalization indications of all patients included in the study, hepatobiliary ultrasound, additional diseases of patients, other operations performed concurrently with laparoscopic cholecystectomy, complications, reasons for switching from laparoscopy to conventional cholecystectomy and hospitalization times were recorded.

### Statistical analysis

The recorded data was compiled entered in a spreadsheet computer program (Microsoft Excel 2010) and then exported to data editor page of SPSS version 20 (SPSS Inc., Chicago, Illinois, USA). Descriptive statistics included computation of percentages, means and standard deviations were calculated. Statistical test applied for the analysis were student t-test and chi-square test. Level of significance was set at $p \leq 0.05$.

## Results

425 laparoscopic cholecystectomy performed in 3 years. 100 male and 325 female patients were included in the study. The average age was 23-77(53.21). The double cystic arteries were detected in the operation of 3 males (3%) and 11 female patients (3.38%). The average age of these patients was 51.4±11.97.It was discovered from ultrasound reports that the indication for operation in 2 of the 14 patients with double cystic arteries was gall bladder polyp while it was multiple stones in the gallbladder for the rest of the patients.

When the additional diseases of the patients were examined, oral anti-diabetic-regulated diabetes mellitus was detected in 2 female patients, and hypertension was detected in 1 male patient. An epigastric hernia was detected in 2 patients other than gallstones and an epigastric hernia correction was performed simultaneously laparoscopically. 3 of the 14 patients (21.43%) with double cystic arteries were switched from laparoscopic to conventional cholecystectomy due to bleeding during surgery. In the operation, the bleeding of the cystic artery located in the posterior of the cystic arteries was detected, it was revealed laparoscopically as the hepatic artery could not be distinguished and cholecystectomy was completed after the cystic artery was found to be double and the secretion of the hepatic artery was detected.

Bile duct injury was detected postoperatively in 2 male patients with a double cystic artery. Upon the detection of 300 ml bile fistula from the postoperative drain of the patient, the injury was detected with the help of MR- cholangiography, and a stent was placed in the common bile duct with the help of endoscopic retrograde cholangiopancreatography (ERCP).

The average duration of hospital stay of patients with a double cystic artery is 5.5 (4-13)days, and (2.9 days) for patients without a double cystic artery. The incidence of a double cystic artery was found to be 3.29 on average. (Table 1) Demographic data, clinical features of study participants and the result of the study is given in (Table 2). No mortality was detected in the operations of patients with double cystic arteries.

**Table- 1: Prevalence of number of cystic artery**

| Total no. of patients | Single cystic artery | Double cystic artery |
|---|---|---|
| 425 | 411 | 14 |

**Table 2: Demographic Profile of Patients**

| Group | | | | | |
|---|---|---|---|---|---|
| **Variables** | | **Single cystic artery (n=411)** | **Double cystic arteries (n=14)** | **Total (425)** | **P value** |
| **Age (in years)** | Min.-max. (median) | 23-77 (49.5) | 29-68 (55.2) | 23-77(53.21) | t:0.687 |
| | Mean±SD (mean) | 45.8±15.57 | 51.4±11.97 | 47.8±15.77 | [a]0.561 |
| **Gender** | Male | 97 (23.60) | 3 (21.43) | 100 (23.53) | $\chi^2$:0.671 |
| | Female | 314 (76.40) | 11 (78.57) | 325 (76.47) | [b]0.354 |
| **Indication** | Multiple stones | 411 (100) | 12 (85.71) | 423 (99.53) | $\chi^2$:3.184 |
| | Gallbladder polyp | 0 (0) | 2(14.29) | 2 (0.47) | [b]0.048* |
| **Switched from laparoscopic to conventional cholecystectomy** | No | 411(100) | 11(78.57) | 422 (99.30) | $\chi^2$:3.059 |
| | Yes | 0 (0) | 3(21.43) | 3 (0.70) | [b]0.041* |
| **Bile duct injury** | No | 411 (100) | 12(85.71) | 423 (99.53) | $\chi^2$:3.88 |
| | Yes | 0 (0) | 2 (14.29) | 2 (0.47) | [b]0.053* |
| **Hospital stay** | Days | 2.9(1-5) | 5.5 (4-13) | --- | t:0.537 |
| | [a]0.482* | | | | |

[a]Student-t test; [b]Pearson Chi-Square test; *p<0,05

## Discussion

The cystic artery often emerges from the right branch of the proper hepatic artery as a single vessel. In 75-80% of reported cases, the hepatobiliary triangle passes through Calot's triangle. When approaching the gallbladder, the cystic artery is divided into superficial and deep branches. These branches form anastomoses in the gallbladder parenchyma. Variations can be seen frequently during the origin and course of the cystic artery. During laparoscopic cholecystectomy, it was observed that mortality was 0.02% in 1.9% cases who suffered vascular damage. The knowledge of other possible variations in this region is essential for safe cholecystectomy.[5,6] In our study, it occurred in 3 patients who suffered intraoperative bleeding. However, it may have occurred in these patients due to the thought that the hepatic artery was injured. When the embryology of the cystic artery was examined, the developmental changes occurring in the primitive ventral splanchnic arteries affect the origin and branching of the cystic artery. In the 4$^{th}$ week of gestation, the liver, gallbladder, and bile ducts develop as a hepatic diverticulum from the caudal part of the stomodeum. Hepatic diverticulum grows rapidly and is divided into two parts between the ventral mesogastrium layers. The larger cranial part in hepatic diverticulum is the primordium of the liver. It extends between the hepatocyte cords with the proliferation of endodermal cells and creates intrahepatic bile ducts. The small caudal part of the hepatic diverticulum forms the gall bladder and the handle of the diverticulum forms the cystic duct.[7] Apart from the double cystic artery, it is essential to connect the cystic artery in laparoscopic cholecystectomy, and some anatomical landmarks should be considered for safe surgery. In conventional and laparoscopic cholecystectomy, it is necessary to know the triangle of Calot's well. The Calot's triangle is an important reference region for cholecystectomy. Rocko described the Calot's triangle formed by the cystic canal, common hepatic canal and lower edge of the liver in 1981. Rocko drew attention to possible variations in this triangle. Hugh renamed the Calot's triangle as a hepatobiliary triangle and named the small cystic artery branches feeding the gallbladder as the arteries of Calot's.[8] Anatomical landmarks in laparoscopic cholecystectomy have been reported mainly as Rouviere's sulcus, cystic lymph nodes, and arteries. Rouviere's sulcus was reported as a correct landmark for the common hepatic canal plane since the dissection of Calot's triangle was safe at the transverse level. When the facial strip in Calot's triangle is flattened, it can be defined as a pulsating structure with the presence of a cystic artery lymph

node. In addition, defining the cystic lymph node can help identify the cystic duct and cystic artery structures.[9] In our study, 2 of the patients with a double cystic artery was found to have a bile fistula, and it was learned that the patient was operated on the thought of acute cholecystitis.

In our study, the incidence of a double cystic artery was found to be 3.29 on average, while the incidence of double cystic artery ranged from 2 to 25%. However, different values were found in different populations. This condition is associated with the congenital absence of the deep branch of the cystic artery. In the study of Dandekar et al in 82 cadavers, a single cystic artery was in 72% and a double cystic artery was in 28%. Considering the origin of the cystic artery with reference to the Calot's triangle, it was observed that 62.2% were inside the triangle and 37.8% were outside. It was detected that cystic arteries passed through Calot's triangle except for 3.6% of them. It was found that the cystic artery passes in 26.8% of the cases in front of the common hepatic canal while 6.1% passes behind it.[10] In our study, it was observed that all the double cystic arteries pass through Calot's triangle, but there was no research about the origin of the double cystic artery.

Many of the studies on the incidence of double cystic artery have been done on cadavers. In the study performed by Ding et al in the Chinese people, in 3 of 600 patients (0.5%) double cystic artery approached the gall bladder from the outside of the hepatobiliary triangle.[11] Likewise, in the study of Suzuki et al it was in 13 of 244 patients (5.3%).[12] In the study conducted by Zubair et al on Pakistani population, it was in 26 of 220 patients (11.8%), Talpur et al in his study, the course of the double cystic artery was outside of the hepatobiliary triangle in 3 of 300 patients (1%).[13,14] It is also seen from these studies that the incidence of a double cystic artery in the people of Pakistan differs from a region to another. This shows to us that there may be differences in the results of the studies carried out as they were retrospective.In some studies, it was found that the double cystic artery originated from the right hepatic artery. For example, Saidi et al, in 8 (7.8%) out of 102 Nairobian patients, 10% in the study of Futara Ethiopian people, Balija et al and Mlakar et al showed that a double cystic artery originated from the right hepatic artery at the rates of 13.6% and 5.5%.[15-18]

The largest study of the origin of the double cystic artery was reported by Sarkar et al compiled accordingly, the cystic artery originated from several areas: right hepatic artery (63.9%), common hepatic truncus (26.9%), left hepatic artery (5.5%), gastroduodenal artery (2.6%), superior pancreaticoduodenal artery (0.3%), right gastric artery (0.1%), celiac body (0.3%) and superior mesenteric artery (0.8%).[19]It can be seen from this study that the double cystic artery originates most often from the right hepatic artery. All the variations mentioned above generally occur separately. The coexistence of variations in hepatic arteries with cases of variation associated with double cystic artery is very rare. In this regard, Bincy et al reported double cases of a cystic artery arising from the proper hepatic artery, in this case, the proper hepatic artery originated from the accessorial left hepatic artery.[20] Loukas et al reported a double cystic artery arising from the right hepatic artery and posterior superior pancreaticoduodenal artery.[21] In this study, the accessory left hepatic artery originated from the left gastric artery. Polguj et al reported that biliary tract damage is a major complication in laparoscopic cholecystectomy, and they talked about the importance of seeing a cystic duct and cystic artery in the same plan.[22] In our study, the coexistence of epigastric hernia was detected in only 2 patient, but no research was conducted for vascular variations for other patients.

In the operation of the patient with an epigastric hernia and multiple stones in the gallbladder, laparoscopic cholecystectomy and laparoscopic hernia correction were applied simultaneously. Facinelli et al reported that patients with epigastric hernia had less collagen in the abdominal wall than in the normal population. In particular, the amount of type 1 collagen was found to be 20% less than the normal population.[23] Some risk factors for epigastric hernia have been identified. These are observed especially as a result of uncoordinated, strong diaphragm contractions, increased intra-abdominal pressure, and a protrusion defect in linea alba and pre-peritoneal fatty defect. This is especially the case in patients with lung disease and athletes and soldiers who lift high force. In our case, because the patient was a farmer, it enters the population that removes high force.[24]

## Conclusion

Laparoscopic cholecystectomy has been accepted as the preferred method of treatment of gallbladder stones in healthy individuals. During laparoscopic cholecystectomy, dissection of a limited field is visualized on the video monitor for detailed anatomical variations of cystic artery. The present study helps to recognition of such type of variations which has surgical importance and requires special attention in gallbladder surgeries and also helpful to radiologist to

perform an intraoperative cystic angiogram during hepatobiliary surgery and pre-requisites for safe and uneventful laparoscopic cholecystectomy and can reduce uncontrolled intraoperative hemorrhage and extrahepatic biliary injury.

## References


1. Hlaing K P , Thwin S , Shwe N. Unique origin of the cystic artery Singapore Med J. 2011; 52(12) : e263.
2. Keith, L.M. and T.V.N. Persaud. The developing human clinically oriented embryology, 8th ed. Elsevier. 2008; 218-220.
3. Balija M . Huis M , Nikolic V , Stulhofer M , Laparoscopic visualization of the cystic artery anatomy World J Surg 1999; 23:703-7.
4. NR: Gallbladder and biliary tree. In Standring S (Ed.): Gray's anatomy, the anatomical basis of clinical practice. 40th ed. Edinburgh. Elsevier Churchill and Livingstone. 2008; pp: 1177-1181.
5. Eyni H, Pasbakhsh P, Azimi A, Fard SB. Case report: variation of the gallbladder vasculature including double cystic arteries. Anatom Sci. 2015;12(1):51-5.
6. 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(3):154-7.
7. Hlaing KP, Thwin S, Shwe N. Unique origin of the cystic artery. Singapore Med J. 2011;52(12):263.
8. Hugh TB, Kelly MD, Li B. Laparoscopic anatomy of the cystic artery. Am J Surg. 1992;163:593-5.
9. Singh K, Ohri A. Anatomic landmarks: their usefulness in safe laparoscopic cholecystectomy. Surg Endosc. 2006;20:1754-8.
10. Dandekar U, Dandekar K, Chavan S. Right hepatic artery: a cadaver investigation and its clinical significance. Anat Res Int. 2015; 2015:412595.
11. Ding YM, Wang B, Wang WX, Wang P, Yan JS. New classification of the anatomic variations of the cystic artery during laparoscopic cholecystectomy. World J Gastroenterol. 2007;13(42):5629-34.
12. 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(2):141- 4.
13. 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):494-6.
14. 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. J Pak Med Assoc. 2010;60(2):89-93.
15. Saidi H, Karanja TM, Ogengo JA. Variant anatomy of the cystic artery in adult Kenyans. Clin Anat. 2007;20(8):943-5.
16. Futara G, Ali A, Kinfu Y. Variations of the hepatic and cystic arteries among Ethiopians. Ethiopian Med J. 2001;39(2):133-42.
17. Balija M, Huis M, Nikolic V, Stulhofer M. Laparoscopic visualization of the cystic artery anatomy. World J Surg. 1999;23(7):703-7.
18. Mlakar B, Gadzijev EM, Ravnik D, Hribernik M. Anatomical variations of the cystic artery. Eur J Morphol. 2003;41(1):31-4.
19. Sarkar AK, Roy TS. Anatomy of the cystic artery arising from the gastroduodenal artery and its choledochal branch- a case report. J Anat. 2000;197(3):503-6.
20. Bincy MG, Somayaji SN. Multiple variations of the subhepatic hepatobiliary vasculature porta. Int J Anatomy. 2010;3:39-40.
21. Loukas M, Fergurson A, Louis RG Jr, Colborn GL. Multiple variations of the hepatobiliary vasculature including double cystic arteries, accessory left hepatic artery and hepatosplenic trunk: a case report. Surgical Radiologic Anatomy. 2006;28(5):525-8.
22. Polguj M, Podgórski 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- 8.
23. Fachinelli A, Trindade MR, Fachinelli FA. Elastic fibers in the anterior abdominal wall. Hernia. 2011;15(4):409-15.
24. Sorensen LT. Effect of lifestyle, gender and age on collagen formation and degradation. Hernia. 2006;10(6):456-61.


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