

## Prospective Observational Study to Assess the Incidence of Double Cystic Artery

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### Abstract

**Aim:** The aim of this study was to find out the prevalence of double cystic arteries. **Methods:** The study was a prospective observational study conducted in the Department of General Surgery, Madhubani Medical College and Hospital, Madhubani, Bihar, India, for 15 months. Total 520 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 included in this study. The characteristics and complications of the patients with double cystic artery were recorded and examined. **Results:** 520 laparoscopic cholecystectomy performed in 1 year. 129 male and 391 female patients were included in the study. The average age was 21-71(53.26). The double cystic arteries were detected in the operation of 4 males (0.77%) and 16 female patients (3.07%). The average age of these patients was 53.4±10.85. It was discovered from ultrasound reports that the indication for operation in 3 of the 20 patients with double cystic arteries was gall bladder polyp while it was multiple stones in the gallbladder for the rest of the patients. An epigastric hernia was detected in 4 patients other than gallstones and an epigastric hernia correction was performed simultaneously laparoscopically. 4 of the 20 patients (20%) with double cystic arteries were switched from laparoscopic to conventional cholecystectomy due to bleeding during surgery. The average duration of hospital stay of patients with a double cystic artery is 5.9 (4-12) days, and (3.2 days) for patients without a double cystic artery. The incidence of a double cystic artery was found to be 3.84 on average. **Conclusion:** Cystic artery variations and other variations can coexist. Awareness of cystic artery variations can reduce the possibility of uncontrolled intraoperative bleeding, extra hepatic biliary injury, and switching to conventional cholecystectomy.

**Keywords:** CRP, Gastric Aspirate, Sepsis, etc.

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## Introduction

The chief source of blood supply to the gallbladder and the cystic duct is the cystic artery[1]. The cystic artery (CA) is a single vessel that originates from the right branch of the proper hepatic artery (PHA). It usually passes through the hepato-biliary triangle or Calot's triangle, which is bounded superiorly by the inferior surface of the liver, inferiorly by the cystic duct and medially by the common hepatic duct[2]. Anatomical variations of the cystic artery are commonly encountered during cholecystectomy. In Approximately 80% of individuals, the cystic artery arises from the right hepatic artery. The other origins include the left hepatic artery, proper hepatic artery, common hepatic artery, gastroduodenal artery, superior pancreaticoduodenal artery and superior mesenteric artery[3]. A good knowledge of Calot's triangle is important for conventional and laparoscopic cholecystectomy. Calot's triangle is an important imaginary referent area for biliary surgery. Cystic artery bleeding is a wearisome complication during laparoscopic cholecystectomy, which increases the rate of conversion to open surgery. If surgery is performed incorrectly, injury to the extra-hepatic bile duct or intra-abdominal organs may occur[4]. Laparoscopic cholecystectomy has been accepted as the preferred method of treatment of gall bladder stones in healthy individuals all over the world. In Zambia, at the University Teaching Hospital (UTH), laparoscopic cholecystectomy is being carried out for treatment of cholelithiasis. Some of the complications experienced by the surgeons during cholecystectomy were injury to the liver and nearby structures such as the stomach, mistaking the right hepatic artery as a cystic duct and bleeding. For safe and uneventful cholecystectomy, especially by means of laparoscopic techniques, it is important to be familiar with anatomic variations in the hepatobiliary arterial

system[2]. 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[5]. The aim of this study was to find out the prevalence of double cystic arteries.

## Material and methods

The study was a prospective observational study conducted in the Department of General Surgery, Madhubani Medical College and Hospital, Madhubani, Bihar, India, for 15 months after taking the approval of the protocol review committee and institutional ethics committee. Total 520 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 included 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 excluded 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.

### Statically analysis

Distribution of normality of quantitative data was tested using the Shapiro-Wilk test and graphical analyses. Student's t-test was used for inter-group comparisons of normally distributed quantitative data. Categorical data were compared with Pearson chi-square test and Fisher-Freeman-Halton exact test. A p level of <0.05 was considered statistically significant. Statistical analyses were done using number cruncher statistical system (NCSS) 2007 (Kaysville, Utah, USA) program

### Results

520 laparoscopic cholecystectomies were performed in 1 year. 129 male and 391 female patients were included in the study. The average age was 21-71(53.26). The double cystic arteries were detected in the operation of 4 males (0.77%) and 16 female patients (3.07%). The average age of these

patients was 53.4±10.85. It was discovered from ultrasound reports that the indication for operation in 3 of the 20 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 4 female patients, and hypertension was detected in 3 male patients. An epigastric hernia was detected in 4 patients other than gallstones and an epigastric hernia correction was performed simultaneously laparoscopically. 4 of the 20 patients (20%) 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 3 male patients with a double cystic artery. Upon the detection of 320 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 5.9 (4-12) days, and (3.2 days) for patients without a double cystic artery. The incidence of a double cystic artery was found to be 3.84 on average. (Table 1) Demographic data, clinical features of study participants and the result of the study is given in Table 2 and table 3). No mortality was detected in the operations of patients with double cystic arteries.

**Table- 1: Prevalence of number of cystic artery 3.84**

Total no. of patients	Single cystic artery	Double cystic artery
520	500	20

**Table 2: Demographic Profile of Patients.**

Group					
Variables		Single cystic artery (n=500)	Double cystic arteries (n=20)	Total (520)	P value
Age (in years)	Min.-max. (median)	21-71 (48.5)	29-71(55.4)	21-71(53.26)	t:0.655
	Mean±SD (mean)	47.6±15.62	53.4±10.85	44.6±14.12	<sup>a</sup> 0.575
Gender	Male	125(25)	4 (20)	129(24.81)	$\chi^2$ :0.521
	Female	375(75)	16 (80)	391(75.19)	<sup>b</sup> 0.391

**Table 3: Parameter of Single cystic artery and Double cystic arteries**

		Single cystic artery (n=500)	Double cystic arteries (n=20)	Total (520)	P value
Indication	Multiple stones	500(100)	17 (85)	517(99.42)	$\chi^2$ :3.489
	Gallbladder polyp	0 (0)	3(15)	3 (0.58)	<sup>b</sup> 0.047*
Switched from laparoscopic to conventional cholecystectomy	No	500(100)	16(80)	516(99.23)	$\chi^2$ :3.985
	Yes	0 (0)	4(20)	4 (0.77)	<sup>b</sup> 0.044*
Bile duct injury	No	500 (100)	17(85)	517(99.42)	$\chi^2$ :3.87
	Yes	0 (0)	3 (15)	3 (0.58)	<sup>b</sup> 0.052*
Hospital stays	Days	3.2(1-6)	5.9 (4-12)	---	t:0.503

<sup>a</sup>0.477\* <sup>a</sup>Student-t test; <sup>b</sup>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[6,7]. In our study, it occurred in 4 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<sup>th</sup> 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 mesogastrum 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[8]. 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[9]. 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[10]. In our study, 3 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 3.84 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[11]. 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[12]. Likewise, in the study of Suzuki et al it was in 13 of 244 patients (5.3%)[13]. 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%)[14,15]. 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 Nairobi

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% [16-19].

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%) [20]. 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 accessory left hepatic artery [21]. Loukas et al reported a double cystic artery arising from the right hepatic artery and posterior superior pancreaticoduodenal artery [22]. In this study, the accessory left hepatic artery originated from the left gastric artery. Polguy 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 [23]. In our study, the coexistence of epigastric hernia was detected in only 3 patient, but no research was conducted for vascular variations for other patients.

### Conclusion

Cystic artery variations and other variations can coexist. Awareness of cystic artery variations can reduce the possibility of uncontrolled intraoperative bleeding, extra hepatic biliary injury, and switching to conventional cholecystectomy.

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