

## Research Article

# Prevalence of anatomical variations of cystic artery in South Indian cadavers

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**Received:** 26 July 2013

**Accepted:** 4 August 2013

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### ABSTRACT

**Background:** The knowledge of variations in the origin and course of cystic artery is important for the surgeons as uncontrolled bleeding from the cystic artery and its branches can be fatal during cholecystectomy. Intra operative bleeding can result in an increase in the risk of intra operative injury to vital vascular and biliary structures. Keeping in view the clinical significance and applied importance of the cystic artery anatomy and to add some more knowledge to the existing ones, the present study was undertaken, to know in detail the level of origin, length, and variations in the course and relation of the cystic artery.

**Methods:** The present study was performed on 100 human liver specimens with intact gallbladder and extrahepatic duct system, obtained after dissection from the cadavers in the Department of Anatomy and from post-mortem cases from the Department of Forensic Medicine, Mysore Medical College and Research Institute, Mysore, over a period of 18 months.

**Results:** Most common source of origin of the cystic artery was the right hepatic artery in 92 cases (92%) followed by aberrant right hepatic artery in 4 cases (4%) and the least common sources observed were the left hepatic artery in 1 case (1%) and the gastroduodenal artery in 1 case (1%). Mean length of the cystic artery was 17.6 mm and ranged between 3.7 mm to 42 mm. Out of the 100 dissected specimens, in 65 (65%) the cystic artery was found inside the Calot's triangle and in 35 (35%) outside the triangle.

**Conclusion:** This study provides details of the normal as well as the variant anatomy of the cystic artery, knowledge of which is very essential for the surgeons to minimize the risk of injury to the blood vessels and the biliary apparatus during cholecystectomy.

**Keywords:** Cystic artery, Gall bladder, Variations, Cholecystectomy, Calot's triangle

### INTRODUCTION

The chief source of blood supply to the gallbladder and the cystic duct is the cystic artery. Cystic artery commonly arises from the right hepatic artery in the angle between the common hepatic duct and cystic duct.<sup>1</sup> Calot's triangle is a triangular space formed between the cystic duct, the common hepatic duct and inferior surface of segment V of the liver. The most important content of

the triangle is the cystic artery. Appreciation of variations in the ductal and arterial anatomy of the triangle is of considerable importance during excision of the gallbladder.<sup>2</sup> The gallbladder and its ducts are more often called for operative treatment than any other intraabdominal viscus, excluding the vermiform appendix. The knowledge of relevant anatomy is important for safe execution of cholecystectomy, because it has been recognized since long that misinterpretation of

anatomy, as well as the presence of anatomical variations contribute to the occurrence of major intraoperative and postoperative complications.<sup>3</sup> Safe cholecystectomy either open or laparoscopic, requires a good knowledge of anatomy of the cystic artery and its variations. Hence appropriate insight into the cystic artery anatomy and its variations is of special importance to both patient and surgeon to avoid injury to the artery that usually leads to complications, morbidity and mortality.

## **METHODS**

The present study was performed on 100 human liver specimens with intact gall bladder and extrahepatic duct system obtained from cadavers from Department of Anatomy and post mortem cases from Department of Forensic Medicine. The organs were taken from both the sexes and from 30-79 year age group. The study was done at Mysore Medical College and Research Institute, Mysore, over a period of 18 months.

### **Method of Collection of Data**

#### *1. From the cadavers*

After exploring the peritoneal cavity, the anterior layer of peritoneum was removed from the lesser curvature of the stomach. Left gastric artery was identified and traced till the omental bursa. Right gastric artery was identified and traced to the common hepatic artery. The common hepatic artery was dissected till the gastroduodenal artery was given off and the proper hepatic artery was defined. The right and left hepatic arteries were identified and cystic artery was studied.<sup>4</sup>

Once the cystic artery was defined it was cleaned and traced up to its division into the superficial and deep branches close to the neck of the gallbladder.

#### *2. From the post-mortem cases*

Cadaver was placed supine on the dissection table and the abdominal cavity was exposed by giving the classic midline incision from the chin to the symphysis pubis. Then the anterior abdominal wall was retracted laterally.

Specimens were collected as block dissection of the liver along with associated structures like the hepatic artery, portal vein, hepatic ducts, part of the abdominal aorta including the celiac trunk and the superior mesenteric artery and part of the inferior vena cava and other related structures like part of the diaphragm, part of the duodenum and pancreas.

Each specimen was thoroughly washed to remove blood clots and then tagged with a token having identification number and fixed in 10% formalin for 15 days. All specimens were dissected carefully to observe the parameters of the study.

### **Parameters Studied**

1. Source of origin of the cystic artery was noted.
2. Distance between the point of origin of the cystic artery and the point of origin of the parent vessel was measured.
3. Length of the cystic artery was measured from point of origin to the division of the artery into superficial and deep branch.
4. Mode of termination of the cystic artery was noted.
5. Relation of the cystic artery to the Calot's triangle was noted (inside/outside).
6. Relation of the cystic artery to the cystic duct, common hepatic duct and common bile duct was also noted (anterior/posterior/medial/lateral/not related).

### **Measurement of Length**

Length was measured with the help of the divider. The ends of the divider were then kept on Vernier calliper and exact length was noted.

Following statistical methods were employed in the present study.

#### *1. Descriptive statistics*

The data was summarised using descriptive statistics like frequency, percentage, mean, standard deviation and cross tabulation. Descriptive statistics provide information about the frequency, distribution, variability and central tendency of a variable.

#### *2. Tests of significance*

These tests were applied to know whether the difference observed in statistical parameters between different samples are due to sampling variation or not.

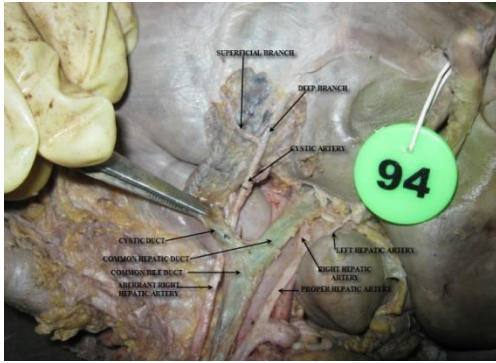
Tests of significance applied in the present study were,

- a) Chi square test.
- b) ANOVA (analysis of variance) – F test.

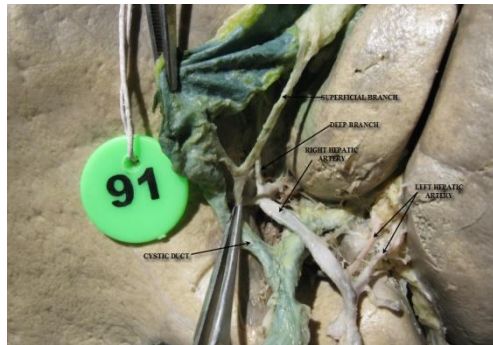
All the statistical calculations were performed using the software SPSS for windows (Statistical Presentation System Software, SPSS Inc, 2004, New York) version 13.0.

## **RESULTS**

It was observed that the origin of the cystic artery was normal in 92% of cases and variations were seen in rest 8% of cases (Aberrant Right Hepatic Artery [AB RHA] 4% (figure 1), Gastroduodenal artery 1%, Proper Hepatic Artery [PHA] 2%, Left Hepatic Artery [LHA] 1% (figure 2)). Most common source of origin of the cystic artery was the right hepatic artery [RHA] (92%).



**Figure 1: Cystic artery arising from aberrant right hepatic artery.**



**Figure 2: Cystic artery arising from left hepatic artery.**

A significant observation in the present study was with regard to the mean distance at which origin of the cystic artery can be expected from the point of origin of various possible sources. This distance varied significantly with change in the source of origin of the cystic artery. When the source was right hepatic artery this distance was 2.012 cm, with AB RHA as the source this distance was 4.27 cm (table 1). A significant difference ( $p < 0.05$ ) was observed in the relation of mean distance between the point of origin of the cystic artery and the point of origin of the parent vessel with respect to the source of origin.

The mean length of the cystic artery in the present study was 17.60 mm and ranged between 3.7 mm to 42 mm. Mean length in males was 17.40 mm and in females 17.88 mm (table 2).

In 97% cases the cystic artery terminated by dividing into superficial and deep branches. In the rest, the artery continued as superficial branch, the deep branch being replaced by the accessory cystic arteries. Out of 97% cases, in 93 cases (96%) the termination was close to the neck of the gallbladder, in 3 cases (3%) away from the neck of gallbladder and only in 1 case (1%) lateral to the CHD.

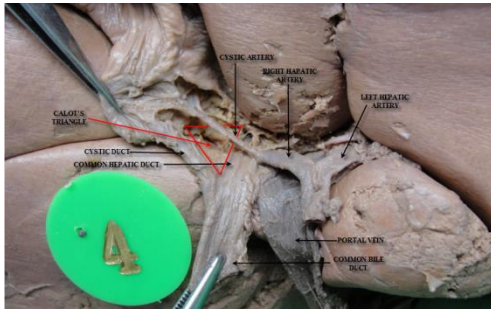
**Table 1: Distance between the origin of the source and origin of the cystic artery.**

Source of Origin	Number of Cases	Mean Distance (cm)	SD	Minimum	Maximum	P-value
RHA	92	2.012	0.8	0.5	5.6	<b>&lt;0.05</b>
LHA	1	0.55	-	0.55	0.55	
PHA	2	2.465	0.5	2.13	2.8	
GDA	1	1	-	1	1	
AB RHA	4	4.275	0.3	3.9	4.6	

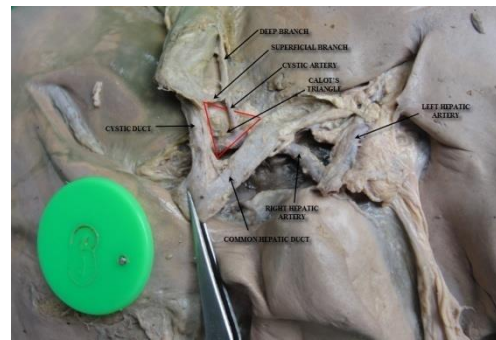
**Table 2: Length of the cystic artery with respect to origin.**

Source of Origin	No. of Cases	Mean Length (mm)	Minimum Length (mm)	Maximum Length (mm)	SD	P-Value
RHA	92	17.23	4.4	32.0	0.56	<b>&lt;0.05</b>
LHA	1	24.3	24.3	24.3	-	
PHA	2	23.75	1.96	2.79	0.58	
GDA	1	42.0	42.0	42.0	-	
AB RHA	4	15.45	12.0	18.2	0.28	

In 65% cases the cystic artery was seen within the Calot's triangle and in 35% it was outside the Calot's triangle (figure 3 and 4). In 67% cases the cystic artery was medial to the cystic duct. In 63% cases the cystic artery was lateral to the common hepatic duct and passed anterior to it in 30%.



**Figure 3: Cystic artery arising within the calot's triangle.**



**Figure 4: Cystic artery arising outside the calot's triangle.**

**DISCUSSION**

Observations on variations in the origin of the cystic arteries in the present study showed that, the most common source of origin of the cystic artery was the right hepatic artery (in 92% specimens). Comparison of this observation with other studies is as follows:

**Table 3: Comparison of source of origin of the cystic artery with other studies.**

Sl. No.	Studies	No. of Cases studied	Source of Origin							
			RHA	PHA	LHA	GDA	CHA	CT	SMA	AB RHA
1	Present study	100	92%	2%	1%	1%	0	0	0	4%
2	Flisinski et al. <sup>5</sup>	34	82.3%	8.8%	5.8%	2.9%	0	0	0	0
3	Flint ER <sup>6</sup>	200	98%	0	1.5%	0.5%	0	0	0	0
4	Daseler et al. <sup>7</sup>	580	71.7%	0	6.2%	2.6%	2.7%	0.35%	0.1%	16 %
5	Michels NA <sup>8</sup>	200	77.5%	0	5%	4%	1.5%	0	0	12%
6	Desilva et al. <sup>9</sup>	50	96%	0	4%	0	0	0	0	0
7	Khalil M <sup>10</sup>	60	90%	2%	3%	2%	2%	0	0	0
8	Pushpalatha K et al. <sup>11</sup>	50	54%	22%	0	8%	12%	0	2%	2%

Lowest observed incidence (54%) of the cystic artery arising from the right hepatic artery is reported by Pushpalatha K. Difference in the incidence between the present study and the above mentioned author might be because of the difference in the number of specimens studied.

Variations in the source of origin of the cystic artery can be explained on embryological basis. The normal pattern of cystic arterial origin is in which this artery arises as a branch from terminal portion of the right hepatic artery. Next in order would be origin from the right hepatic artery, but from the more proximal portion of that vessel.

Then an origin from the distal portion of the hepatic artery proper, before division into right and left hepatic arteries, would be expected to follow in frequency; after that an origin from the left hepatic artery. Further migration down the arterial tree would bring the cystic to arise as a branch from the gastroduodenal artery. Next would be origin as a branch of the common hepatic artery, then derivation from celiac axis itself. Spatially more remote would be a right or accessory right hepatic artery, arising not from the celiac axis or common hepatic arteries, but from superior mesenteric artery, the cystic branch then being derived from the terminal portion of such an anomalous right hepatic artery.<sup>7</sup>

Migration downward towards the source branch derived from the aorta or even from the axial vessel itself could be expected as less frequent pattern, the cystic artery thus arising from the celiac axis, superior mesenteric artery, or aorta itself. In rare instance, origin could be conceivably take place from the terminal gastroduodenal branches, the right gastroepiploic and superior pancreaticoduodenal arteries or even from a supraduodenal branch of hepatic or gastro duodenal origin.<sup>7</sup>

Mean length of the cystic artery in the present study was 17.6 mm and ranged from 3.7 mm to 42 mm. Observation regarding the mean length of the cystic artery in the present study was in agreement with the work of Desilva et al. Surgeons should be aware of such short type of cystic artery as this can most often be confused for double cystic artery.

In the present study the cystic artery was seen within the Calot's triangle in 65% cases. Comparison of this observation with other studies is as follows:

**Table 4: Comparison of relation of the cystic artery to the calot's triangle with other studies.**

Sl. No.	Studies	No. of cases studied	Relation to the Calot's triangle	
			Inside	Outside
1	Present study	100	65%	35%
2	Flisnski et al. <sup>5</sup>	34	97.06 %	2.94%
3	Michels NA <sup>12</sup>	200	81%	19%
4	Daseler et al. <sup>7</sup>	580	69.8%	31.2%
5	Desilva et al. <sup>9</sup>	50	86%	14%
6	Futura et al. <sup>13</sup>	110	89%	11%

Present study adds to the existing knowledge about the anatomical variations associated with the arterial supply of gall bladder. To conclude, knowledge of variations in the origin of the cystic artery is essential in performing cholecystectomy, open or laparoscopic. Hence it is important for the biliary and minimally invasive surgeons to appreciate the basic anatomical facts and to have a sound knowledge of anatomical variations of the cystic artery thereby minimizing the chances of complications during cholecystectomy.

#### ACKNOWLEDGEMENTS

I owe a great debt of gratitude to my respected Principal, Dr. MG Shivaramu, for his encouragement and guidance. My heartfelt thanks to Dr. Rajendra R, Head of the Department of Anatomy who has been a constant source of support and motivation in my endeavours. His

academic excellence and vast knowledge base are a boon to a learner.

*Funding: None*

*Conflict of interest: None declared*

*Ethical approval: Approved by the Institution Ethical Committee*

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DOI: 10.5455/2320-6012.ijrms20131122

**Cite this article as:** Tejaswi HL, Dakshayani KR, Ajay N. Prevalence of anatomical variations of cystic artery in South Indian cadavers. Int J Res Med Sci 2013;1:424-8.