

Original research article**Study of Origin, Course, Branching Pattern, Relations and Clinical Significance of the Cystic Artery in Human Cadavers**

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Abstract

Background: The cystic artery normally arises as a single stem from the right hepatic artery within the Calot's triangle and crosses neither the common hepatic duct nor the common bile duct. As it approaches the neck of the gallbladder it typically divides into two branches, one of which passes on to the free surface and one on to the attached surface. Liver and biliary related diseases are among the common health problems all over the world.

Methodology: The study was conducted on 100 human liver specimens with intact gallbladder and extrahepatic duct system, collected from the Department of Anatomy and Department of Forensic Medicine, Patna medical college and Hospital, Patna. Study duration of Two years. The specimens obtained were fixed in 10% formalin and were finely dissected. Parameters observed were the source of origin of the cystic artery, its length and diameter, mode and level of termination, relation to the Calot's triangle and the extrahepatic duct system.

Conclusion: The present study adds up to the existing knowledge regarding anatomy and variations of the cystic artery. Knowledge of the normal anatomy and variations of the cystic artery is essential for the surgeons before performing any surgeries on the gallbladder and its duct system.

Keywords: Cystic artery; Calot's triangle; Cholecystectomy; Double cystic artery; Accessory cystic artery; Gallbladder.

Introduction

Human beings are singularly alike in their general anatomical construction: yet when one particular region is investigated in detail, variations are frequently observed. These variations are more commonly encountered in the vascular system, especially in the liver.¹ The gallbladder and its ducts are more often called for operative treatment than any other intraabdominal viscus, excluding the vermiform appendix. According to Flint, "Technically, gallbladder surgery is the most difficult of any abdominal surgery and inadequate appreciation of abnormalities of this region does not reduce the risks". The knowledge of relevant

anatomy is important for safe execution of cholecystectomy, because it has been recognised since long that misinterpretation of anatomy and as well as the presence of anatomical variations contribute to the occurrence of major intraoperative and postoperative complications.² 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. According to Moore KL, the cystic artery arises from the right hepatic artery within the Calot's triangle in 75.5% cases and variations in the origin and course occurs in 24.5% of cases.³ 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.⁴ The recent intense development in certain fields of abdominal surgery has made imperative to have a descriptive atlas whereby surgeons may obtain a clear appreciation and knowledge of the varied blood supply of the upper abdominal organs. Anatomic variations are worth knowing as accurately and extensively as possible. Halsted, a pioneer American surgeon is remembered for the message he left to surgeons "The best way to avoid injury to the blood vessels is to know them and to know how, when and where to ligate them properly".⁵ 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 that increases the risk of intraoperative lesions to vital vascular and biliary structures. Cystic artery bleeding is a troublesome complication during laparoscopic cholecystectomy, which increases the rate of conversion to open surgeries. According to Thomson,⁶ rate of conversion of laparoscopic cholecystectomy to open procedure due to blood vessel injury is 0-1.9%. 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 uncontrolled lesions to the artery that usually leads to complications, morbidity and mortality. 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.

Objectives

Study the source of origin of the cystic artery, Study the level of origin and termination of the cystic artery, Study the mode of termination of the cystic artery. Measure the length of the cystic artery, Measure the external diameter of the cystic artery at its origin, mid level and termination.

Review of Literature

In 1882 July 15, first elective cholecystectomy was done by Langenbush.⁷ In 1923, Shellshear JL⁸ wrote, "The distribution of arteries obeys some definitive ontogenic and phylogenic law. The evolution of vessels is dependent and proceeds the evolution of their field of distribution". In 1923, Flint ER¹ made dissections on the vessels and the ducts of the liver in 200 postmortem subjects. He stated, "So frequent are variations in the region of the liver and gallbladder, it is impossible to regard any one type as normal". In 200 dissections of the liver and gallbladder region, the cystic artery as seen arising from the right hepatic artery in 196 cases, in 3 cases from the common hepatic artery and in 1 case from the gastroduodenal artery. In 32 cases the cystic artery passed in front of the common hepatic duct and in 168 cases it was arising just to the right side of the common hepatic duct or behind it. In 31 cases there was presence of an accessory cystic artery. There was therefore, a

single cystic artery in only 169 cases. Out of 31 cases which had the accessory cystic artery, 16 took their origin from the right hepatic artery, 11 from the gastroduodenal artery, 3 from the left hepatic artery and 1 from the superior pancreaticoduodenal artery. In 1951, Michels NA⁹ studied the arteries supplying the supramesocolic organs (liver, gallbladder, stomach, duodenum, pancreas and spleen) in 200 cadavers, over a span of 6 years. In the 200 bodies statistically estimated, the cystic artery was single in 75% and double in 25%, the latter including one triple cystic artery. Out of the 150 cases (75%) where there was a single cystic artery, in 140 cases (70%) the cystic artery took its origin from the right hepatic artery and only in 10 cases (5%) from other sources like the left hepatic artery, the middle hepatic, the proper hepatic artery, the retroduodenal artery and the gastroduodenal arteries. The site of origin of single cystic artery was within the Calot's triangle in 57% cases and in 18% outside of it. Of the 18% of the single cystic arteries which took their origin outside the Calot's triangle, 13% were present to the left of the common hepatic duct and in 5% to the left of the common bile duct. In 1953, Michels NA¹⁰ wrote that the course of the cystic artery in the Calot's triangle may be short or long, depending on its site and mode of origin. On reaching the gallbladder it usually bifurcates into its characteristic superficial and deep branches, "the cysticae gemellae", which was described by Vesalius in 1564. The superficial and the deep cystic branches are anastomosed at various points on the gallbladder, and both emit a variable number of twigs to the liver substance, sometimes more to the right than to the left side of the gallbladder or vice versa. In 1958, Hayes et al.¹¹ stated, "In no area of the human body are the relationships as described in the textbooks of anatomy more misleading as to constancy than the region encompassing the extrahepatic biliary ducts". In 1976, Gammon K, Jacob M¹² conducted a pilot study on the right hepatic artery, the cystic artery and the extrahepatic biliary apparatus in South Indian cadavers. In 33 dissected specimens, single cystic artery was found in 26 (78.8%) and double cystic arteries in 7 (21.2%). Out of 26 cases which had single cystic artery, in 22 (84.6%) the cystic artery was a branch from the right hepatic artery, in 2 (7.8%) from the accessory right hepatic artery, in 1 (3.8%) from the left hepatic artery and in 1 (3.8%) from the common hepatic artery. Of the 26 cases of single cystic arteries, 16 (48.5%) were seen arising within the Calot's triangle and 10 (30.5%) outside the Calot's triangle.

Material and methods

The present study was performed on 100 human liver specimens with intact gallbladder and extrahepatic duct system of both sexes (males – 64, females – 36) and age ranging from 30-79 years, collected from the cadavers from the Department of Anatomy and post-mortem cases from the Department of Forensic Medicine, at Patna medical college and Hospital Patna, Bihar. Study duration of two years.

Inclusion criteria

Liver specimens with intact gallbladder and arterial supply irrespective of age and sex. Specimens with intact right and left hepatic duct, common hepatic duct and cystic duct.

Exclusion criteria

Injured or lacerated liver and gallbladder, Liver specimens with absent gallbladder, Liver specimens from decomposed bodies.

METHOD OF COLLECTION OF DATA

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.¹⁷ 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

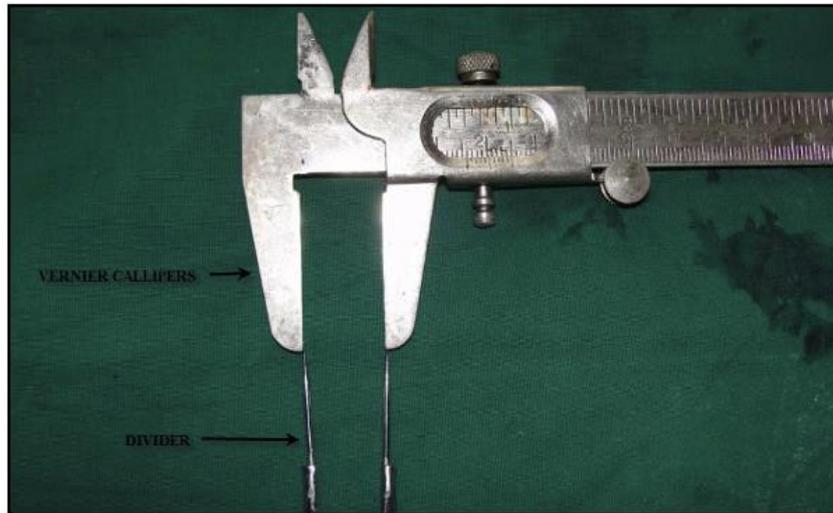


Figure 1: Measurement of length of the cystic artery with the Vernier calipers

Measurement of External Diameter External diameter of the cystic artery was measured at three levels (origin, midlevel, termination) with the help of screw gauge. Care was taken to see that the artery was not compressed by the ends of the screw gauge while measuring the diameter.

Results

Table 1: DISTRIBUTION OF SPECIMENS WITH RESPECT TO AGE AND GENDER

AGE GROUP(yrs)	MALE	FEMALE	TOTAL NUMBER
30-39	7	3	10
40-49	20	10	30
50-59	23	11	34
60-69	5	9	14
70-79	9	3	12
TOTAL	64	36	100

Out of the 100 dissected specimens of the gallbladder with intact arterial supply, 64 (64%) specimens belonged to males and 36 (36%) specimens were of females. Majority of the cases belonged to the age group between 40-59 years

Table 2: VARIATIONS IN THE SOURCE OF ORIGIN OF THE CYSTIC ARTERY

SOURCE OF ORIGIN	NUMBER OF CASES	PERCENTAGE
RHA	92	92%
LHA	1	1%
PHA	2	2%
GDA	1	1%
AB RHA	4	4%
TOTAL	100	100%

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%).

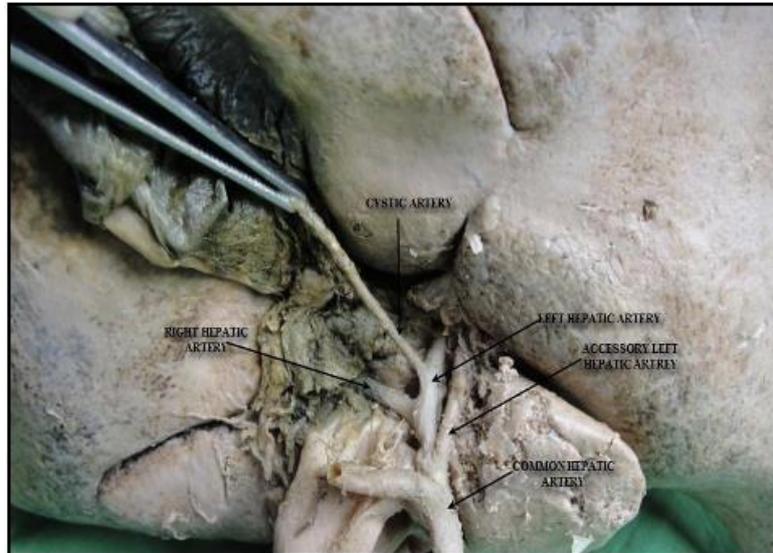


Figure 2: Cystic artery arising from the Left hepatic artery

When the source of origin of the cystic artery was the right hepatic artery mean distance at which the cystic artery originated was 2.01 cm and ranged from 0.5cm to 5.6cm. When the source was the aberrant right hepatic artery this distance was about 4.27cm. A significant difference (**p-value=0.000**) 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. Out of the 100 dissected specimens, in 67 (67%) the cystic artery was related medial to the cystic duct and in 24 (24%) it was not related to it. A significant difference (**p-value=0.000**) was observed in relation of the cystic artery to the cystic duct with respect to the source of origin.

Table 3: RELATION OF THE CYSTIC ARTERY TO THE COMMON HEPATIC DUCT WITH RESPECT TO SOURCE OF ORIGIN

Origin	Lateral	Medial	Anterior	Posterior	Not related	Total	p-value
RHA	62	1	27	0	2	92	0.000
LHA	0	0	1	0	0	1	
PHA	0	0	2	0	0	2	
GDA	0	0	0	0	1	1	
AB	1	0	0	0	3	4	
RHA							
TOTAL	63	1	30	0	6	100	

Out of the 100 dissected specimens, in 63 (63%) the cystic artery was related lateral to the common hepatic duct and in 30 (30%) the artery passed anterior to it. A significant difference (**p-value=0.000**) was observed in relation of the cystic artery to the common hepatic duct with respect to the source of origin

Table 4: ACCESSORY CYSTIC ARTERIES

SOURCE OF ORIGIN	NUMBER OF CASES	MEAN LENGTH (mm)	MEAN DIAMETER (mm)
AB RHA	2	15.35	2.45
RHA	1	26	1.5

Three (3%) accessory cystic arteries were noted in 100 dissected specimens. In two the source was the aberrant right hepatic artery and in one from the right hepatic artery.

Discussion

Variations in origin of vessels related to the liver are extremely common. Each may vary not only in respect to its own immediate source, but also in respect to derivation of the branch from which it, in turn, may spring. Opportunity for variation would ofcourse, increase as a particular vessel arose further distalward on the arborizing arterial tree. Among the two distinct extremes, far greater variation would be expected to occur in the case of the cystic artery than in that of the celiac axis. 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. In rare instance, origin could be conceivably take place from the terminal gastroduodenal branches, the right gastroepiploic and superior pancreatico duodenal arteries or even from a supraduodenal branch of hepatic or gastro duodenal origin.¹³

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). This observation was in agreement with the work done by Flint (98%), Desilva et al. (96%) and Khalil M (90%).

Table 5: COMPARISON OF RELATION OF THE CYSTIC ARTERY TO THE COMMON HEPATIC DUCT WITH OTHER STUDIES

Sl. No.	Studies	No of cases studied	Relation to the common hepatic duct				
			Lateral	Medial	Anterior	Posterior	NR
1	Present study	100	63%	1%	30%	0	6%
2	Flisnski et al.15	34	-	-	29.4%	66.7%	-
3	Daseler et al.13	580	-	-	21.2%	2%	-
4	Futura et al.16	110	-	-	28.2%	10.9%	-

Observations in the present study were in agreement with work done by above mentioned authors except for the posterior relation of the cystic artery to the common hepatic duct in the study done by Flisnski et al. In the present study the cystic artery was most commonly related lateral to the common hepatic duct and none passed posterior to it. Relation of the

cystic artery to the extrahepatic duct system is very important, because the ducts are often mistaken for the cystic artery and are accidentally ligated which can lead to life threatening complications. Hence the surgeon should have a sound knowledge of the variations in relation of the cystic artery to the extrahepatic duct system to avoid injuries to the duct system.

Table 6: COMPARISON OF INCIDENCE OF DOUBLE CYSTIC ARTERIES WITH OTHER STUDIES

Sl.No.	Studies	No of cases Studied	Incidence of Double cystic arteries
1	Present study	100	3%
2	Flint et al.1	200	15.5%
3	Michels NA9	200	25%
4	Daseler et al.13	580	14%
5	Pushpalatha K14	50	0

Incidence of the double cystic arteries were significantly low compared to other studies. Possible reason for such difference is the number of specimens studied. Incidence of double cystic arteries was considerably higher in work done by Michels NA, because the author had traced the right hepatic artery very close to its intra hepatic course. Double cystic arteries represent separate origins of superficial and deep branches of the cystic artery. Surgeons should keep in mind possibility of such double cystic arteries during cholecystectomy to minimise the bleeding.

Conclusion

The number of cholecystectomies, especially laparoscopic, being performed in India has increased phenomenally in the last few years. In view of the importance of anatomy and its variations, it is logical to look at the possibility of assessing the anatomy accurately during the performance of cholecystectomy.

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