Variations in origin and course of cystic artery and its relations to Calot’s triangle with its clinical implications

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Abstract
Introduction
Calot’s triangle is considered to be the important reference area for biliary surgeries and the cystic artery is usually given off by the right hepatic artery inside the triangle. Variations are more frequent in origin, course and length of the cystic artery. Hence this study aimed to study the normal as well as the variations of cystic artery with its relation to the calot’s triangle.

Materials and methods
The study was conducted in 40 adult human cadavers in Madras Medical College, Chennai.

Results
Out of 40 cases studied in 38 cases, cystic artery arose from the right hepatic artery, in one it arose from the common hepatic artery and in two specimens it arose from the proper hepatic artery. In one an accessory cystic artery from the common hepatic artery was also noted which travelled anterior to the common hepatic duct. In 3 cases the cystic artery was not seen inside the calot’s triangle and these arteries passed anterior to the common hepatic duct to reach the surface of the gallbladder.

Conclusion
Complete knowledge about these vessels is necessary for the operating surgeons to avoid unnecessary bleeding during surgical procedures and to prevent any biliary injuries post operatively.

Introduction
Cystic artery is a branch of the right hepatic artery which is given inside the calot’s triangle. Both the right hepatic and cystic artery forms the main content of the triangle. The course and length of the cystic artery inside the calot’s triangle is variable. Inside the triangle it bifurcates into superficial and deep branches which enters the neck or body of the gallbladder. In addition to the origin of the cystic artery from the right hepatic artery it can also arise from left hepatic artery, proper hepatic artery, common hepatic artery, gastroduodenal artery, superior pancreaticoduodenal artery, and superior mesentric arteries. Apart from the various origins as described by the literatures, the cystic artery may arise outside the calot’s triangle and it passes anterior to the common hepatic duct. These anomalous origins along with the variation in the course of the cystic artery can cause serious problems resulting from severe arterial bleeding during any surgical procedures. So a complete knowledge of these calot’s triangle with its contents both normal and its variations are must for the surgeons working in that area.

Materials and methods
The dissection was carried out in 40 adult human preserved cadavers in Madras Medical College, Chennai. Abdomen opened as per Cunningham’s manoeuvre, cystic duct, right and left hepatic duct, common hepatic duct, common bile duct were traced and dissected out. Boundaries of calot’s triangle were defined. Cystic artery, right hepatic artery, common hepatic artery, and proper hepatic artery were traced out. The origin and course of the cystic artery was noted with its relation to the duct system and to the calot’s triangle. Variations if found were documented and photographed.

Results
Out of 40 dissected cadavers, the cystic artery arose from the right hepatic artery in 37 cases (92.5 %). In two cases it arose from the proper hepatic artery (5%) (Figure 1 and Figure 4) and in one it was from the common hepatic artery (2.5 %). In this case we were able to dissect out a much higher division of the common hepatic artery which gives branches very close to the hilum of the liver (Figure 3). Apart from

Figure 1: GB-Gallbladder; CD-Cystic duct; CHD-Common hepatic duct; CBD-Common bile duct; CA-Cystic artery;PHA-Proper hepatic artery;CHA-Common hepatic artery.

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this in one specimen, we traced an accessory cystic artery (2.5%) which arose from the common hepatic artery outside the calot's triangle and passed ventral to the common hepatic duct to reach the superficial surface of the gallbladder, and a normal cystic artery from the right hepatic artery inside the calot's triangle (Figure 2). In all these cases the boundaries of calot's triangle was observed and found to be normal. Regarding the relation of cystic artery to the calot's triangle in 3 specimens (7.5%) it was not seen as a content of triangle and it originated outside the triangle, whereas in 92.5% of cases the cystic artery was observed to be the content of the calot's triangle. When observing for the course of the cystic artery in 4 specimens which doesn't have the origin inside the calot's triangle they travelled ventral to the common hepatic duct to reach the surface of the gallbladder in 10% of cases. In 90% of cases it passed posterior to the duct system to reach the gallbladder.

Discussion

The Liver and gallbladder develop from the hepatic diverticulum of the foregut during the 4th week of foetal life. This diverticulum is richly supplied by the abdominal aorta and its branches. Most of the branches of the abdominal aorta degenerate during its development leaving only the mature vascular system. This degeneration pattern is highly variable resulting in variations of the blood supply of the corresponding organs supplied by it. The liver and gallbladder develop from the primitive duct system and it may receive blood both from the celiac and mesenteric arteries. With this embryological basis the cystic artery originates from the following sources:

- Right hepatic artery: 63.9%;
- Hepatic trunk: 26.9%;
- Left hepatic artery: 5.5%;
- Gastro duodenal artery: 2.6%;
- Superior pancreatico duodenal artery: 0.3%;
- Right gastric artery: 0.1%;
- Celiac trunk: 0.3%;
- Superior mesenteric artery: 0.8%.

The other sources in which the cystic artery arises was hepatic artery proper in 2.2% and common hepatic artery in 0.6%. In our present study, the cystic artery arises from the right hepatic artery in 37 cases (92.5%); proper hepatic artery (5%); and the common hepatic artery (2.5%). The classification of the cystic artery in relation to the calot's triangle is as follows:

- Type 1: shows normal anatomy
- Type 2: more than one artery in calot's triangle
- Type 3: no artery inside the triangle.

In our study type 1 classification was observed in 92.5% of cases and type 3 classification was seen in 7.5% of cases. Regarding the course of the cystic artery as mentioned in literatures the artery crossed posterior to the right hepatic duct in the majority of cases and in a few cases it passed anterior to the common hepatic duct. In our study it passed posterior to the common

Figure 2: GB-Gallbladder; CD-Cystic duct; CHD-Common hepatic duct; CBD-Common bile duct; CA-Cystic artery; PHA- Proper hepatic artery; CHA-Common hepatic artery; ACA-Accessory cystic artery; ARHD-Accessory right hepatic duct; RHA-Right hepatic artery; LHA-Left hepatic artery. In this fig we can notice cystic artery arose from right hepatic artery inside the triangle with its normal course. An accessory cystic artery from common hepatic artery passed ventral to the common hepatic duct and accessory right hepatic duct.

Figure 3: GB-Gallbladder; CD-Cystic duct; CHD-Common hepatic duct; CBD-Common bile duct; CA-Cystic artery; CHA-Common hepatic artery. Common hepatic artery divided into right, left hepatic arteries and cystic artery at a very higher level closer to the hilum of liver.
hepatic duct in (90%) of cases and in (10%) of cases it passed anterior to the common hepatic duct, which coincides with the above mentioned author. Rahman et al. in their study mentioned that the cystic artery as a content of calot’s triangle in 96.65% of cases and in 3.35% it is seen outside the triangle. This coincides with our present study of the cystic artery inside the calot’s triangle in 92.5% of our cases and outside the triangle in 7.5% of cases.

And regarding the course of it, the artery crossed anterior to the common hepatic duct in 6.67% of cases and behind the common hepatic duct in 90% of cases and in 3.33% it passed below the cystic duct8.

Whereas in our study the cystic artery crossed anterior to the common hepatic duct in 10% and crossed posterior to the right hepatic duct in 90% of cases and we didn’t notice the cystic artery pass posterior to the cystic duct.

Similarly, Flisinski et al. Mentioned the cystic artery inside the calot’s triangle as 97.6% and outside the triangle as 2.94%9. This coincides with the present study of the cystic artery as a content of calot’s triangle in 92.5% and outside the calot’s triangle in 7.5% cases.

Hence a detailed knowledge of the arterial system of the extra hepatic biliary ductal system along with its variations is necessary to prevent iatrogenic biliary injuries. Cystic artery bleeding is considered to be the one of the main reasons for converting laparoscopic cholecystectomy to open cholecystectomy and the mortality rate due to blood vessel injury is 0.02%10.

**Conclusion**

So this study would provide definite guidelines not only for the surgeons working in this area but also for the interventional radiologist for diagnostic purposes in clinical practice.

**References**


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**Figure 4:** GB—Gallbladder; CD—Cystic duct; CHD—Common hepatic duct; CBD—Common bile duct; CA—Cystic artery; PHA—Proper hepatic artery; CHA—Common hepatic artery.