Cystic Artery: An Anatomic Morphological Study and Its Clinical Significance

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Abstract

Background  Cystic artery is one of the arteries which is of utmost surgical importance, as it originates from the vast range of blood vessels, associated to the coeliac trunk and superior mesenteric artery and its relation to the biliary ducts is variable. Cystic artery is not only difficult to visualize, but difficult to approach during the surgery. This study was undertaken to study the anatomy of arterial variations of cystic artery in the specimens of liver and gallbladder by exploring the extrahepatic duct system, and in addition the relations of cystic artery in the Calot's triangle were also studied and observed.

Materials and Methods  The study was conducted on 50 human liver specimens with intact gallbladder and extrahepatic duct system, collected from the Department of Anatomy over a period of 5 years. The specimens obtained were fixed in 10% formalin and were finely dissected. The specimens were observed for parameters like the 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.

Results  Origin of the cystic artery was normal in 92% of cases and variations were seen in approximately 8% cases. The most common origin of the cystic artery was from the right hepatic artery, which was in 92% of the cases. In the present study, in 97% cases the cystic artery terminated by dividing into the superficial and deep branches. In the rest, the artery continued as a superficial branch, the deep branch being replaced by the accessory cystic artery. In 64% cases, the cystic artery was seen within the Calot's triangle, and in 36% of cases, it was outside the Calot's triangle. In 67% cases, the cystic artery was medial to the cystic duct, in approximately 63% cases the cystic artery was lateral to the common hepatic duct, and in 30% of the cases the cystic artery passed anterior to the cystic duct. Incidence of accessory cystic arteries in the present study was approximately 4%.

Keywords

► cystic artery
► Calot's triangle
► cholecystectomy
► double cystic artery
► accessory cystic artery
► extrahepatic duct system
► variation
► gallbladder

Introduction

The main arterial supply to the gallbladder and the cystic duct (CD) is the cystic artery (CA). CA commonly arises from the right hepatic artery (RHA) in the angle between the common hepatic duct (CHD) and CD. Normally, the CA presents as single in number but sometimes also as double. The CA usually passes posterior to the CHD and anterior to the CD to reach the superior aspect of neck of the gallbladder, then it divides into superficial and deep branches and supplies the gallbladder. The most common variation of CA is, when it originates from the common hepatic artery (CHA) and when its origin is in the lower down, sometimes from the left hepatic or gastroduodenal artery (GDA), and rarely from the superior pancreaticoduodenal, celiac, right gastric, or superior mesenteric arteries. In these cases, it crosses anterior (or less commonly posterior) to the common bile duct (CBD)
or CHD to reach the gallbladder. An accessory CA may arise from the CHA or one of its branches. The CA when presents as double, it often bifurcates close to its origin, giving rise to two vessels before approaching the gallbladder.1

Materials and Methods
The study was conducted on 50 human liver specimens with intact gallbladder and extrahepatic duct in the regular dissection, collected from the Department of Anatomy over a period of 5 years. The specimens obtained were fixed in 10% formalin and were finely dissected. The specimens were observed for parameters like the origin of the CA, its length and diameter, mode and level of termination, and its relation to the Calot’s triangle, and the variations were noted, photographed, and studied.

Observations and Results
The CA was found in all 50 cases, out of which in 46 cases (92%) the artery originated from the RHA, 2% from the left hepatic artery (LHA) shown in ►Fig. 1 2% from the GDA, and in approximately 2 cases (4%) aberrant CA was found. In the present study, the mean length of the CA was 17.60 mm and the range of length of the CA was between 3.5 and 42 mm where the shortest CA was 3.5 mm and the longest was 42 mm (4.2 cm). The mean length of the CA in males was 17.40 mm and in females it was 17.88 mm. All the values were statistically significant at a p-value of ≤ 0.001. Mean external diameter of the CA was 2.20 mm and ranged between 1.1 and 3.2 mm. Mean external diameter in males was 2.20 mm and in females it was 2.19 mm. ►Fig. 2 shows a double cystic artery, incidence of accessory cystic arteries in the present study was 4% only. In 32 cases, the CA was seen within the Calot’s triangle and in 18 specimens the CA was outside the Calot’s triangle. In 67% cases, the CA was medial to the CD. In 63% cases, the CA was lateral to the CHD and the CA was anterior to the CD in 30% of the cases. ►Fig. 3 shows the variation of cystic artery arising outside the Calot’s triangle. The artery was found to terminate in 96% of the cases by dividing into superficial and deep branches. In one specimen Cystic artery was found give three branches which is shown in ►Fig. 4. The artery was found to continue as a superficial branch without dividing in the remaining 4% of the cases.

Discussion
The explanation for the variations in the CAs is based on the developmental pattern of the biliary system. The extrahepatic biliary system during the development arises as a diverticula from the developing gut, which supplied by
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The CA normally originates from the celiac axis as its blood supply and the developing superior mesenteric axis. The developing CA originates from any other artery in the vicinity of the biliary apparatus. The CA is always found to be variant in its number, origin, course, and its relations to biliary ducts. These abnormalities have been mentioned from time to time by various studies in the literature. The CA normally originates from the RHA which is a branch of the celiac trunk and the CA has a tendency to originate from one of the many branches of the celiac trunk. In these cases, it arises from the LHA, CHA, hepatic artery pseudoaneurysm (HAP), aberrant right hepatic artery, GDA, superior mesenteric artery (SMA), celiac trunk, or aorta. The variations in the origin of the CA along with comparisons of the various studies have been shown in Table 1. In a study by McVay, the CA has been classified based on its origin (parent vessel) which is classified into four categories: Category I: (1) from the RHA, (2) from the HAP at the point of division, (3) from the LHA, and (4) from the HAP proximal to the point of division; Category II: from the GDA or superior pancreaticoduodenal artery; Category III: from the same arteries mentioned in Category I but differing from them in the deviation of the parent vessel; and Category IV: from the right gastric artery, CHA, celiac trunk, or SMA which is similar to the present study.

The mean length of the CA found in the study by Tejaswi et al was 17.6 mm with a range of 3.7 to 42 mm. In a study by Taimur et al where the CA is described according to its length and divided into three groups, short (less than 1 cm = 7%), normal (1–3 cm = 82%), and long (more than 3 cm = 8%), similar classification is reported in a study by Dandekar and Dandekar. The developing CA was found to be 17.60 mm and the range of length of the CA was between 3.5 and 42 mm where the shortest CA was 3.5 mm and the longest was 42 mm (4.2cm). The mean length in males was 17.40 mm and in females it was 17.88 mm.

Table 1 Comparisons of various studies for cystic artery: its artery of origin

<table>
<thead>
<tr>
<th>Sl. no.</th>
<th>Studies</th>
<th>No. of cases studied</th>
<th>Artery of origin</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>RHA</td>
</tr>
<tr>
<td>1</td>
<td>Flišiński et al</td>
<td>34</td>
<td>82.3%</td>
</tr>
<tr>
<td>2</td>
<td>Flint</td>
<td>200</td>
<td>98%</td>
</tr>
<tr>
<td>3</td>
<td>Khalil et al</td>
<td>60</td>
<td>90%</td>
</tr>
<tr>
<td>4</td>
<td>Michels</td>
<td>200</td>
<td>77.5%</td>
</tr>
<tr>
<td>5</td>
<td>de Silva et al</td>
<td>50</td>
<td>96%</td>
</tr>
<tr>
<td>6</td>
<td>Pushpalatha and Shamsundar</td>
<td>50</td>
<td>54%</td>
</tr>
<tr>
<td>7</td>
<td>Daseler et al</td>
<td>580</td>
<td>71.7%</td>
</tr>
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<td>8</td>
<td>Tejaswi et al</td>
<td>100</td>
<td>92%</td>
</tr>
<tr>
<td>9</td>
<td>Kankhare Sonali et al</td>
<td>40</td>
<td>70%</td>
</tr>
<tr>
<td>10</td>
<td>Kumari et al</td>
<td>36</td>
<td>94.4%</td>
</tr>
<tr>
<td>11</td>
<td>Dandekar and Dandekar</td>
<td>82</td>
<td>79.3%</td>
</tr>
<tr>
<td>12</td>
<td>Present study</td>
<td>50</td>
<td>92%</td>
</tr>
</tbody>
</table>

Abbreviations: ARHA, aberrant right hepatic artery; CHA, common hepatic artery; CT, Coeliac Trunk; GDA, gastroduodenal artery; LHA, left hepatic artery; PHA, persistent hypoglossal artery; RHA, right hepatic artery; SMA, superior mesenteric artery.

Table 2 Site of origin of the CA with relation to the Calot’s triangle

<table>
<thead>
<tr>
<th>Site of origin of CA</th>
<th>Authors</th>
<th>Inside Calot’s triangle</th>
<th>Outside Calot’s triangle</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Michels</td>
<td>81%</td>
<td>19%</td>
<td></td>
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<tr>
<td>Bakheit</td>
<td>25%</td>
<td>75%</td>
<td></td>
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<tr>
<td>Flint</td>
<td>84%</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>Tejaswi et al</td>
<td>65%</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>Gawali</td>
<td>90%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Saidi et al</td>
<td>2%</td>
<td>98%</td>
<td></td>
</tr>
<tr>
<td>Daseler et al</td>
<td>69.8%</td>
<td>30.2%</td>
<td></td>
</tr>
<tr>
<td>Taimur et al</td>
<td>88%</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Ding et al</td>
<td>87%</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Dandekar and Dandekar</td>
<td>62.2%</td>
<td>37.8%</td>
<td></td>
</tr>
<tr>
<td>Present study</td>
<td>64%</td>
<td>36%</td>
<td></td>
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</tbody>
</table>

Abbreviation: CA, cystic artery.
Calot's triangle. In their study, the CA is divided into three groups: (1) inside the Calot's triangle type 85.5%; (2) outside the Calot's triangle 13%; and (3) compound type, 1.5%, which is similar to the classification presented in the present study. In the present study, in 64% cases the CA was seen within the Calot's triangle and in 36% specimens the CA was outside the Calot's triangle. In 67% cases, the CA was medial to the CD. In 63% cases, the CA was lateral to the CHD and passed anterior to the CD in 30%. Incidence of double CAs in the present study was only 4%. Ahmed and Sylvia have concurred and reported similar method of classifying CA.

Due to the vast variability in the occurrence, origin, and course of the CA seen in this study, an operating surgeon needs to be conscious in studying the course of the CA and CD during both laparoscopic and conventional approach of cholecystectomy. Hence, a few per-operable surgical significances are that the CA originating outside the Calot's triangle usually passes anterior to the bile duct and may be posterior to the CD; therefore, it could be the first structure encountered during exploration of the Calot's triangle which is prone to injury. As the CA courses anterior to the CHD or CBD, it increases the chances of injuries to both the CHD and CBD. An accessory CA is liable to bleed or tear if not explored thoroughly.

Conclusion

The importance of a thorough knowledge of arterial supply of the extrahepatic biliary ductal system especially arterial supply of the gallbladder could always present with variations. It requires an extensive in situ exploration before approaching the artery, which helps in reducing uncontrolled bleeding which may increase the risk of intraoperative lesion to vital vascular and biliary structures. A hemorrhagic episode or a bile leakage which may commonly occur due to variations of the Calot’s triangle structures can be avoided if the artery has been explored for its variations in origin, course, and its number. The extensive bleed or bile leak may be one of the most common causes for conversion of laparoscopic cholecystectomy to open cholecystectomy during surgery. To avoid hemorrhagic accidents involving vessels or the CBD during laparoscopic cholecystectomy, with or without cholecotomoy, it commands a thorough exploration of the Calot's triangle and the hepatoduodenal ligament. We hope to shed some light on the variations of the CA which is of utmost anatomical and surgical importance to reduce the incidence of bile duct and artery injuries during laparoscopic cholecystectomy.

Conflict of Interest
None.

Funding
None.

Ethical Approval
Not required.

References

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