Anatomical Variations Of Cystic Artery: Telescopic Facts

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INTRODUCTION

The introduction of laparoscopic cholecystectomy has stimulated a renewed interest in the anatomy of Calot's triangle [1]. This triangle is a focal area of anatomical importance in cholecystectomy and a good knowledge of its anatomy is essential for both open and laparoscopic cholecystectomy [2, 3]. This triangle was described by Calot in 1891 as bounded by the cystic duct, the right hepatic duct and lower edge of liver [4]. In its present interpretation the upper border is formed by the inferior surface of the liver with the other two boundaries being the cystic duct and the common hepatic duct [2,5]. Its contents usually include the right hepatic artery (RHA), the cystic artery, the cystic lymph node (of Lund), connective tissue and lymphatics [5,6]. The cystic artery is a branch of the RHA and is usually given off in Calot's triangle [7].

Anatomic variations in Calot's triangle are common. Variations in cystic artery anatomy, based on its origin, position and number are well described [3, 8] because of its importance in avoiding inadvertent bleeding and its consequences. The reported incidence of these variations is from 25 to 50 % in various studies [3,9] with the magnified laparoscopic view having increased the frequency of recognition of these variations. The methods of retraction used in the laparoscopic procedure gives a different view of the area, thus introducing the term 'laparoscopic anatomy'[7].

Accurate knowledge of cystic artery anatomy and its variations can reduce the likelihood of uncontrolled intra-operative bleeding, an important cause of iatrogenic extra hepatic biliary injury and conversion to open cholecystectomy [3, 7, 8]. The incidence of conversion to open surgery due to vascular injury is reported to be 0-1.9% and its mortality 0.02% [3], hence these variations should stay in surgical conscience to prevent procedure related morbidity. We aim to present the variations in cystic artery seen in laparoscopic cholecystectomy in our patient population.

PATIENTS AND METHODS

Laparoscopic cholecystectomy was carried out in 220 patients with standard four port technique from January 2008 to March 2010. Eight operations were excluded from the study due to open conversion one due to cholecystoduodenal fistula and other seven due to dense adhesions in Calot's triangle, none because of vascular injury. Each operation was recorded and operative images were analysed for variation of cystic artery, based on the classification proposed by Suzuki [10]. He divided the different vascular patterns into 3 groups:

Group 1

Cystic artery or arteries seen in Calot's triangle and no other source of supply is present. This group is further sub-divided into two groups:

- **1a** Single artery is seen in Calot's triangle (normal anatomy).
- **1b** Two vessels are identified in Calot's triangle.

Cystic artery syndrome (figure 1) is described as a variation in group 1. This is a single cystic artery originating from the right hepatic and then hooking round the cystic duct from behind, reappearing at the peritoneal surface near the neck of the gallbladder.

Group 2

In this group more than one blood vessel is identified, one within the Calot's triangle and the other artery is seen outside the triangle.

Group 3

Cystic arteries are only observed outside Calot's triangle. He divided this group based on the number of arterial supplies to the gall bladder.

- **3a** Single artery is visualized outside the triangle.
- **3b** More than one vessel seen outside the Calot's triangle.

RESULTS

The different patterns of arterial supply to the gall bladder were grouped according to the classification proposed by Suzuki.

Group 1 was seen in 192 (87.27%) patients. Of these, 166 (75.45%) had a single artery (1a) and 26 (11.82%) had 2 arteries (1b). Cystic artery syndrome was observed in 4 (1.82%) patients. This was a single cystic artery seen in Calot's triangle then hooked around the cystic duct from behind, and reappeared at the peritoneal surface near the neck of the gallbladder.

Cystic artery originating from aberrant right hepatic artery was observed in 2 (0.91%) patients. This variation is not present in Suzuki's classification but is described by Balija M[9] and we included this in Group 1a, as a single cystic artery was seen in Calot's triangle.

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Table I: Comparison of our result with others' classifications

Arterial Anatomy	Present Study (n=220)	Suzuki M (n=244)	Ding YM (n=600)	Balija M (n=200)
Group 1 (Artery in Calot's triangle)	192(87.27%)	193(79.09%)	513(85.5%)	189(94.5%)
Group 1a (Single artery)	164 (74.5%)	187 (76.6%)	440(73.3%)	147(73.5%)
Group 1b (Double artery)	26 (11.8%)	6 (2.45%)	73(12.2%)	31(15.5%)
*Artery from aberrant right hepatic artery	2 (0.9%)			11 (5.5%)
Group 2 (Artery both within & outside triangle)	12 (5.46%)	18 (7.37%)	9 (1.5%)	
Group 3 (Artery outside triangle)	16 (7.27%)	32(13.11%)	78 (13%)	11 (5.5%)
Group 3a (Single artery)	14 (6.36%)	30(12.29%)		
Group 3b (Double artery)	2 (0.9%)	2 (0.81%)		

*This variation is described by Balija M[9]

Group 2 pattern was seen in 12 (5.46%) patients. In 4(1.82%) patients the second vessel (outside the triangle) was observed running caudal and parallel to cystic duct. In 8(3.64) patients the second artery was seen running between the gall bladder and liver parenchyma along the right lateral border of the gall bladder, yielding multiple small branches to this organ. Group 3 pattern was seen in 16 (7.27%) patients. Single artery (3a) was seen in 14 patients while multiple arteries (3b) were seen in 2 patients.

DISCUSSION

Laparoscopic cholecystectomy was initially associated with a significant increase in morbidity due to increased incidence of biliary injuries and haemorrhages. This was perhaps due to a lack of knowledge of the 'laparoscopic anatomy', two dimensional 'laparoscopic view' and the dissection with long instruments without tactile feedback [3,11]. Misinterpretation of normal anatomy and anatomical variations contributed to major postoperative complications [7]. Conventional textbook description of the regional blood supply did not seem adequate in laparoscopic view [10]. This was the time when anatomy of Calot's triangle was revisited and various classifications of cystic artery were proposed in the literature. Ignjatovic *et al*[12] described 3 types of cystic artery; Type 1 was described as single artery in Calot's triangle; Type 2 more than one artery in Calot's triangle and Type 3 no artery in Calot's triangle. Balija et al [9] described two groups; in group 1, cystic artery, either single or double, was present in the triangle and in group 2 no artery was seen in the triangle on laparoscopic visualization. He did not comment on cases where vessels were seen both inside and outside the Calot's triangle. Ding *et al*[3] in their classification describe 3 groups; Group I has artery/arteries in the triangle, Group II has the artery outside the triangle and Group III has compound arteries, both inside and outside the triangle. They also described these arterial variations according to their origin.

Suzuki has also described the arterial anatomical variations in 3 groups. His description of vascular classification is based on laparoscopic visualization of arterial supply to the gall bladder and no comment has been made on their anatomical origin [10]. This was the reason we chose this classification, as it is practical for those practicing laparoscopic surgery.

In the present study we found normal positioned single cystic artery in 75.45% cases and variations in arterial supply were observed in 24.55% of patients. These observations are consistent with the findings of Suzuki and other authors, who described variations in the range of 23 to 28% [3,9,10,13]. The comparison of our findings with other authors' observations is shown in Table I.

The commonest variation in our study was that of double arteries in Calot's triangle in 11.8% patients. This pattern has been seen in 15 to 25 % of many published series [9] and [13], but Suzuki has described this pattern in only 2.45 % of his patients [10]. We saw cystic artery syndrome in 1.82% of our patients. This variation is described by Suzuki only and he assumes that poor biliary flow due to partial or complete obstruction of the cystic duct is the cause of stone formation. Balija describes a cystic artery originating from aberrant right hepatic artery entering the Calot's triangle from behind the portal vein and paralleling the cystic duct, occasionally forming a prominence in this area (caterpillar hump) This artery yields multiple small branches, rather than a single branch, but within the triangle [9]. We found this pattern in 2 of our Group 1 patients.

We found arteries both within and outside the Calot's triangle in 5.46% of patients. This pattern is seen in 7.3% of Suzuki's patients, compared to 1.5% of patients by Ding YM, who called this pattern a compound artery [3]. Balija has not described this pattern [9]. Within this group we found an interesting variant, an artery passing between the right border of gall bladder and liver parenchyma, entering the liver parenchyma near the fundus, yielding multiple small branches to the gall bladder. Ding YM has also described a similar artery, which he calls aberrant right hepatic artery [3], but unlike our patients, his patients had no normally placed cystic artery in the Calot's triangle. Cystic artery only outside the Calot's triangle was observed in 7.27% of our patients. This pattern was described in 5 to 13% of patients in different studies [3,9,10].

The high frequency of vascular anatomical variations in our study and other published literature clearly emphasizes the necessity of every laparoscopic surgeon being well aware of the vascular anomalies to be able to accomplish laparoscopic cholecystectomy safely [10,13,14]. Newer and sophisticated techniques have recently been introduced to identify biliary and arterial anatomy per operatively, like laparoscopic ultrasonography, laparoscopic Doppler and tactile sensor probe, but these techniques are costly and currently unavailable in our country. There is certainly no alternative to meticulous dissection and clear definition of anatomy. Looking at these highly variable vascular patterns, it is evident that securing the single artery either within or outside the triangle is not the end of gall bladder pedicle dissection and the surgeon should always be prepared to deal with other vessels until the completion of dissection in gall bladder fossa.

CONCLUSION

The vascular supply of the gall bladder is variable and may cause special problems in laparoscopic cholecystectomy. Knowledge of anatomy and recognition of variations are essential prerequisites for safe and uneventful laparoscopic cholecystectomy.

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