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STUDY ON THE ANATOMIC VARIATIONS OF CYSTIC ARTERY DURING LAPAROSCOPIC CHOLECYSTECTOMY AND ITS CLASSIFICATION

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ABSTRACT
The cystic artery is the key structure to be clipped or ligated during laparoscopic or conventional cholecystectomy. The possible complications like hemorrhage or hepatobiliary tract injuries are always centred on the process of search, dissection, and clipping or ligation of the cystic artery, many a time because of possibility of variations in its course and relations to the biliary ducts. This descriptive study was carried out to document the normal anatomy and different variations of the cystic artery with a objective to contribute to improve surgical safety. This study was conducted in a Government teaching hospital on 100 patients undergoing laparoscopic chole cystectomy. Based on our laparoscopic dissection of the calots triangle on this 100 non-emergency patients, 32 men and 68 women, who underwent laparoscopic cholecystectomy for different gallbladder diseases, including 92 with cholecystitis and gallstones, and 8 with gallbladder polyps had the mean age of 38.5 years, we observed and classified cystic artery anatomy into three groups. Group one comprises two subtypes of having cystic artery in calot"s triangle as single or double cystic artery.85 patients were had group one with single cystic artery in 3 patients and double cystic artery in 12 patients. Group 2 comprises four types and termed as outside calots triangle group had 12 cases with 7 cystic artery arising from gastroduodenal artery, 3 from aberrant right hepatic artery and one each from left hepatic and liver parenchyma.Group 3 was a mixed group and had present in three patients. The knowledge of such variations and its awareness will decrease morbidity and help to keep away from a number of surgical complications during cholecystectomy.

KEYWORDS: Cystic artery, hcholecystectomy, anatomy. Haemorrhage. Calots triangle.

1.INTRODUCTION
By virtue of the developments in the fibre optic systems and advances in the minimally invasive surgical accessories, the laparoscopic cholecysetectomy has been revolutionised the applicability of minimally invasive surgery for multiple surgical conditions.[1] Today for the treatment for Gall bladder disorders, laparoscopy is widely accepted as the gold standard.[2] During the early period of its usage since Erich moughe, this was associated with a significant increase in morbidity, especially in iatrogenic biliary injury and hemorrhage[3], probably due to a lack of knowledge of the laparoscopic anatomy of the gallbladder pedicle and its various anamolous positions.. Hence there were multiple studies on the anatomy of calots triangle both in vivo and vitro which has empowered the laparoscopic surgeons to deal with them confidently.

A good knowledge of Calot's triangle is mandatory for conventional and laparoscopic cholecystectomy. Calot's triangle is an important imaginary referent area for biliary surgery with cystic duct, common hepatic duct and hepatic border as boundaries.In 1981, Rocko drew attention to possible variations in the region of Calot's triangle.[4] Hugh etal renamed Calot's triangle in 1992, as the hepatobiliary triangle, with the small cystic artery branches supplying the cystic duct being called Calot's arteries.[5]

Cystic artery bleeding is a troublesome complication during laparoscopic cholecystectomy, and constitute the main reason for conversion to open surgery and often the resultant complications. If adequate care is not implied in delineating the calots triangle, it can end up with, injury to the extrahepatic bile duct or intra-abdominal organs. The incidence of conversion to open surgery because of blood vessel injuries is approximately 0%-1.9% during laparoscopic cholecystectomy[6] as reported by Thompson JE etal, and its mortality is about 0.02%.[7] It is obvious Safety of laparoscopic cholecystectomy depends on the sound knowledge of the anatomy of the cystic artery and its variations.

The cystic artery originates mainly from the right hepatic artery.[8] It is pertinent to note the anatomy with respect to the cystic artery between laparoscopic cholecystectomy and open cholecystectomy are different. In this study we assessed the appearance of the cystic artery during laparoscopic cholecystectomy, and categorised them in to various groups as per the classifications proposed by You-Ming Ding in 2007 in to three groups.[9]

2: MATERIALS AND METHODS

Between January 2017 to December 2018, a prospective evaluation of 100 non-emergency patients, 32 men and 68 women, who underwent laparoscopic cholecystectomy for different gallbladder diseases, includes 92 with cholecystitis and gallstones, and 8 with gallbladder polyps. All of the patients were examined with ultrasound before surgery.All Laparoscopic cholecystectomy surgeries were carried out under general anesthesia by the same operating team using the three ports technique. The information of Calot's triangle and distribution of cystic artery on endoscopic visualization was recorded respectively. 30 degree telescope was used. The anatomical structures were viewed on a video monitor and recorded.

2.1: Ethical Aspects

This study has been approved by the Ethical Committee of Kanyakumari Government Medical College. From all the patients included in the study a written informed consent was obtained after explaining about them the details of the study.

2.2: Inclusion criteria

All the patients admitted with cholecystitis, willing for laparoscopy surgey and willing for included in the study were included.

2.3: Exclusion criteria

1. Patients with Malignant features.
2. Comorbid conditions.
3. Not fit for General anesthesia.
4. Patients not willing to participate in the study.

2. 4: Groups

Group I: (Calot's triangle type)

All patients in whom the cystic artery passes through Calot's triangle are grouped in this group. However under laparoscopic observation, the anatomic location of the cystic artery are found ahead or behind of the cystic duct, and in hepatoduodenal ligament. Group 1is the most common type and has been reported in about 80%-96% of cases in previous studies[12] as reported by Welter etal. In our study out of 100 lap cholecystectomy 85 patients (85%) had this type. Group I patients were further subdivided into two subtypes, as follows.

1. a. Classical single cystic artery

Here the cystic artery originates from the right hepatic artery within Calot's triangle. Nearer to the neck of the gallbladder, the artery is divided into deep and superficial branches. The superficial branch progress along the left side of the gallbladder and the deep branch runs between the gallbladder and liver connective tissues. The deep branch also gives rise to tiny branches to supply the gallbladder, and it gets anastomosis with the superficial branches. In contrast to open cholecystectomy in which the cystic artery is laterally positioned from the cystic duct within Calot's triangle, in laparoscopic cholecystectomy it is just behind and slightly deeper than the cystic duct. As per the literature review, this type is found in 70%-80% of cases.[13] In our study it was recorded in 74of 100 patients (74%) (Figure1).

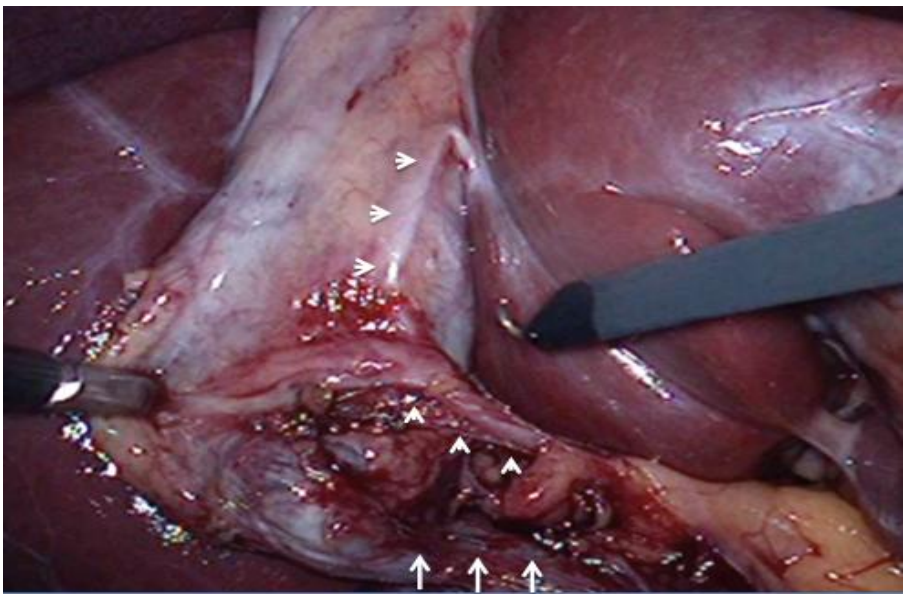

Figure 1: Classical single cystic artery.

1. b.Double cystic artery

Here though the cystic artery also originates from the right hepatic artery, it divides into the anterior and posterior branches at their cystic artery origin itself unlike near the neck of gall bladder in type 1 a. Often in some cases,the posterior cystic artery is very delicate and is cut by electrocoagulation during dissection. Huge et al have reported in their study A double cystic artery has previously been found in 15%-25% of patients.[5] During our laparoscopic cholecystectomy we recorded 11 patients (11%) with double cystic artery (Figure:2).

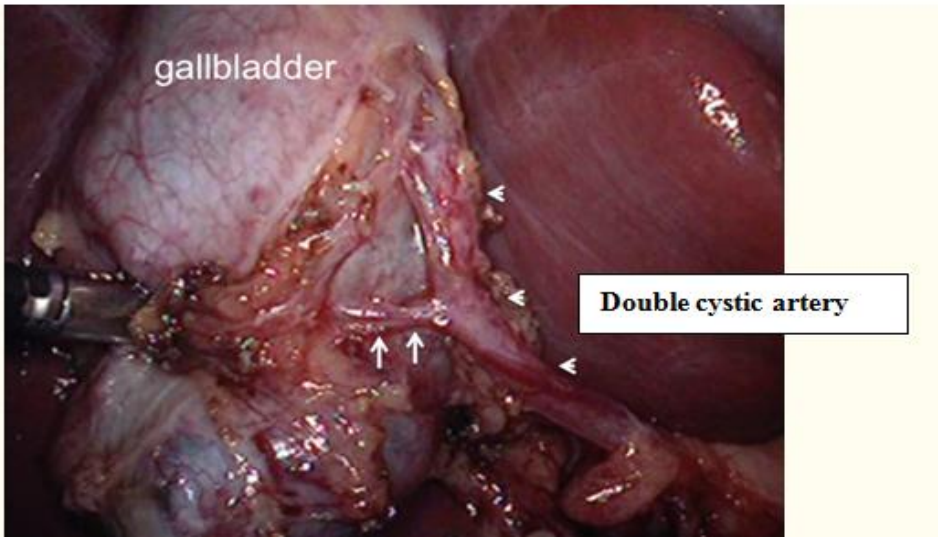

Figure 2: Double cystic artery.

Group 2: Outside Calot's triangle group

Cystic artery approaches the gallbladder outside Calot's triangle and cannot be observed within the triangle by laparoscopy during dissection. In our study 12patients (12%) had the similar findings and grouped in group II during laparoscopic cholecystectomy. This group includes the following four subgroups.

2.a.Cystic artery originating from gastroduodenal artery: The cystic artery does not pass through Calot's triangle but approaches the gallbladder beyond it and is also called low-lying cystic artery . In open cholecystectomy it is noted as inferior to the cystic duct, while it usually localizes superficially and anterior to the cystic duct from a laparoscopic viewpoint. Its terminal segment as it approaches the gallbladder is important for laparoscopic surgeons as it must be manipulated at first, or else it is highly susceptible to be injured resulting in hemorrhage during dissection of the peritoneal folds that connect the hepatoduodenal ligament to Hartman's pouch of the gallbladder or to the cystic duct. This anatomic variation was found in 7 patients (7%) in our study (Figure3).

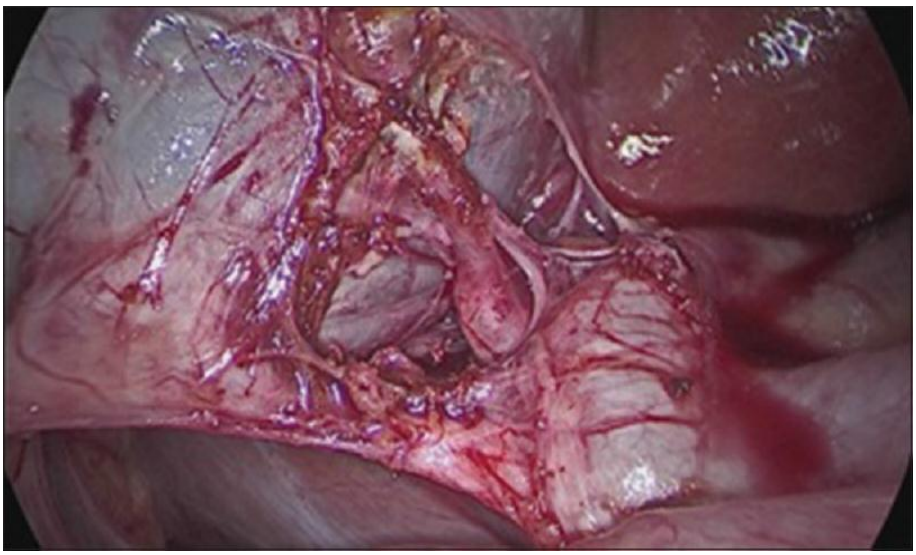

Figure 3: 2.a: Cystic artery originating from gastroduodenal artery.

b. Cystic artery originating from the variant right hepatic artery

The variant right hepatic artery usually originates from the superior mesenteric artery or aorta.[14] It enters Calot's triangle behind the portal vein, and runs parallel to the cystic duct on its passage through the triangle. It can be completely covered by the cystic duct of the gallbladder.[5] This anatomic variation was found in 3 patients (3%) in our study (Figure .4). Suzuki Metal has reported the Variant right hepatic artery has a prevalence of approximate 4%-15%.[15]

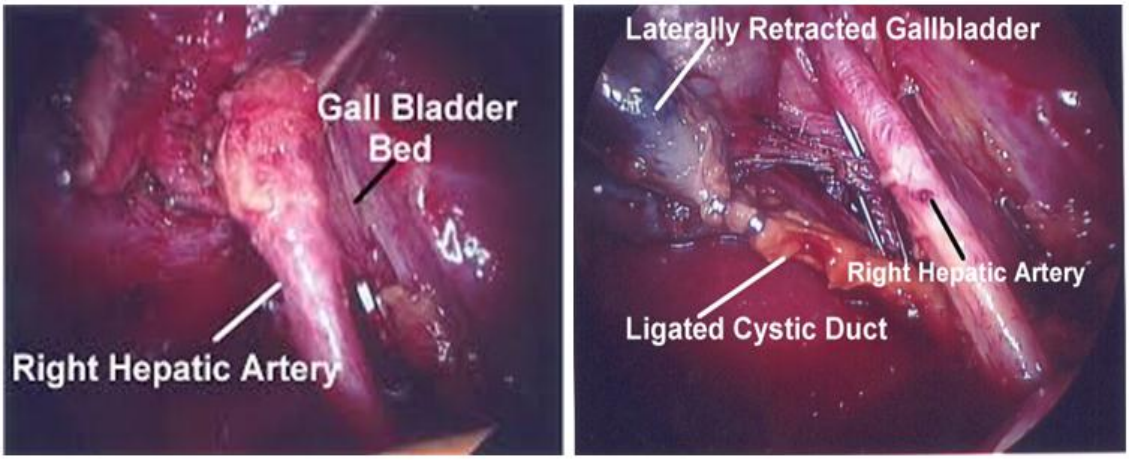

Figure 4: Cystic artery originating from variant right hepatic artery.

2. C.Cystic artery originating directly from the liver parenchyma

Here cystic artery pierces the hepatic parenchyma approaching from the gallbladder bed usually in the right lateral border of gallbladder body and bottom. No other arteries are found within Calot's triangle. This anatomic variation of the cystic artery is not observed until bleeding and is caused by dissection of the gallbladder fundus. It is difficult to explore and requires careful dissection. In our study we found it in 1 patient (1%) (Figure5).

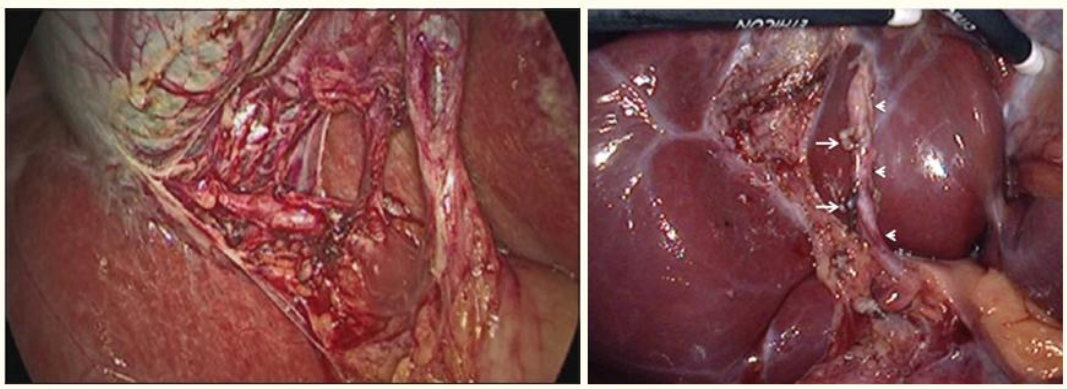

Figure 5: Cystic artery arising from hepatic parenchyma.

2.d.Cystic artery originating from the left hepatic artery: The cystic artery occasionally originates from the left hepatic artery, passes through the liver parenchyma, and reaches the middle of the gallbladder body, at which point it bifurcates into ascending and descending branches. Balija M et al have reported a prevalence of 1%.[16] In our study we had one patient with this type of variant cystic artery.

Figure 6: Cystic artery arising from L hepatic ARTERY.

Group III
It is a compound cystic artery type as it has more than one blood supply. The cystic arteries exist not only in Calot's triangle, but also outside it. We found that 3 patients (3%) belonged to this group. two of these patients had a normal single cystic artery in Calot's triangle, and an artery extending along the cystic duct but posterior to it, and some small arteries that passed immediately from the liver parenchyma to the gallbladder. one of the thee patients had another cystic artery superficial to the cystic duct in addition to the normal cystic artery.

The observations of the cystic artery are tabulated in table I.

Table 1: Position of cystic artery in the study group.

S.N.	Group	Type	Total number of patients	percentage	Total
1	Calot's triangle type	1 a: Classical single cystic artery	74	74	85
		1 b: Double cystic artery	11	11	
2	Outside Calot's triangle	2 a: Cystic artery originating from gastroduodenal artery	7	7	12
		2 b: Cystic artery originating from the variant right hepatic artery	3	3	
		2 c: Cystic artery originating directly from the liver parenchyma	1	1	
		2 d: Cystic artery originating from the left hepatic artery	1	1	
3	Compound cystic artery type		3	3	3

DISCUSSIONS
Anatomic variations in and around Calot's triangle are frequent (biliary tree, cystic artery)[17], to the tune of 20%-50% of patients. Hence it is absolute to exercise careful blunt dissection of Calot's triangle for both conventional and laparoscopic cholecystectomy.

It is mandatory and important for every laparoscopic surgeon to be familiar with the anatomic variations in the extrahepatic biliary tree and those of the arterial supply of the gallbladder. The possible anatomic position and variations of the cystic artery are difficult to establish before surgery. They were only identified during disconnection of Calot's triangle and the gallbladder. The laparoscopic anatomy of the cystic artery can be considered as a precondition for performing safe laparoscopic procedures. The variations of cystic artery often make surgeons recognize an error, causing them to abscise incorrectly and, subsequently, leading to a hemorrhage. When hemorrhage cannot be controlled, conversion to open cholecystectomy is inevitable.

Previous studies have contained fewer reports on the laparoscopic classification of the cystic artery. Some have divided the cystic artery into low-lying cystic artery and cystic artery originating from variant right hepatic artery. Balija classified cystic artery variations into two groups. Group I comprises five variations of the cystic artery within the hepatobiliary triangle.[16]
(a) Normal position
(b) Frontal cystic artery
(c) Backside
(d) multiple
(e) short cystic artery that arises from an aberrant right hepatic artery.

Group II consists of variations of the cystic artery that approaches the gallbladder beyond the hepatobiliary triangle:
(a) Low-lying
(b) trans hepatic
(c) Recurrent cystic artery.

Ignjatovic (18) has divided the cystic artery into three types in minimally invasive surgical procedures:
- Type 1 shows normal anatomy
- Type 2 more than one artery in calot's triangle
- Type 3 no artery in calot's triangle

However, none of the above classifications satisfies the practical needs of laparoscopic surgery. You-ming Ding has postulated the anatomic variations of the cystic artery can be classified into three groups. Group I showed the cystic artery passing within Calot's triangle. It included two types: (1) single cystic artery, found in 440 patients (73.3%); and (2) double cystic artery, observed in 73 patients (12.2%). Group II showed the cystic artery situated outside Calot's triangle.

This group included four variations.
(1) Cystic artery originating from the gastroduodenal artery, found in 45 patients (7.5%)
(2) Cystic artery originating from the variant right hepatic artery, found in 18 patients (3%)
(3) Cystic artery directly arising from the liver parenchyma, observed in 15 patients (2.5%)
(4) Cystic artery originating from the left hepatic artery.

Group III had a compound appearance, with the variant cystic artery situated not only within Calot's triangle, but also outside it. This classification of cystic artery can help surgeons understand the cystic artery more

thoroughly, and hence we have used this model for our study.

The published results are compared with our study and mostly it is replicating the same findings and are tabulated in table 2.

Table 2: Comparison of various published reports on the grouping.

	Present study n-100	Suzuki M (n=244)	You-Ming Ding (n=600)	Balija M (n=200)	Mohamed Zubare etal (n-224)
Group 1 (Artery in Calot's triangle	85(85%)	193(79.09%)	513(85.5%)	189(94.5%)	192(87.27%)
Group 1a (Single artery)	73(73%)	187 (76.6%)	440(73.3%)	147(73.5%)	164 (74.5%)
Group 1b (Double artery)	12(12%)	6 (2.45%)	73(12.2%)	31(15.5%)	26 (11.8%)
Group 2 (Artery outside triangle)	12(12%)	32(13.11%)	78 (13%)	11 (5.5%)	16 (7.27%)
2 a: Cystic artery originating from gastroduodenal A	7(7%)	14(7%)	45(7.5%)	9 (4.5%)	
2 b: Cystic artery originating from the variant right hepatic A	3(3%)	12(6%)	18 (3%)	-	
2 c: Cystic artery originating directly from the liver parenchyma	1(1%)	2(1%)	15 (2.5%)	-	
2 d: Cystic artery originating from the left hepatic artery	1(1%)	1(0.5%)	0 ((0%)	2 (1%)	
3.compound cystic artery type	3 (3%)	18 (7.37%)	9 (1.5%)	-	12 (5.46%)

The commonest variation in our study was that of double arteries in Calot's triangle in 12% patients. This pattern has been seen in 15 to 25 % of many published series but Suzuki has described this pattern in only 2.45 % of his patients.

4. CONCLUSION

Variations in the cystic artery are miscellaneous, and we must be cautious during the performance of laparoscopic cholecystectomy. This laparoscopic classification of the cystic artery is very useful for dissection of Calot's triangle, reduces uncontrollable cystic artery hemorrhage, and may be advantageous for avoiding extrahepatic bile duct injury and its resultant conflications.

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