The Incidence of Cystic Artery Variation during Laparoscopic Surgery

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Abstract

The attractiveness of laparoscopic cholecystectomy has led to a new understanding of biliary anatomy especially of the Calot's triangle area in order to perform a successful surgery. This study aims to describe the common and variant anatomy related to the cystic artery during laparoscopic cholecystectomy so that to minimize anatomical complications and to recommend an anatomically safe procedure. The analysis involved fifty patients who underwent laparoscopic cholecystectomy by (American technique) at different Iraqi centers during a 6-month-period.

Females constituted 84% of the patients. Routine preoperative ultrasound examination revealed gallstones in 86% of the patients. 18% of the cases demonstrated anomalous vascular anatomy.

Vascular anomalies included caterpillar configuration of the right hepatic artery, a previously unreported right hepatic artery in the gallbladder bed, and cystic arteries that were early divided, low inserted, and originating from proper hepatic artery. Hartmann's pouch, cystic lymph node, and the superficial branch of the cystic artery were recognized as important anatomical landmarks during the procedure

الخلاصة

أدت الجاذبية التي تتمتع بها جراحة استئصال المرارة بواسطة تنظير البطن إلى ظهور فهم جديد لتشريح الاقنية الصفراوية وبخاصة فيما يتعلق بمنطقة مثلث كالوت وذلك لغرض تحقيق جراحة ناجحة . تهدف الدراسة إلى وصف التشريح الاعتيادي والمتفاوت المتعلق بالشريان المراري خلال إجراء جراحة استئصال المرارة بواسطة تنظير البطن وذلك للتقليل من المضاعفات التشريحية وللخروج بتوصيات نحو إجراء جراحة آمنة من الناحية التشريحية.

تم تقييم الاستقصاءات الروتينية السابقة للجراحة أما الخطوات الجراحية وما كشف عنه أثناء الجراحة والمضاعفات فقد تم تسجيلها فيديو يا وتحليلها من وجهة النظر التشريحية.

تضمن هذا التحليل خمسين مريضا ممن أجريت لهم جراحة استئصال المرارة بواسطة تنظير البطن (الطريقة الأمريكية) في مستشفيات عراقية مختلفة وخلال فترة ستة أشهر. شكلت الإناث 84% من المرضى وأظهرت فحوص السونار السابقة للجراحة وجود تفاوتات تشريحية في 34% من المرضى. كانت 18% من هذه التفاوتات وعائية و 14% منها متعلقة بالمرارة فيما شكلت تفاوتات الاقنية الصفراوية 2% منها .

اشتملت التفاوتات الوعائية على وجود الشكل اليسروعي للشريان الكبدي الأيمن، وجود الشريان الكبدي الايمن في مضجع المرارة وهذا ما لم يتم الإخبار عنه مسبقا، وجود شرايين للقناة المرارية مسبقة الانقسام، أو منخفضة الأنغراز ، أو ناشئة من الشريان الكبدي المخصوص. إما التفاوتات المتعلقة بالمرارة فقد تضمنت شكل القلنسوة الفرنجية، والمرارة داخل الكبد ، وحالة نادرة من الأحشاء مقلوبة الموضع.

أما التفاوت المتعلق بالأقنية الصفراوية فقد تمثل بوجود قناة مرارية منخفضة الانغراز. تم تمييز جيبة هارتمان، والعقدة اللمفاوية المرارية والفرع السطحي للشريان المراري على أنها معالم تشريحية مهمة خلال إجراء جراحة استئصال المرارة بواسطة تنظير البطن.وجاءت التوصيات التشريحية لإجراء جراحة آمنة لاستئصال المرارة بواسطة تنظير البطن :

- التشريح الحذر والمنتبه لمثلث كالوت،
- تسليط الأبعاد على كل من قاع وقمع المرارة
- البدء بتشريح القناة المرارية من جهة جيبة هارتمان،

- ضرورة تبيين فراغ بين القناة المرارية والكبد،
- تشخيص الفرع السطحي للشريان المراري كونه يمهد لتشريح جذعه
- بقاء الجراح على الجهة الوحشية للعقدة اللمفاوية المرارية أثناء تشريح العنيقة المرارية ، كما أن عليه البقاء بعيدا عن الكبد أثناء فصل المرارة وان يكون ملما بالمنظر التشريحي الجديد والذي يواجهه أثناء جراحة استئصال المرارة بواسطة تنظير البطن.

Introduction

Embryogenesis of the gallbladder and biliary tract

Normal development

During the course of the fourth week of gestation, the embryonic foregut at its junction with mid-gut gives rise to the hepatic diverticulum. From the distal end of the diverticulum develops the parenchyma of the liver; the extra hepatic biliary tract and the gallbladder develop from the proximal portion.

The biliary tract is the site of great variation and even gross anomalies: some are fatal in postnatal life while others, although physiologically functional, may result in operative catastrophes if they are unrecognized during surgical procedures later in life [1]

The gallbladder, the hepatic ducts, and upper portion of common bile ducts are supplied by the cystic artery. Other vessels derived from the hepatic artery pass to the gallbladder from the bed in the liver.

Cystic veins are numerous and minute; those from the hepatic surface pass through the gallbladder bed to enter the quadrate lobe of liver. Veins under peritoneal surface may reach the neck of gallbladder and enter the quadrate lobe to be directly or by way of a plexus around bile duct. These veins entering the liver open into the hepatic veins not the portal vein. Veins from the lower part of common bile duct drain into the portal vein by the start of the fifth week, all the parts of the system are indicated. During this stage, the future duct system ,like the duodenum itself ,is a solid cord of cell, toward the end of the fifth week, growth of the left side of the duodenum initiates a shift of the attachment of the liver and the two pancreatic diverticula's to their final position on the dorsal surface of the duodenum. During the sixth week, the lumina of the ducts become established, starting with the common bile duct and progressively extending to the remainder of the system. The gallbladder remains solid until the twelfth week. During the process of recanalization, two or three lumina may appear and eventually coalesce. This pattern of solid stage followed by recanalization parallels the changes in the duodenum, but strangely, no solid stage appears in the pancreatic ducts. More than one duodenal opening of the common bile duct is not unusual at this stage .The lower one usually vanishes, but a case in which a bifurcated common bile duct persisted was describe by [1].

The proximal portion of the hepatic diverticulum, the future common bile duct ,becomes absorbed into the expanding duodenum so that the bile and pancreatic ducts enter the wall together. In most individuals ,the dividing septum between the two passages retracts to leave a common ampulla of variable length [1].

The biliary tract is the site of great variation and even gross anomalies: some are fatal in postnatal life. while others, although physiologically functional. Cystic artery supply both gallbladder and cystic duct commonly arise from the right hepatic artery in angle between the common hepatic duct and the cystic duct. Variation in the origin and course of the cystic artery are common. The common bile duct is a very vascular structure, especially around the retroduodenal segment. There is rich ensheathing epicholedochal arterial plexus derived primarily from the retroduodenal or posterior superior pancreaticoduodenal artery [2]. There may be considerable variation in the origin of this ductal blood supply. There is also a rich intramural plexus, the duct should not be denuded or traumatized for more than 2 cm in the supraduodenal portion, or an vascular stricture may result. Strictures that result from stripping the adventitia probably occur when the blood supply is minimal. [2]

Materials and Method

Patients

The study involved fifty patients who underwent laparoscopic cholecystectomy from October 2007 to march 2008 at Kadhmiya Teaching Hospital-Baghdad (50 cases). All the patients had a history of symptomatic cholelithiasis. Investigations including, liver function tests, blood grouping, and ultrasound of the abdomen emphasizing on the gallbladder, liver, and extra-hepatic biliary tract were performed. Previous history of any surgical operation especially in upper part of abdomen was taken into consideration.

Age and gender distribution of the patients included in this study are summarized in Table 1.

Table 1 Age and gender distribution of the patients.

Gender	Age in years					
	20-29	30-39	40-49	50-59	60-69	Total
Male	1 (2%)	0 (0%)	2 (4%)	4 (8%)	1 (2%)	8 (16%)
Female	11 (22%)	18 (32%)	4 (8%)	8 (16%)	1 (2%)	42 (84%)
Total	12 (24%)	18 (32%)	6 (12%)	12 (24%)	2 (4%)	50 (100%)

- Female: Male ration = (42/8) = 5.25:1
- Mean age = 39.3 years

Materials

The laparoscopic equipments used were produced by Richard Wolf (Germany).

Method

The patients were operated in the supine position with 10°-20° head up (reverse Trendelenberg position) and with a left tilt once the pneumoperitoneum has been established.

The surgeon stands on the left side of the patient and the first assistant is on the right side of the patient. The person operating the camera stands to the left of the surgeon (American technique).

Results

Patients' age and gender distribution

Patients' age ranged from 20-69 years, with a higher frequency during the third and fourth decade for females. Most of the male patients were in their fifth decade onwards. Females constituted 84% of the patients with a female: male ratio of 5.25:1.

Anatomical variations

Nine (18%) of the cases operated in this study demonstrated anomalous vascular anatomy. The anomalies observed can be categorized into five main types: Caterpillar configuration, Early divided cystic artery, Low inserted cystic artery, Right hepatic artery in the bed of Gallbladder, and Cystic artery originated from proper hepatic artery (Table-3.1).

The usual configuration is an anterior cystic duct close to the laparoscopic view and appearing larger than the cystic artery which lies postero-superior. The cystic artery arising from the right hepatic artery and appearing smaller and farther away. This normal pattern was present in about (82%) of the patients (Fig.3-1).

In the caterpillar configuration, the right hepatic artery comes close to the gallbladder and cystic duct, this arterial loop renders the right hepatic artery tortuous and results in a short cystic artery (Fig.3-2).

In the early divided cystic artery, the anterior and posterior branches of the cystic artery, which commonly divide upon reaching the neck of the gallbladder, divide before reaching Calot's triangle (Fig.3-3A). In this case, two arteries traverse the triangle. On further traction of the gallbladder and dissection of the peritoneum, the two arteries appeared to stem from a single cystic artery in a Y-shaped configuration (Fig.3-3B).

Table-3.1 Incidence of Vascular anomalies types and distribution

Vascular anomalies	Number of patients	Percentage
Caterpillar configuration	2	4%
Early divided cystic artery	2	4%
Low inserted cystic artery	2	4%
Right hepatic artery in the bed of Gallbladder	2	4%
Cystic artery originated from proper hepatic artery	1	2%
Total	9	18%

In a low-inserted cystic artery (Fig.3-4), the artery originated from vessels other than the right hepatic artery (e.g. gastroduodenal, superior mesenteric, etc. The low inserted cystic artery, in order to reach its final destination passed anterior or inferior to cystic duct but not posterior to it. The operation field in laparoscopic cholecystectomy and its technique hinders further dissection to confirm the origin of the variant vessel.

When the cystic artery originated from proper hepatic artery (Fig.3-5, its relation to the cystic duct was the common posterior relation. In both, low-inserted cystic artery and when the cystic artery originated from the proper hepatic artery, the cystic artery runs a long course before reaching the gallbladder.

In two patients there was an overlap in the anatomical variations. In one case there was a Phrygian cap anomaly associated with a low inserted cystic artery. In the second case there was a Phrygian cap anomaly associated with a caterpillar configuration of the right hepatic artery.

A rare anatomical variation encountered in this study was a right hepatic artery found in the bed of gallbladder (Fig.3-6). Commonly, the right hepatic artery courses behind the bile duct and joins the right pedicle high up in Calot's

Discussion

Important anatomical landmarks of the operative field

Infundibulum (Hartmann's pouch)

The most important anatomical landmark to start dissection of the cystic duct was the infindibulum of gallbladder. The junction of the neck of the gallbladder with the cystic duct should always be identified and visualized prior to further dissection.

The dissection of Calot's triangle can be done safely starting at Hartmann's pouch and moving towards the cystic duct (Figure 4-1).

Cystic lymph node

In Calot's triangle the cystic node (Node of Lund) usually overlaps the cystic artery. To be on the safe side, it was found that staying lateral to the node during dissection of the cystic duct and artery reduces the incidence of injury to boundaries and contents of Calot's triangle. In other words, the cystic node was used as an end-point in the dissection of Calot's triangle (Figure.4 -2).

Superficial branch of the cystic artery:

The superficial branch of the cystic artery on the surface of the gallbladder was a good landmark to lead to the site of the parent cystic artery when pathology obscures clear anatomy of the cystic artery (Figure 4-3)

Gender distribution

Patients' age ranged from 20-69 years, with a higher frequency during the third and fourth decade for females. Most of the male patients were in their fifth decade onwards. Females constituted 84% of the patients with a female: male ratio of 5.25:1

Recent postoprative study [3] of one handred and fifty consecutive patients with calculi of biliray system created on as elective cholecystectomy in 1999 / October to 1st october 2000. There were 112 females (74.7%) and 38 males (25.3%) with age range of 20 – 80 years and a mean age of 46 years, with a peak incidence in the fifth decade of life, as shown in table 4-1.

Table 4-1 Age ad Sex distribution [3]

Age	20-29	30-39	40-49	50-59	60-69	70-80	Total %
Male	2	5	12	8	6	5	38(25.3%)
Female	7	22	36	23	18	6	112(7.47%)
Total	9	27	48	31	24	11	150(100%)

Female: Male ration = (112/38) = 3:1

Mean age = 46 years

Vascular anomalies

An important consideration during dissection of Calot's triangle is the frequent anomalies of cystic artery and cystic duct. Nine (18%) of the cases operated in this study demonstrated anomalous vascular anatomy.

In other study [3] found that the total number of extrahepatic biliary anomalies were 81 out of 150 cases (incidence 54%), and these was divided into vascular (40%), ductal (12%), and GB anomalies (2%), Table 4-2.

Table 4-2: Incidence of total extrahepatic biliary anomalies. [3]

Anomalies	No.	%
Vascular anomalies	**60**	**(40)**
Ductal anomalies	18	(12)
GB anomalies	3	(2)
Total	81	(54)

Vascular anomalies (40%) are much commoner than ductal anomalies (12%).

The main arterial supply to the gallbladder is the cystic artery and presented an unusually high degree of variability not only in origin but also in its course to the gallbladder. Since it is always sought for ligation during cholecystectomy irrespective of its origin, the most practical method of locating the cystic artery would be the relationship of its course to the biliary-duct system and the Calot's triangle. Commonly the cystic artery passes superior and medial to the cystic duct within the Calot's triangle as in this study (96%), while it is found outside in 6 cases only (4%), inferior to cystic duct especially when there is high insertion of this duct. So it is important to be aware of the situation when no artery is seen in Calot's triangle, because various abnormalities in position may exist and overlooking them result in sever hemorrhage.

Table4-3: Incidence of vascular anomalies in150 cholecystectomies and its several subtypes[3]

Anomaly	No.	(%)
Accessory cystic artery	27	(18)
Anterior cystic artery of anterior RHA	24	(16)
Caterpillar hump right hepatic artery	9	(6)
Total	60	(40)

1- Accessory cystic artery (18%),

This high incidence also reported in many studies (no statistical significant difference between our study and other studies: P > 0.05), as shown in (Table 6).Therefore after carefully ligating or clipping one artery, the surgeon must search carefully for the possibility of another supply which may have any source of origin, and if not identified this may be torn and bleeding may obscure the operative field and hurried blind clamping may produce a disaster.

2- Anterior transposition of the cystic artery, or (the right hepatic artery) anterior to the (CHD) or (CBD), was found in (16%), again there is no statistical significant difference between our study and other studies: P > 0.05 as shown in Table 4-4.

Table 4-4 Comparison between this study and other studies about vascular anomalies.[3]

Studies	Anterior cystic or anterior RHA(%)	Accessory cystic artery (%)
Baker study (2000)	(16)	(18)
Adkins RB (2000)	-	12
Shwartz (1999)	15	25
Toouli (1993)	-	12
Stremple J.F (1986)	20	25
Benson and Page (1976)	20.7	26.4
Nicholas (1951)	18	25
Moosman (1951)	19.6	25.2
Daseler et al (1947)	-	14

(P > 0.05)

It is clinically important to note especially when doing an exploration of (CBD), and when the anterior cystic artery being ligated there is always a possible risk of direct injury to either (CBD) or (CHD), depending on where the anterior cystic artery runs, how closely it is related to the ductal structure and how far proximally the ligation is placed.

3- Caterpillar hump right hepatic artery, which is much less common (6%). This artery can pass anterior or posterior to the (CBD) or (CHD). If the right hepatic artery replaces the cystic artery within the Calot's triangle, and it is tortuous and projects forwards to the right of the (CHD), something like the hump of caterpillar back during progression, with convexity downward or upward and from the summit of the U-shape loop a short cystic artery arises and passes to the neck of the gallbladder, and it is definitely not a traction artifact, it is potentially a more treacherous and dangerous anomaly for the following reasons: [3]

a. It may be mistaken for the cystic artery (especially if vigorous traction is applied) and an attempt may then be made to ligate it, and this can fatal in the presence of impaired liver functions.

b. Since the cystic artery which arises from a caterpillar hump right hepatic artery is frequently short and stubby, it is relatively easily avulsed from the parent trunk (particularly when strong traction is applied to the gallbladder), again producing brisk bleeding with possible unfortunate sequence of events outlined above.

c. It must be emphasized that an artery resembling the cystic artery in its course and paralleling the cystic duct is not necessarily the cystic artery but may be the right hepatic artery because the caliber of the vessels to be divided is not a reliable index if it is the cystic or right hepatic artery. It is therefore essential to visualize the right hepatic artery above and below the origin of the cystic branch

Conclusions

The advent and popularity of LC has led to a new look and insights into biliary anatomy especially of the Calot's triangle area. The term 'laparoscopic anatomy has actually found a place in anatomy texts, educational multimedia, and on the World Wide Web (e.g. Online Laparoscopic Technical Manual. [http://www.Laparoscopv.net] & Laparoscopy Hospital. [http://www.laparoscopyhospital.com/article.HTML].

Anatomical recommendations for a safe laparoscopic cholecystectomy:

Surgeons do not perform routine imaging investigations other than a preoperative ultrasound; thus, they should rely on solid anatomical knowledge. Although a detailed discussion of all the factors peculiar to laparoscopy that contribute to an increased incidence of injuries is beyond the scope of this study, a good knowledge of anatomy and the expectation of its intricacies are regarded as the corner stone in performing a safe procedure.

1. Attention should be paid to the dissection of Calot's triangle.
2. Retraction should be applied on the fundus and infundibulum of the gallbladder.
3. Cystic duct dissection should start from Hartmann's pouch.
4. a space should be demonstrated between the cystic duct and the liver,
5. the superficial branch of the cystic artery facilitates dissection for the stem,
6. the surgeon should stay lateral to the cystic node during dissection of the cystic pedicle, stay away from the liver

during gallbladder detachment, and get acquainted with a new anatomical view encountered during laparoscopic cholecystectomy

Vascular injury

The most obvious danger is that of haemorrhage from large blood vessels lying anterior to the biliary tree .Such vessels are inconstant but frequent the posterosuperior pancreaticoduodenal artery to the retroduodenal portion of the common bile duct ,is the vessel most frequently encountered [1] .The cystic artery is an example of some pitfalls to be expected .

1. It may be single or double, short or long.
2. It may be passing anterior or posterior to the right and left hepatic ducts, the common hepatic or the common bile duct.
3. It may be large, mimicking a small right hepatic artery.
4. It may bifurcate at the neck of the gallbladder or two arteries may have a separate origin.
5. Bleeding from veins of the gallbladder bed or from veins of the common bile duct is a minor complication, injury to the portal vein [4] or the inferior vena cava is more serious, these vessels must be repaired at once.
6. A second complication is ischemia to the liver from unintended ligation of the right hepatic artery or an accessory replacing of aberrant right hepatic artery. Interference with the blood supply of the common bile duct may result in ischemia and stricture. Other surgeon feel that the blood supply is good and that collateral circulation will prevent local ischemia [5] , [6] , [7]

Vascular variations

Uncontrolled arterial bleeding during laparoscopic cholecystectomy is a serious problem and may increase the risk of bile duct damage. Therefore, accurate identification of the anatomy of the cystic artery is important [8].

The common pattern of a cystic artery arising from the right hepatic artery and appearing smaller and farther away from the cystic duct in the laparoscopic view was present in about (85%) of the patients (Fig.3-1). Other studies revealed the typical pattern of the cystic artery to be present in 72% [9], 73.5% [10], and 76.6% [11] of patients operated laparoscopically. The nomenclature of arterial variants and their types vary from one study to another [9],[10],[11]. Absence of cystic artery in Calot's triangle was reported in H.1%"(9) and 5.5%[10] of the cases. A cystic artery that runs inferior to the cystic duct was found in 6% of the cases [9]. In this study, the low inserted cystic artery and the cystic artery originating from a right hepatic artery in the liver bed imply absence of the artery in Calot's triangle; this was observed in 8% of the cases.

The right hepatic artery normally courses behind the bile duct and joins the right pedicle high up in the Calot's triangle. In the caterpillar configuration, the right hepatic artery comes very close to the gallbladder and the cystic duct the form of a hump. Although the incidence of this variation was 4% in this (Fig.3-2), it seems that its incidence may be as high as 50% [12]. If such a is present, the cystic artery in turn is very short. In this situation the right hepatic artery is either liable to be mistakenly identified as the cystic artery or tarn in attempts to ligate the cystic artery. The ensuing bleeding in turn predisposes to biliary injury [8].

A rare anatomical variation encountered in this study was a right hepatic artery coming very close to the gallbladder so that it was found in its bed (Fig.3-6). An accessory or replaced right hepatic artery from superior mesenteric artery has been reported in almost 15% of individuals, whereby the right hepatic artery courses through the Calot's triangle and therefore nearer the gallbladder [8]. Nevertheless, a right hepatic artery within the gallbladder bed has not been previously reported. The presence of such an artery renders the cystic artery short and may require meticulous dissection of the gallbladder from its bed. In addition, right hepatic vascular injury has been reported to lead to liver necrosis in the right liver lobe [13]. The possibility of the presence of a right hepatic artery in the bed of the gallbladder emphasizes the necessity to dissect close to the gallbladder rather than the liver parenchyma.

Accessory cystic arteries were observed in 7.4% of the cases and doubling of the cystic artery was observed in (22%)[9] and (15.5%)[10] of the cases. Doubling of the cystic artery was indicated to be the most common cystic artery variation [10]. In this study a double cystic artery was found in Calot’s triangle in 4% of the cases (Fig.3-3); however, the double artery was found to originate from a single stem in a Y-shaped configuration.

A cystic artery originating from the gastroduodenal artery was found in (4.5%) patients. In this study a low inserted cystic artery of obscure origin was found in (4%) of the cases. The long course of such an artery and its course anterior to structures in the free margin of lesser omentum were also reported. Small branches of the cystic artery, suggested to be named Calot's arteries, supply the cystic duct and may cause troublesome bleeding during laparoscopic dissection in the hepatobiliary triangle. These small vessels have been better appreciated in the era of laparoscopic cholecystectomy and need to be divided to obtain a length of cystic duct before division [8].

Careful identification of arterial anomalies should help to reduce uncontrolled bleeding and the incidence of bile duct injuries during laparoscopic cholecystectomy. Investigations pre and intra-operative do not give any clue about arterial variation so knowledge of anatomy is crucial.

<u>Some golden rules in case of difficulty</u>[14]

- When the anatomy of the triangle of Calot is unclear, blind dissection should stop.
- Bleeding adjacent to triangle of Calot should be controlled by pressure and not by blind clipping or clamping.
- When there is doubt about the anatomy a fundus first cholecystectomy dissecting on the gallbladder wall down to the cystic duct, can be helpful.
- If the cystic duct densely adherent to the common bile duct and there is possibility of Mirizzi syndrome (stone ulcerating through into the common duct) the infundibulum of gallbladder should be opened and the stone removed and the infundibulum oversewn.
- Occasionally, the gallbladder bed bleeding profusely, the use of suction and diathermy is advisable for laparotomy and laparoscopic operation.
- The gallbladder bed may be filled with omentum and a drain placed over the omentum (not between the bed and the omentum).
- Regardless of the direction of the procedure the junction of the cystic and common hepatic ducts should be identified.
- Short cystic duct may cause inadvertent injury to the common bile duct.

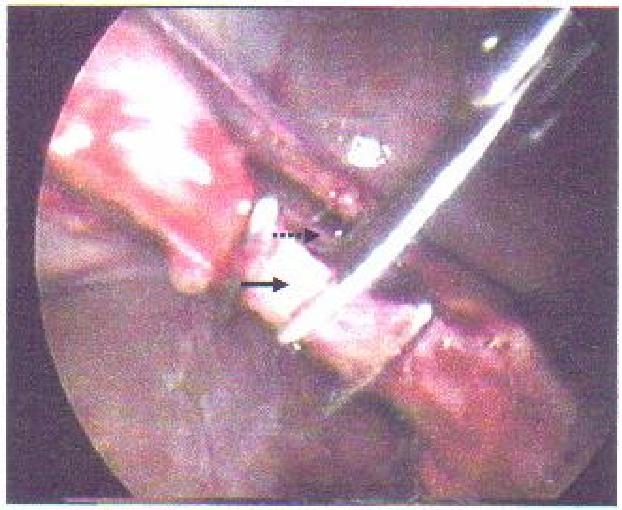


Figure 3-1: The most common configuration of cystic duct and artery encountered in this study. Cystic duct (à), cystic artery (interrupted arrow).

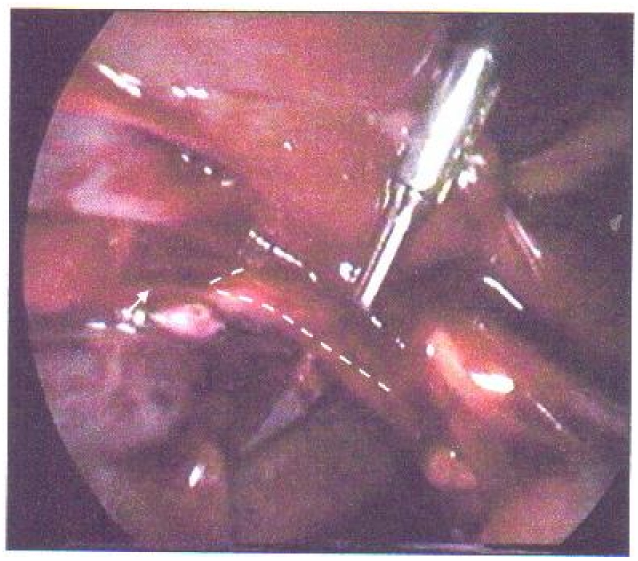


Figure 3-2: Short cystic artery (à) arising from caterpillar right hepatic artery (interrupted line).

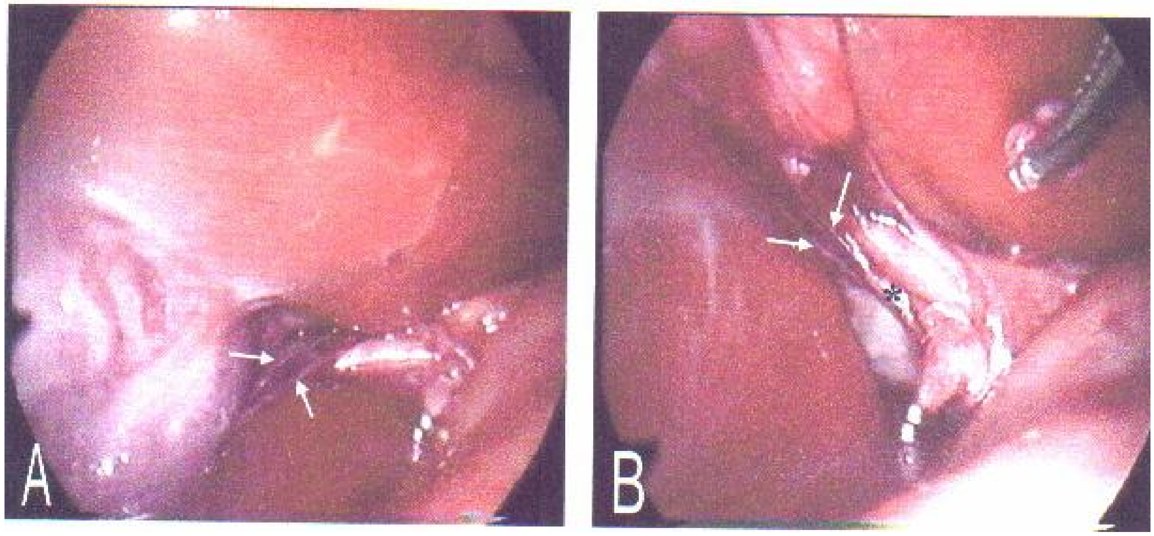
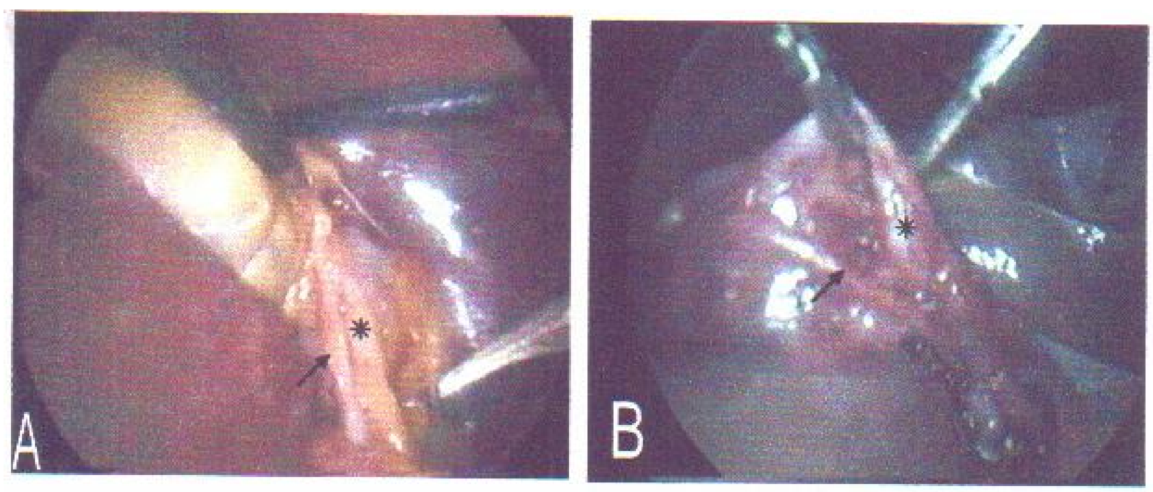


Figure 3-3 early divided cystic artery. (A) The anterior and posterior branches of the cystic artery (arrows) traverse Calot's triangle. (B) Further traction of the gallbladder reveals the two arteries (arrows) arising from a single cystic artery (*) in a Y- shaped configuration.



<u>Figure 3-4:</u> (A) Low inserted cystic artery (à) passing infront of the cystic duct (*) ; (B) Low inserted cystic artery (à) passing inferior to the cystic duct (*)

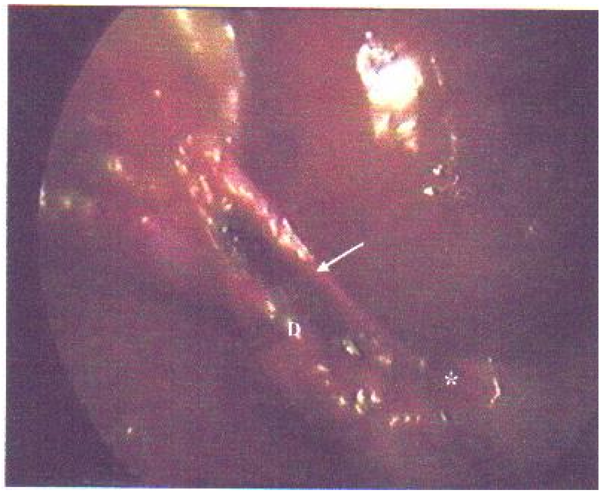


Figure 3-5: cystic artery (à) originated from proper hepatic artery (*).Note that the cystic artery lies posterior to the cystic duct (D).

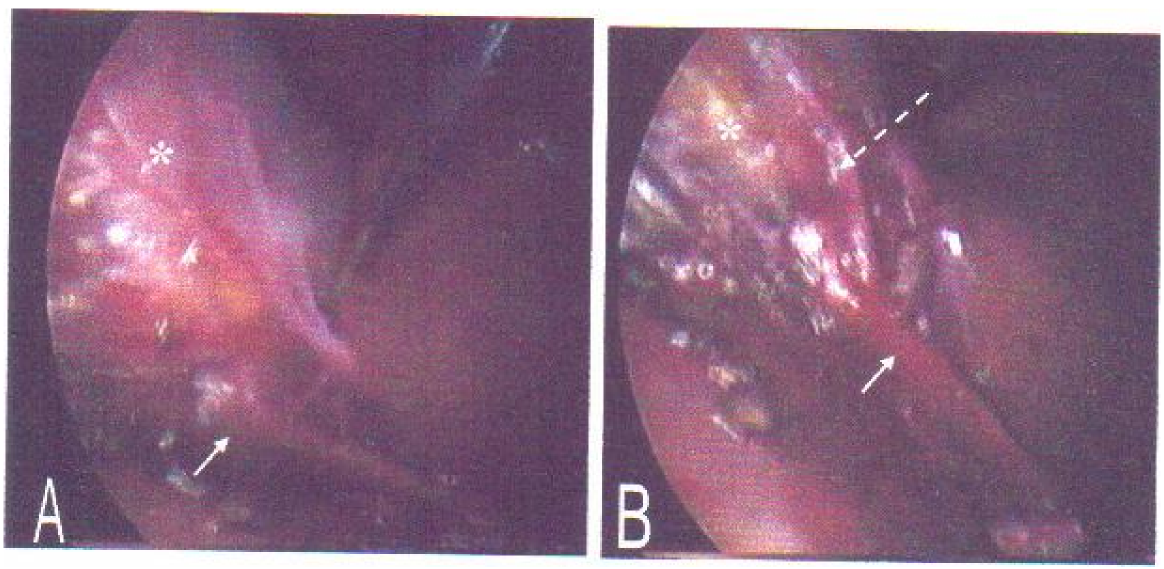


Figure 3-6: (A) right hepatic artery (à) in the bed of the gall bladder (*); (B) cystic artery (interrupted arrow) arising from the right hepatic artery (à) within the bed of the gall bladder.

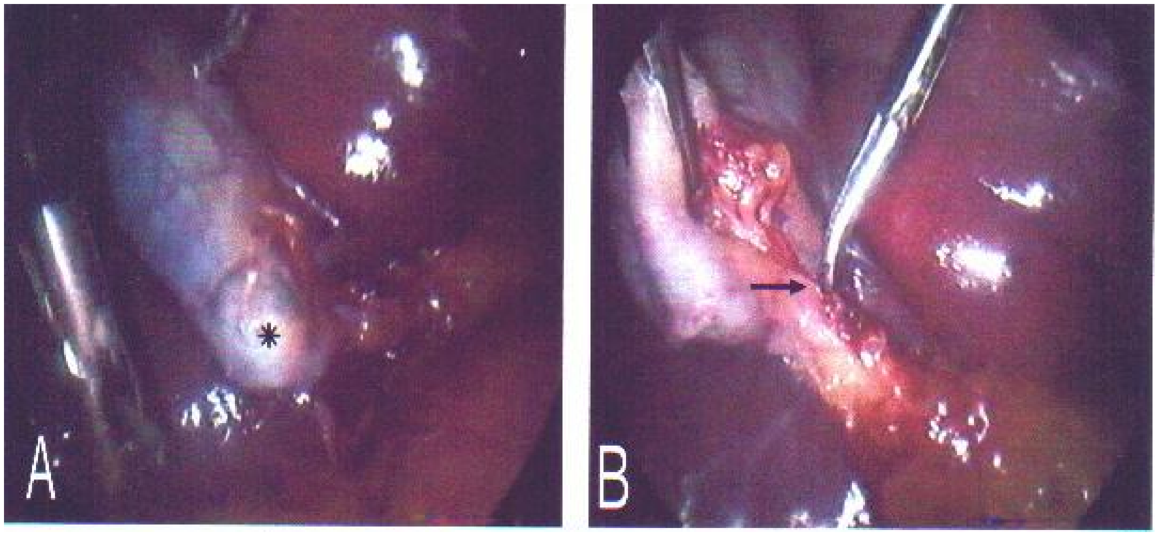


Figure 4-1 anatomical landmark to start dissection of the cystic duct during laproscopic cholecystectomy. (A) Hartman's pouch(*) (B) the junction of the neck of the gallbladder with cystic duct (→) where dissection of the cystic duct was started.

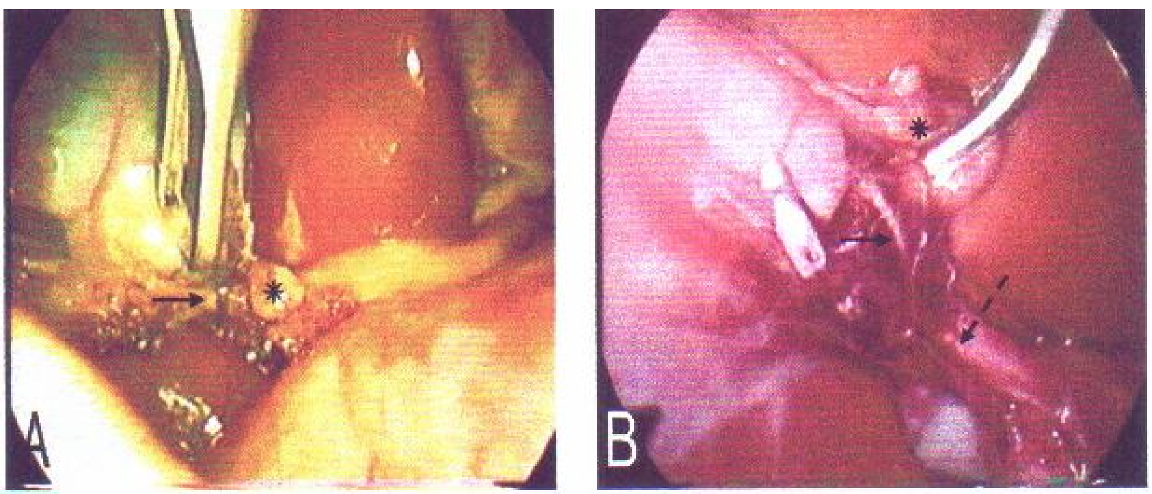


Figure 4-2 cystic lymph node as an anatomical landmark. (A) cystic lymph node (*) overlying the cystic artery (⟶) : (B) traction on the cystic node(*) reveals the underlying cystic artery (⟶) and exposes the boundaries of the calot's triangle. Note the common hepatic duct (the interrupted arrow)at the medial border of the triangle.

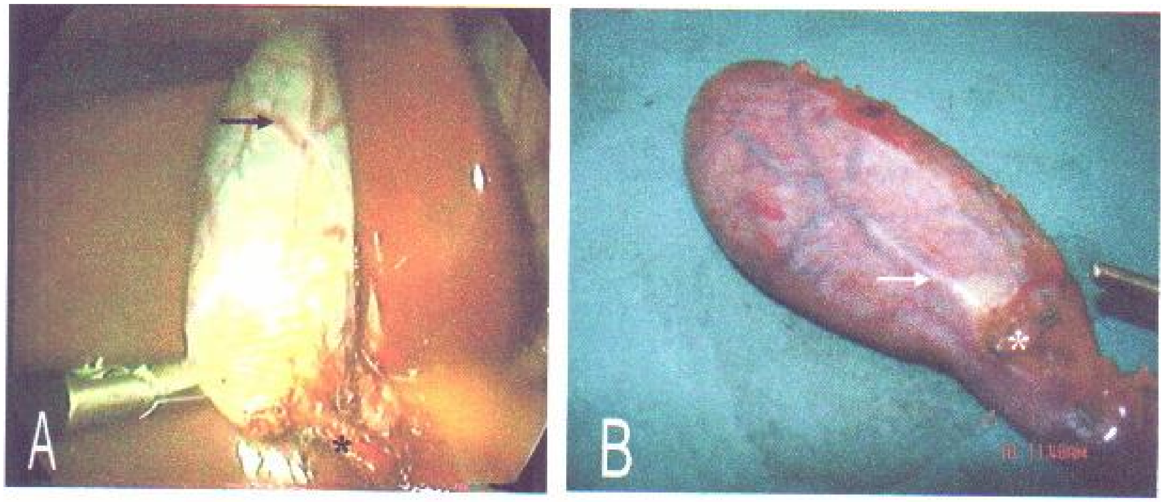


Figure 4-3 the superficial branch of the cystic artery as an anatomical landmark. (A) the superficial branch (arrow) leading to the parent cystic artery(*). (B) extracted gall bladder showing the superficial branch of the cystic artery ( )and it's continuation with clipped cystic artery (*).

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