Calot's Triangle: Proposal to Rename it as Calot's Region and the Concept of 'Ducto-Arterial Plane'

Sunil Kumar · Mohit Kumar Joshi

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Abstract The anatomical description of the area requiring dissection during cholecystectomy is incomplete and incorrect. We carefully observed the anatomy of this region for over 20 years in various biliary pathologies and present our view. Describing this area in the form of triangles is incorrect. There exists a definite plane between the two folds of peritoneum in this region, wherein the cystic duct and the cystic artery traverse. The description of the “triangles” that require dissection during cholecystectomy are not strictly geometrical triangles; hence, the area bounded by these so-called triangles should be renamed as “Calot's region.” The surgeons should take advantage of the existence of a definite “ducto-arterial plane” in the Calot's region and dissect it sharply to avoid ductal and vascular injuries.

Keywords Bile duct · Calot's triangle · Triangle of cholecystectomy · Cholecystectomy · Cystic artery · Cystic duct

Introduction

Cholecystectomy is one of the commonest surgery performed worldwide. Operative bile duct and arterial injuries are the major concerns for the surgeon performing cholecystectomy. The incidence of these injuries is equal in cholecystectomies being performed by laparoscopic or open technique, although initially, they were believed to higher in laparoscopic group

[1, 2]. The secret of avoiding these fearsome complications lie in meticulous attention to the bloodless dissection in the region where these structures are present and in identification of the normal or abnormal anatomy.

The anatomy of this region has been described for more than a century now in the form of well-known “triangles” viz., “triangle of Calot” (CT) and “triangle of cholecystectomy” (TC). In its original description by Calot in 1891 [3], the triangle was described to be bounded medially by hepatic duct (HD), laterally by cystic duct (CD), and superiorly by cystic artery (CA) (Fig. 1). Nearly after a century in 1981, Rocko and DiGioia described a triangular area bounded medially by HD, laterally by CD, and superiorly by the under surface of liver and named it as “triangle of cholecystectomy” [4] (Fig. 1). These classically described triangles are said to contain loose areolar tissue sandwiched between the two layers of the peritoneum with CA traversing these triangles from the left to reach the gall bladder.

We have been carefully observing the anatomy of this region since the last two decades, and believe that (a) this anatomical description is grossly incomplete and (b) to describe this area in the form of a triangle is erroneous. We wish to describe the area bounded by these so-called triangles as “region.” Our description is detailed below.

Our Description of this Region and the “Ducto-Arterial Plane”

We have observed that the peritoneal folds covering these conventionally taught triangles quite often (30–40 %) run up to the superior border of the first part of the duodenum; in these circumstances, it resembles a rectangle or square rather than a triangle. In other situations, these triangles are virtually non-existent; Mirizzi's syndrome is a typical example, wherein this oversimplified triangular shape is completely missing.

S. Kumar
Department of Surgery, UCMS & GTB Hospital, Delhi, India

M. K. Joshi (✉)
Department of Surgery, University College of Medical Sciences and
Guru Teg Bahadur Hospital Delhi, C-1/1201, Olive County Sector 5,
Vasundhara, Ghaziabad, UP 201012, India
e-mail: drmohitjoshi@gmail.com

Fig. 1 Line diagram of “triangles” in Calot’s region. *A* Calot’s triangle; *A* + *B* triangle of cholecystectomy

Its triangular shape is also lost in the malignant conditions of this region. Given all these uncertainties and possibilities, it is probably better to refer this area as “Calot’s region” (CR).

These triangles (better and henceforth termed in this manuscript as CR) contain the fat pad, instead of loose areolar tissue, sandwiched within the two folds of peritoneum. Usually, the CA runs across the CT/TC from left to right, positioned between the CD below and the under surface of the liver above. However, in 10 to 15 %, of subjects it is the CD that runs across the CT/TC from right to left positioned between the CA below and the under surface of the liver above. Thus, it is completely erroneous to say that the CT/TC is bounded by CD. It is more close to the truth to say that CT/TC contains CD as well as CA, taking variable positions between the under surface of the liver and the superior surface of the first part of the duodenum.

Howsoever variable their relative position may be, one thing is very certain: that the CD and CA run in a relatively avascular plane between the two peritoneal folds of CR. The authors refer to this as the “ducto-arterial plane” (Fig. 2). It is

Fig. 2 Ducto-arterial plane. Arrow Dissected anterior layer of peritoneum CD cystic duct; CA cystic artery; F fat between the peritoneal folds

in this plane that any abnormal duct or artery shall run; thus, this plane should be carefully exposed by sharp dissection to look for abnormalities of biliary and vascular structures.

During open cholecystectomy the ducto-arterial plane is generally “lost” to dissection very rapidly because of crude dissection. Same happens in laparoscopic cholecystectomy (LC) if performed by using the blunt dissector. We avoid blunt dissection in the CR as poking by the dissector can cause undue bleeding and subsequent disastrous complications. Instead we sharply dissect the anterior peritoneal fold of the CR from the gall bladder (GB) neck by means of the electro-surgical hook. The anterior leaf of the peritoneum of the CR can easily be lifted up to the free edge of the HD, thereby exposing the CD and CA embedded within the fat pad of the CR. It is in this (ducto-arterial) plane that any abnormal duct or artery will be visualized, thereby giving the surgeon every chance to avoid injury to these structures. The ducto-arterial plane dissection is virtually bloodless. Further, after lifting and separating the anterior peritoneal leaf of the CR, one can see the following structures clearly: medially, the HD (running upward towards the porta hepatis); laterally, the neck of the GB; and superiorly, the under surface of the liver (Fig. 2). This guarantees the clear visualization of the HD, giving unparalleled safety against operative injury to the HD and hepatic artery.

After identifying CD, CA, and HD, the CD and CA can be treated as per the preference of the surgeon. However, we practice and recommend the following five “commandants” before clipping or ligating and dividing the CD and CA. (i) CD must be seen to emerge from the neck of the GB and join the HD, (ii) CD should be ligated or clipped only and only while avoiding any traction on the GB neck (this ensures that the HD is not tented), (iii) clips or ligature on CD should be placed at least 5 mm away from the HD, (iv) no other non-pulsatile tubular structure should be seen to emerge from GB and join the HD, and (v) the CA should be seen pulsating before clipping/ligating and dividing (this ensures that the structure is identified as CA).

Discussion

Cholecystectomy is one of the most common procedures a general surgeon performs. It is also the commonest procedure used for laparoscopic training. Nonetheless, operative injuries remain a concern even today despite nearly four decades of its coming to fore. The key to avoid operative injuries to the HD and hepatic artery lies in paying attention to the anatomy in the CR while dissecting it meticulously.

Despite the convention and traditional teaching of this region in the form of triangles, we feel that this region is not strictly a triangle. Triangle is a geometrically fixed shape with little anatomical variation, while anatomic variations are not uncommon in this region [5, 6]. In addition, Mirizzi’s

syndrome and malignancies in this region completely destroy these so-called triangles. As a certain degree of anatomical variability is inherent to the term “region,” we believe and advocate that the term CR should replace the term CT/TC.

Further, the classical description of the anatomy in these triangles is less than adequate. We have observed that the space between the two layers of the peritoneum is avascular because of the existence of a definite ducto-arterial plane which is traversed by the CD and CA. Since the peritoneum splits again on the right border of the HD to go around it and the hepatic artery, any anomalous duct and the artery shall also lie in this avascular ducto-arterial plane. Therefore, the normal CA, any abnormal artery, and any abnormal duct are best visualized in this plane by lifting the anterior layer of the peritoneum in the CR; this is a vital step to prevent operative injuries to the biliary and vascular structures during LC.

During LC, the CR can be dealt with either the blunt or sharp dissection. The American technique describes the blunt dissection [7]. The French and the Dundee techniques, on the other hand, advocate sharp dissection (by electrosurgical hook) [8]. However, none of these techniques emphasize the existence of the ducto-arterial plane. Similarly, the description of the CT/TC remains unchallenged. This is the first description of the avascular ducto-arterial plane and first attempt to rename CT/TC as CR.

The authors dissect the anterior layer of the peritoneum in the CR by cutting it close to the GB neck by means of the electrosurgical hook, and then lift it upward and medially to inspect the ducto-arterial plane and the structures traversing it. By and large, the anterior peritoneal leaf can be lifted off like a one-piece curtain in most cases. However, in a few, it can be achieved in bits because of past intense inflammation; although even then, the ducto-arterial plane can be identified in virtually all.

The standard key points advocated for safety against the operative injury include clear delineation of the CD joining the gall bladder neck, identifying the CA running across the CR towards the GB neck, and avoidance of undue traction on CD and CA while clipping or ligating. Careful dissection of the CR in ducto-arterial plane is central to all these operative steps. Thereafter, opening a window beyond the CR well up onto the liver bed to avoid misinterpretation of the right hepatic duct as CD is essential for the safe completion of cholecystectomy [9].

The principal author is using the two-handed technique of dissecting the CR using electrosurgical hook from anterior aspect for the last two decades, and has constantly observed the ducto-arterial plane. We appeal that surgeons should take advantage of the existence of this plane and look for anomalous duct or artery in it to avoid the injuries to the bile duct and CA. The dissection of the CR from the anterior aspect by electrocautery is nearly always possible. The authors strongly

feel that the most risky and inappropriate way of dealing with the CR is to blindly poke it using the dissector.

The principal author has had only two bile duct injuries so far in the last two decades. Both these cases were recognized intra-operatively and CBD was repaired primarily. There has been no instance of the arterial injury. The author had to resort to a combination of anterior and posterior approach less than 5 % times, when anterior dissection had become difficult and non-progressive.

Conclusion

The description of the triangles that require dissection during cholecystectomy are not strictly geometrical triangles. This becomes more obvious in pathological conditions; hence, the area bounded by these so-called triangles should be renamed as CR rather than CT/TC. The surgeons should take advantage of the existence of a definite ducto-arterial plane in CR and dissect it by sharp dissection to delineate the biliary and vascular structures before ligating or dividing them to avoid injuries to these structures.

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