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INTRODUCTION:

The complexity of writing a review on surgical anatomy or laparoscopic cholecystectomy is no easy task , “ anatomy associated with observations is important for the safe execution of any operative procedure. Specifically in the context of a cholecystectomy, it has been recognized since long that misinterpretation of normal anatomy as well as presence of anatomical variations contribute to the occurrence of major postoperative complications specially biliary injuries. Such injuries in turn can cause significant morbidity and occasionally even mortality. They are also one of the commonest causes of litigation against abdominal surgeons in the developed world.

There is now a fair amount of data to suggest that the acceptance of laparoscopic Cholecystectomy (LC) as the standard procedure, has led to an increase in bile duct injuries. This seems partly related to the different anatomical exposures the ,the calot’s triangle during the laparoscopic proceedure.

Hence, it is important for biliary and minimally invasive surgeons to appreciate basic anatomical facts as they apply to the performance of cholecystectomy as well as understand from literature how anatomical distributions or variations can contribute to complications and ive personally witness. It is not an exhaustive description of biliary anatomy but discusses anatomical facts that are of relevance to the performance of a safe cholecystectomy.

Anatomy:

It is pear shaped organ siistuated in a fossa on the liver undersurface. It variable in shape and volume. Normally present at the junction of the right lobe and medial segment of the left lobe on the visceral surface of the liver in between the segments IV(b) and V and at the lower limit of the principal plane or Cantlie’s line (Couinaud, 1954).

Segment IV (anterior part) is quadrate lobe). Its position in relation to liver may vary. The hepatic surface is attached to the liver by connective tissue of the liver capsule. Both the non-hepatic surface and the fundus are completely covered with peritoneum. The body is also completely covered by peritoneum and has its own mesentery.

GB without this mesentery (floating or roving) is subjected to torsion and infarction. A layer of connective tissue binds the upper surface of the body of the GB to the cystic fossa whereas its inferior surface is closely related to the transverse colon and to the first and proximal part of the second part of the duodenum. For example it may be partially or completely embedded within the liver parenchyma; the so called intrahepatic GB.

This may create difficulties in dissection and may increase the chance of intraoperative injury to the liver. Although the main right pedicle is fairly deep in the liver parenchyma large portal and hepatic venous branches traverse the liver at a depth of around one cm from the Cystic plate . Thus a deep liver tear during the dissection of the GB off its fossa can occasionally bleed profusely.

The GB is stratified into four anatomic portions, a fundus, a body and a neck and infundibulum , this terminology in my opinion eases communication in the procedure . The Hartmann’s pouch an outpunching of the wall in the region of the neck is recognized more as an outcome of pathology in the form of dilatation or presence of stones. This pouch is variable in size but a large Hartmann’s pouch may obscure the cystic duct and the Calot’s tringle.

This may be result of plain enlargement or due to adherence to the cystic duct or bile duct.

Thus a small cystic duct can get completely hidden and traction on the GB can lead to the bile duct looking like the cystic duct. An exaggerated form of the same process is the Mirizzi’s syndrome in which a large stone in the Hartmann’s pouch area is either adherent to or erodes into the bile duct. This can create major difficulty during a cholecystectomy.

It is overwhelming that cholecystohepatic duct can join the GB at any point in its hepatic bed. Thus a duct encountered in the GB fossa is most likely a subvesical duct , commonly called the duct of Lushka.

Cystic Duct: The cystic duct is a ductal pathway from the gallbladder to the bile duct and is one of the important structures needing proper identification and division during a standard cholecystectomy. The cystic duct may run a straight or a fairly convoluted course. Its length is variable and usually ranges from 2-4 cm. Around 20% cystic ducts are less than 2 cm. This in my opinion is where excessive traction on the fundus leads to tenting of the CBD thus leading to very little space to put clips which causes the surgeon to apply a clip that may include part of the circumference of the duct

True absence of cystic duct is very rare and if the duct is not seen is more likely to be hidden. The cystic is usually 2-3 mm wide. It can dilate in the presence of pathology (stones or passed stones).The normal bile duct is also around 5 mm and hence can look like a mildly dilated cystic duct. In general a cystic duct larger than 5 mm (or the need to use a very large clip to completely occlude the duct) should arouse a suspicion of mistaken identity with the bile duct before it is clipped or ligated.

may

The cystic duct joins the gallbladder at the neck and the angle in which they unite may span from being acute or maybe Also the complications that they mode of joining be smooth tapering or abrupt. On the bile duct side its mode of union shows significant variations Fig-9. Since such variations Fig-5 are not uncommon it may not be safe to try and dissect the cystic duct to its junction with the bile duct. It is important to remember that even in the low insertion variety the cystic duct rarely goes behind duodenum and therefore a ductal structure passing behind the duodenum is more likely to be the bile duct itself.

Double cystic ducts are described but are exceedingly rare and therefore two ductal structures entering the gallbladder should always be viewed with suspicion. Also the cystic duct does not have vessels traveling on its surface whereas the bile duct has such visible vessels.

Fig [9]

Cystic Artery and Right Hepatic Artery:

The cystic artery is a branch of right hepatic artery (RHA) and is usually given off in the Calot’s tringle. It has a variable length and enters the gallbladder in the neck or body area. The course and length of the cystic artery in the calot’s triangle is diverse and vague Although classically the artery traverses the tringle almost in its center, it can occasionally be very close or even lower than the cystic duct. It usually gives off an anterior or superficial branch and a posterior or deep branch Fig-7.

This branching usually takes place near the neck gallbladder. When the point of dissection is very close to the gallbladder as in a LC or the branching is proximal, one may have to separately ligate the two branches. Also if the presence of a posterior branch is not appreciated it can cause troublesome bleeding during posterior dissection.

In addition the cystic artery gives of direct branches to the cystic duct. These small vessels have been better appreciated in the era of LC3, 4 and need to be divided to obtain a length of cystic duct before division. It is very important that any pulsatile structure in the hepatobiliary triangle is not the cystic artery, it is something else, cystic artery become pulsatile only after ligation and division.

The RHA normally courses behind the bile duct and joins the right pedicle high up in the Calot’s triangle. It may come very close to the gallbladder and the cystic duct Fig-6in the form of the ‘caterpillar’ or ‘Moynihan’s’ hump. Although the incidence of this variation is variable it seems common enough to merit detailed description and may be as high as 50%. If such a hump is present, the cystic artery in turn is very short. In this situation the RHA is either is liable to be mistakenly identified as the cystic artery5 or torn in attempts to ligate the cystic artery. The ensuing bleeding in turn predisposes to biliary injury.6

There are fair numbers of other arterial variations of cystic artery Fig-8 also described. Many of these are unlikely to cause confusion if the artery is divided very close to the gallbladder wall. There is a 2-15% incidence of double cystic artery. Therefore it may be occasionally necessary to ligate two arteries to the gallbladder. When the cystic artery is given off not from the RHA but from other vessels like the common hepatic artery (2-5%) it crosses the bile duct anteriorly and may be prone to injury.

Also the Superior Mesenteric Artery may give off the cystic artery in which case it ascends to the gallbladder below the cystic duct. An accessory or replaced Right Hepatic Artery (RHA) from SMA which is a variation seen in almost 15% of individuals the RHA courses through the Calot’s triangle (and therefore nearer the gallbladder) and in turn has a shorter cystic artery.

“Biliary Abnormalities is the Rule but not the Exception”: A standing surgical dictum. Not less than 25-30% of arterial and ductal abnormalities are detected during cholecystectomy operation. Every GB is a different GB. It is said. Hence possibilities of injuries cannot be ruled out in this surgery even in the hand of experienced surgeon.

Origin of Cystic Artery:

Right hepatic artery:

(a) Normal-61.4%

(b) Aberrant(accessory)-10.2%

(c) Aberrant(replacing)- 3.1%

Left hepatic artery-5.9%:

Bifurcation of common hepatic artery-11.5%

Common hepatic artery-3.8%

Gastroduodenal artery-2.5%

Superior pancreaticoduodenal artery-.15%

Right gastric artery-.15%

Coeliac artery-.3%

Superior mesenteric artery-.9%

Right gastroepiploic artery-Rare

Aorta-Rare

(Source: Anson BJ. Anatomical considerations in surgery of gallbladder. Q Bull Northwest Univ Med School 1956; 30:250)

Accessory and Aberrant Ducts: There are a large number of accessory ducts Fig. 4 described in the biliary drainage network of the liver. However, the accessory ducts likely to be encountered during a cholecystectomy are those draining parts of the right lobe. These ducts are typically small and course through the Calot’s tringle (and therefore closer to the gallbladder) before they enter the common hepatic duct separately below the confluence of the right and left duct at variable distances. Sometimes the cystic duct may actually join the accessory duct.

These ducts may drain substantial portions of the right lobe of the liver, either one of the sectors (two segments) or a segment and may in fact be the sole drainage of that part of the liver in which case they are more precisely termed as ‘aberrant’ ducts. It has been suggested that most such ducts are aberrant rather than accessory in which case it is even more important to safeguard them.7,8 Cholangiographic studies have shown that there is almost a 20% incidence of the right anterior or the right posterior ducts joining the common hepatic duct separately rather than in the form of a right duct. If such a duct is injured it can lead to substantial biliary stasis or leak.9, 10

The size of the duct may be an indirect indicator of the amount of liver it drains. It has hence been recommended that in case of injury if the duct is more than 3 mm it should always be drained into a Roux loop. Alternatively one can perform a cholangiogram through the duct to assess the amount of liver it drains as well as whether it is accessory or aberrant. With increasing recognition of injury to such ducts these have now been grouped into separate type in the recent Strasberg classification of bile duct injuries.

Calot’s Triangle and Hepatocystic or Hepatobiliary Triangle: The famous triangle Fig-3 was described as bounded by the cystic duct laterally, CHD medially and the cystic artery superiorly in its original description by Calot in 1891.In its present in the present the upper border is formed by the inferior surface of the liver with the other two boundaries being the cystic duct and the bile duct. Most appropriately it should term as cholecystohepatic or cholecystobiliary triangle Fig-10.

Its content usually includes the RHA, the cystic artery, the cystic lymph node (of Lund), connective tissue, and lymphatics. Occasionally it may contain accessory hepatic ducts and arteries and aberrant right hepatic artery and aberrant bile duct as discussed previously. The right aberrant hepatic artery courses along the medial aspect of the triangle; posterior to the cystic duct.

It is this triangular space, which is dissected in a cholecystectomy to identify the cystic artery and cystic duct before ligation and division. In reality, it may be a small potential space rather than a large triangle making the dissection of its contents without damaging the bordering structures the most challenging step of a cholecystectomy. In addition the space may be obscured and shrunken by various mechanisms. The left (or medial) boundary of the triangle formed by the bile duct is the most important structure, which needs to be safeguarded.

Laparoscopic Anatomy: The advent and popularity of LC5, 9 has led to a new look and insights into biliary anatomy especially of the Calot’s triangle area and the term ‘laparoscopic anatomy’ has actually found a place even in anatomy texts. Although a detailed discussion of all the factors peculiar to laparoscopy that contribute to an increased incidence of injuries is beyond the purview of this review, the different anatomical ‘laparoscopic view’ of the area around the gallbladder especially the Calot’s triangle does contribute to misidentification of structures.

The method of retraction during the laparoscopic procedure tends to distort the Calot’s triangle Fig-17 by actually flattening it rather than opening it out. Also, the reluctance to (or difficulty in) performing a fundus first cholecystectomy during the laparoscopic procedure as opposed to the open procedure also contributes to the same lack of exposure of the Calot’s triangle. Finally, the ‘posterior ‘or ‘reverse ‘dissection of the Calot’s triangle, which is popular during an LC, again gives a different view of the area and since the gallbladder is flipping over during this method may lead to further anatomical distortionFig-18.

The Rouviere’s sulcus5 is a fissure Fig-2 on the liver between the right lobe and caudate process and is clearly seen during a LC during the posterior dissection in a majority of patients, it corresponds to the level of the porta hepatic where the right pedicle enters the liver. It has hence been recommended that all dissection be kept to a level above (or anterior) to this sulcus to avoid injury to the bile duct Fig.12, 13.

Also, this being an ‘extrabiliary’ reference point it does not get affected by distortion due to pathology. Similarly, a clear delineation of the junction of the cystic duct with the gallbladder along with the demonstration of a space between the gallbladder and the liver clear of any other structure other than the cystic artery (safety window or critical view) is also recommended as an essential step to prevent bile duct injury.

Investigations to Assess the Anatomy: Drawing of the Calot’s triangle from anatomy texts are very different from the anatomy seen during the performance of a cholecystectomy. In the first place all the structures forming the boundaries of the Calot’s triangle are not seen during surgery as they are covered with tissue. Also, in a significant number of individuals since the cholecystectomy is performed for pathology in the form of cholecystitis the anatomy is obscured by inflammation, edema, adhesions, fibrosis, and presence of stones.

In view of the importance of anatomy and it’s variations in injuries caused during cholecystectomy it is logical to look at the possibility of assessing the anatomy accurately with the help of imaging before or during the performance of a cholecystectomy. Most cholecystectomies are performed after identification of gallstone disease on ultrasound examination. Although on occasion an ultrasound examination can predict gross distortions of anatomy like Mirizzi’s syndrome, in the usual case it does not through any light on anatomical relations.

Thus knowledge of the specific anatomy in that individual is not available to the surgeon preoperatively as a routine. If a cholangiogram in the form of a magnetic resonance cholangio pancreatography (ERCP) has been performed for some reason, it may reveal anomalies like the presence of accessory ducts or a low insertion of cystic duct.