Chapter

Safety Landmarks in Laparoscopic Cholecystectomy

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Abstract

Laparoscopic cholecystectomy stands as one of today's most frequently performed medical procedures. The advent of laparoscopy and its widespread availability has instilled confidence in patients worldwide, leading them to embrace it as a preferred treatment. Given the procedure's extensive adoption by surgeons across all skill levels —from novices to experts—it becomes imperative to establish a set of guidelines to ensure its safety for patients. With each patient exhibiting a distinct anatomical makeup and the complexity of surgeries ranging from straightforward cholecystectomies to intricate cases involving a frozen Calot's triangle, it becomes paramount to approach gallbladder surgeries meticulously to avert any potential harm. Given its global prevalence, even a 0.1% complication rate translates to a significant figure. Therefore, practicing safe cholecystectomy is advocated strongly. This chapter provides the fundamental structure for performing a safe laparoscopic cholecystectomy. Encompassed within the chapter are insights into identifying critical landmarks for assessing the positioning of vital structures when confronted with compromised anatomical conditions.

Keywords: safe laparoscopic cholecystectomy, critical view of safety, anatomical landmarks, timeout, difficult laparoscopy, bailout procedures, SAGES

1. Introduction

There is no other surgical procedure that has been more affected by advent of laparoscopy than cholecystectomy. Laparoscopic cholecystectomy has been more necessary in steering the laparoscopic age further than any other procedure. Laparoscopic cholecystectomy (LC) has fleetly come as the procedure of choice for routine gallbladder [1].

Laparoscopic cholecystectomy is the gold standard treatment of gallstones and is one of the commonest operations performed laparoscopically worldwide. The increasing demand of patient for laparoscopic intervention in the treatment of gallstones has played a major role in the fast development of laparoscopic cholecystectomy. Laparoscopic cholecystectomy comes with the advantage of decreased postoperative pain and thus the need for postoperative analgesia decreased hospital stay and early return to normal activity. Laparoscopic cholecystectomy also delivers superior cosmesis and patient satisfaction as compared with open cholecystectomy [2].

The procedure-related vascular and bowel injuries and complications of pneumoperitoneum have increased the morbidity of the procedure to 2% [3]. The new range of complications is noticed now because of increased use of energy sources, such as stapling devices, harmonic, and vessel sealing systems [4, 5]. The rates of bile duct injuries in open cholecystectomy are 0.125–0.25% but in laparoscopic surgery, even after the learning curve is over, the incidence is said to be 0.2–0.8% [6]. This incidence remains high and hence, the aim of all surgeons should be to minimize the rates similar to that in open surgery. This chapter is an overview of a safe cholecystectomy.

2. Patient selection

LC is performed for symptomatic cholelithiasis and for complications like acute cholecystitis, pancreatitis, and obstructive jaundice. Careful selection of patient is very important for the procedure. For example, there is increased risk in patients with cirrhosis and portal hypertension for two reasons: low peripheral resistance and increased bleeding tendency during the procedure. Laparoscopic cholecystectomy in such patients should be attempted by appropriate expertise (**Table 1**) [10].

History
Male gender
Age more than 65 years
History of acute cholecystitis for more than 72 to 96 hours
Repeated biliary colic
Previous attack of acute cholecystitis
Previous upper abdominal surgery
Previous failed attempt of cholecystectomy
Physical examination
Pyrexia
Higher ASA score (ASA Score 3 or 4)
Morbid obesity
Laboratory tests
Leucocytosis (more than 18,000/mm3)
C-reactive protein >3
Imaging (USG/CT/MRI-MRCP)
Gallbladder wall thickness (> 4–5 mm)
Contracted gallbladder
Stone at neck of gallbladder
Complication like: Gangrenous gallbladder, perforated gallbladder, Liver disease
Mirizzi syndrome

Intraoperative
Small and shrunken gallbladder
Retracted Liver edge with puckering near fundus/fissure (Liver pucker sign)
Fatty/firm cirrhotic liver (difficulty in retraction)

Table 1.
Predictors of difficult cholecystectomy [7–9].

3. Creation of pneumoperitoneum

The creation of pneumoperitoneum is the primary step for all laparoscopic procedure. For gaining peritoneal access, both open and closed methods are used and are nominally safe. A meta-analysis was done in 2003, which incorporated 17 randomized controlled trials compared complication rates of open and closed access techniques and found no difference in complication rates; however, injuries to blood vessels were noted in 0.9 per 1000 procedures (0.1%) and 1.8 per 1000 procedures had bowel injuries [11]. With increased advocacy for safe laparoscopic cholecystectomy, the complication rate has come down over the last many years.

There is always a probability of major visceral or vascular injury in blind pneumoperitoneum creation. It should be kept in mind that the distance between anterior abdominal wall and major vessels, such as aorta, vena cava, and iliac vessels is approximately 2 cm in lean patients under relaxation. The rate of complications is 0.18%, 0.09%, and 0.27% in closed, open, and optical trocar method, respectively [12].

Hence, it can be stated that there is no significant difference noted in both the techniques used for creation of pneumoperitoneum. Decisions of choosing the technique should be surgeons choice based on case assessment and the individual's training and skills. The other precautions that prevent major injuries are: asking the patient to empty the bladder before the procedure and to aspirate the stomach before putting the needle/trocar. Following are the various techniques:

i. Verres needle

ii. The open Hasson technique

iii. Direct trocar placement without prior pneumoperitoneum

iv. The optical view technique can be used where laparoscope is placed within the trocar and the layers of the abdominal wall are visualized as they are being traversed [11].

3.1 Open technique

A small incision is made below umbilicus and extended below to linea alba. Fat is separated from the umbilical scar using langenbeck retractors. The junction between linea alba and umbilical scar is delineated by uplifting the umbilicus by a towel clip. Here, the linea alba is fused with umbilical cicatrix and is thinnest. A vertical incision is made at this place and fascia and rectus sheath are incised.

The little finger is then placed gently inside the incision to breech the peritoneum and to remove any adhesions from the peritoneal surface. Now, the trocar is placed

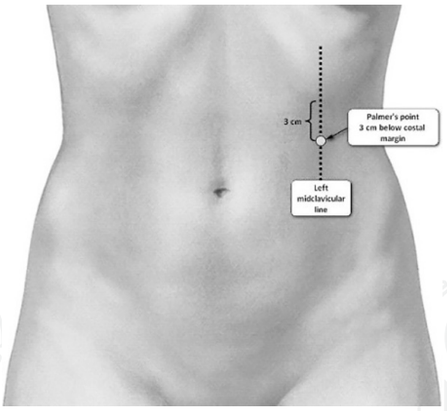

Figure 1.
Palmer's point. Source: Granata et al. [15].

inside peritoneum under vision and hence the injury during the first port placement is prevented. This should be performed in patients who have undergone surgery previously and can have intraperitoneal adhesions.

3.2 Closed technique or Verres needle

This technique involves placement of an incision supra or infraumbilically and then directing the Verres needle toward pelvis to enter the peritoneal cavity. While performing this the anterior abdominal wall is held upwards so that the intestinal loops fall back and do not get injured by the needle. Verres needle is held like a dart and placed at 45 degrees in thin patients and at 90 degrees in obese and as soon as a feeling of "give away" comes, it means the peritoneum has been breached. Confirmation of correct placement is done by water drop test and then the insufflation begins. Once the abdomen is distended by pneumoperitoneum, the trocar can be placed blindly or optical trocars can be used.

This port is used for the telescope and rest of the port placement is done under vision. A 10 mm port in the epigastrium at the junction of upper 1/3rd and lower 2/3rd of the line joining xiphisternum and umbilicus, a 5 mm port at the midclavicular line about 2 cm below the costal margin, and a 5 mm port at the anterior axillary line at the 5–8 cm below the costal margin. The epigastric port is placed just right of the falciform ligament. A general laparoscopy is done visualizing all the structures.

Midline scars are at a greater risk for injury as compared to peripheral scars. The closed method of pneumoperitoneum can be used for the peripheral scars but open should be used in a midline scarred abdomen. An optically trocar insertion is highly recommended in these cases [11–14].

In a scarred abdomen, Palmer's point can be used. It lies 3 cm below costal margin in left midclavicular line (**Figure 1**) [15].

4. Port placement, retraction, dissection

Four ports are used: The camera port (10–12 mm), one 5 mm and one 10 mm operating, and one 5 mm assisting port (**Figure 2**). A 30-degree telescope is used for

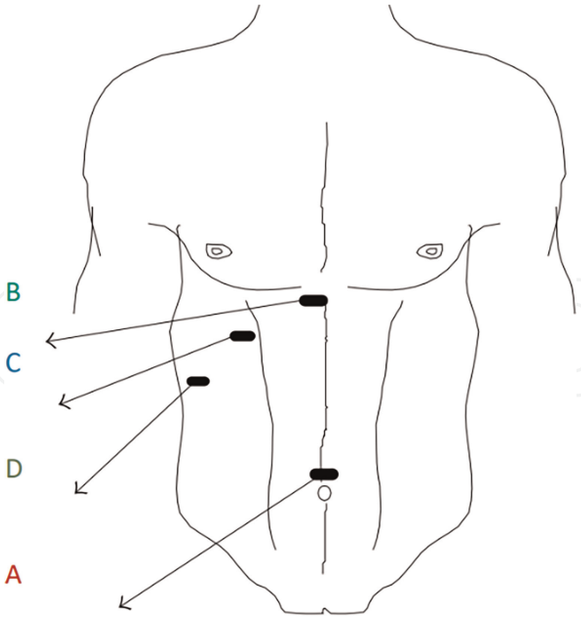

Figure 2.
Port placement. Source: Granata et al. [15].

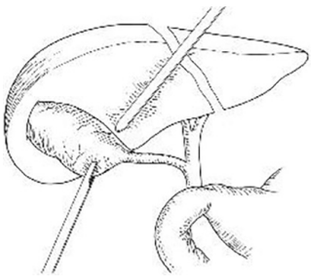

Figure 3.
Gallbladder lift. Source: SAGES [13].

laparoscopy. An initial diagnostic laparoscopy is done by scanning the entire abdomen to check any injury or bleeding while placement of trocars and to identify any gross disease other than the initial diagnosis. The gallbladder lift is usually used to expose the triangle of Calot (**Figure 3**).

The assistant grabs the fundus of the gallbladder with a ratcheted grasper and retracts it toward the right shoulder of patient in a cranial direction toward patient's right shoulder. Gallbladder is freed from all the adhesions remaining close to its wall. The third port (subcostal) is used to retract the infundibulum of gallbladder inferiorly and laterally to expose the Calot's triangle. The peritoneal fold is stretched and dissection is done by curved dissector or hook to expose the cystic duct and the artery. Slow and meticulous dissection is done by short bursts of cautery. One should always remain close to the gallbladder [13].

Correct retraction of fundus in the direction of right shoulder of the patient and right inferolateral retraction of neck permits satisfactory exposure of the hepatocytic triangle. Merely relying on fundal retraction is insufficient at this juncture, as it aligns the common bile duct with the cystic duct, posing a potential risk of misidentification [16].

5. Hug the gallbladder

This saying helps preventing major injuries while dissecting gallbladder. Surgeon should clip the cystic duct at cystic duct and gallbladder neck junction and not at the cystic duct and common bile duct junction. Also, the cystic artery should be clipped as close to gallbladder as possible even if it means clipping anterior and posterior branches of the artery separately [17].

6. Rouviere sulcus

A sulcus of varying size is present at the level of hilum in majority of patients containing the right posterior sectoral portal pedicle (**Figure 4**). Dissection should be kept superior/anterior to the plane of the sulcus.

The useful mnemonic of "RANGERS"– Rouviere's at Neck of Gallbladder Eases Recognition of Structures can be kept in mind to enable safer laparoscopic cholecystectomy [18].

The sulcus is best seen when GB is flipped over toward the left side. It is absent in 10% of patients [19]. In a study conducted by Jha et al., Rouviere sulcus was found above the level of CBD in 79.36% patients [20]. Peti and Moser described it as a safety landmark for conducting safe lap cholecystectomy that all dissection is to be done above the level of Rouviere sulcus [21]. In a study, Cheruiyut et al. stated that Rouviere sulcus which has a constant anatomy can be used to delineate the lower limit of dissection in LC to prevent extra biliary and common duct injuries [21, 22]. Another study by Basukala et al. stated its use for preventing cystic artery injuries [19].

7. BE – SAFE approach and laparoscopic ultrasound

See (**Figure 5**).

The challenges in dropping the number of BDI to less than a certain level force the surgeons to foster new methods of intraoperative visual positioning. Amid are the five B-SAFE landmarks (mnemonic): the Bile duct, the Sulcus of Rouviere, the left hepatic Artery pulsation, the umbilical Fissure, and the duodenum (Enteric) used for surgeon orientation around the gallbladder before dissection in the hepato-cystic triangle. An additional approach that aids in getting orientation during laparoscopic cholecystectomy prior to achieving the critical view of safety involves the utilization of

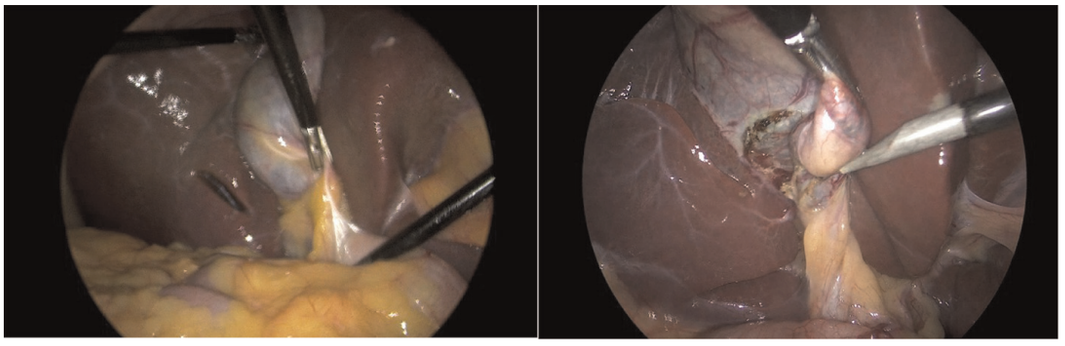

Figure 4.
Rouviere sulcus.

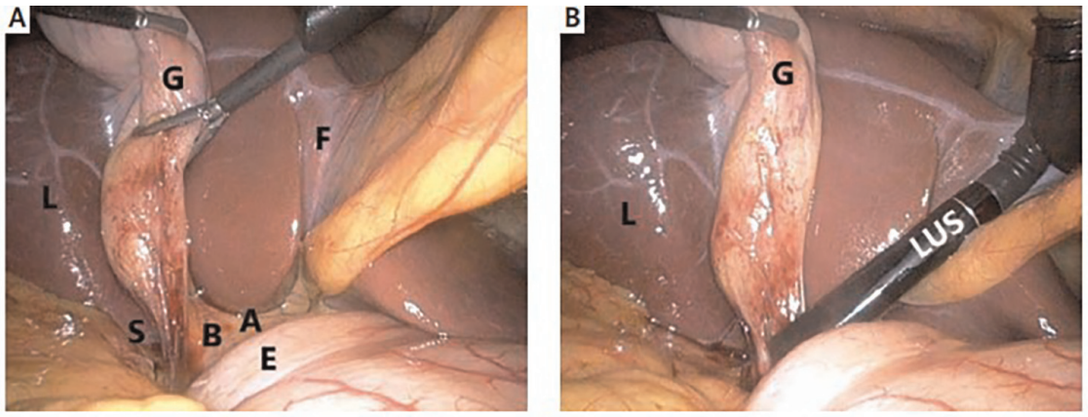

Figure 5.
A – B-SAFE landmarks visible during laparoscopic cholecystectomy. B – LUS is used to obtain ultrasonographic landmarks a – Arterial pulsation, B – Bile duct, E – Duodenum, F – Umbilical fissure, G – Gallbladder, S – Sulcus of Rouviere, L – Liver, LUS – Laparoscopic ultrasound. Source: The evaluation of B-SAFE and ultrasonographic landmarks in safe orientation during laparoscopic cholecystectomy, Sebastian et al. [23].

laparoscopic ultrasound. (LUS). LUS is noninvasive, non-irradiating, and can be done as many times as needed for differentiation between vascular and avascular structures. In a study by Sebastian et al., the identification rate of ultrasonographic landmarks – the upper border of "Mickey Mouse" sign (MMS) was significantly higher in patients who had a body mass index of more than 30 kg/m2, or in a fibrosed gallbladder and in presence of chronic inflammation in the gallbladder neck than B-SAFE. However, laparoscopic ultrasound is not available everywhere [23].

8. The R4U line

The R4U line is an imaginary line extending from the Rouviere's sulcus roof to the segment 4 base till the umbilical fissure. The area above this line is the "safe area" (**Figure 6**). However, it cannot be stated that the area above this line is entirely safe as important biliary/vascular structures may still be there in this area.

The RS is sometimes congenitally absent or it may not be visible due to adhesions. In these cases, the extension of umbilical fissure in the right direction of the hepatic hilum can be taken as the lower boundary of dissection [24].

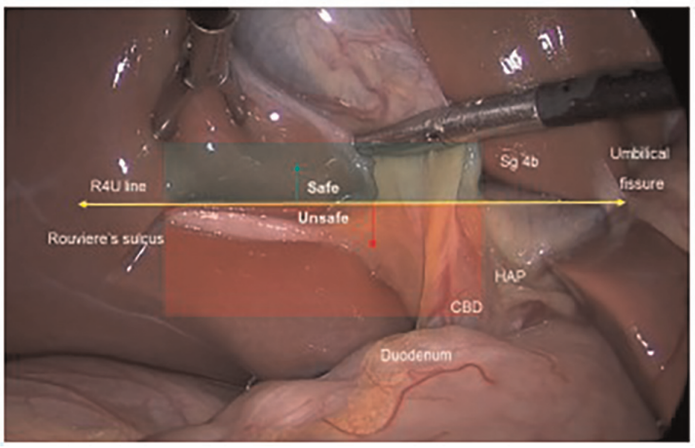

Figure 6.
CBD: Common bile duct, HAP: Hepatic artery proper, Sg4b: Segment 4b. Source: Gupta et al. [24].

9. The critical view of safety

Identification of cystic artery and duct can be done by the use of critical view of safety method which was defined by Strasberg et al. and recognized by SAGES. It includes the following three criteria:

A. Fat and fibrous tissue is cleared from the hepatocytic triangle, the boundary of which is formed by the cystic duct, the common hepatic duct, and inferior edge of the liver. There is no need of exposing common bile duct and common hepatic duct.

B. The lower one-third of the gallbladder is separated from the liver to expose the cystic plate or liver bed.

C. Two and only two structures should be seen entering the gallbladder (**Figure 7**).

9.1 Critical view of safety (doublet view)

"Doublet view" is achieved where both structures and lower 1/3rd of cystic plate should be identified from anterior and posterior views (**Figure 8**) [26, 27].

The concept of CVS is quite useful but is not always easily attainable in difficult procedure because of the following reasons. First, the procedure that leads to achievement of CVS in severe cholecystitis, where there is shrinkage of hepatocytic triangle occurs also carries the risk of injury. Second, achieving CVS is difficult as unless the cystic structure is divided, gallbladder cannot be lifted from the liver bed. In a meta analysis, the two main supporting evidence for CVS being an effective means of target identification reported. First, there are multiple reports containing thousands of patients where no biliary injury occurred due to misidentification of structures when CVS was used as the technique of target identification. Secondly, in most studies examining the mechanisms behind significant biliary injuries, the critical view of safety (CVS) has not been utilized for the purpose of target identification. Disseminating new information is a difficult delinquent in surgery. The concept of CVS is as old as 20 years but the surgeons who have not

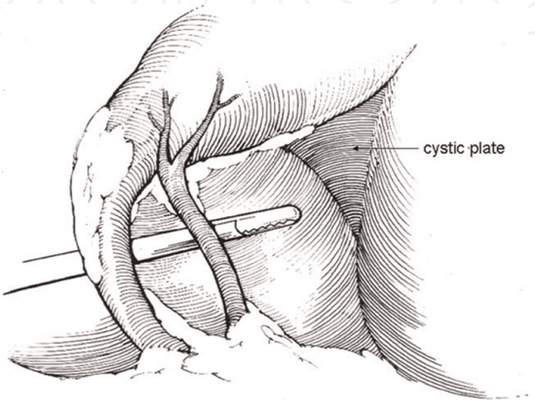

Figure 7.
Doublet view; source: SAGES [13].

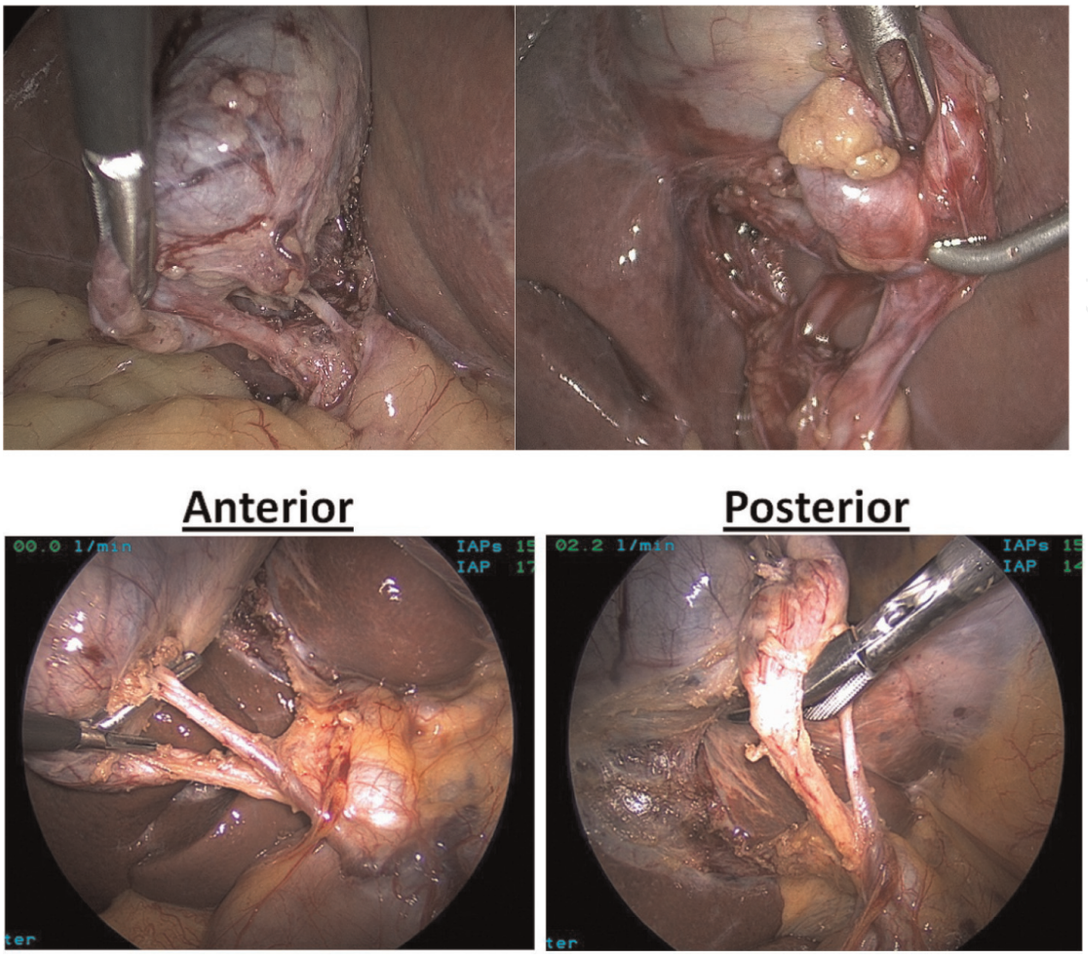

Figure 8.
Critical view of safety; source: Sanford DE, Strasberg SM. A simple effective method for generation of a permanent record of the critical view of safety during laparoscopic cholecystectomy by intraoperative "doublet" photography. J Am Coll Surg. 2014 [25].

studied and practiced this technique during their residency still face difficulty in understanding it [25–27].

Nakazato et al. stated that safe CVS curriculum should be widespread so as to increase the quality and frequency of attaining the critical view of safety. A structured curriculum on achieving a quality CVS will improve confidence and frequency of obtaining the critical view of safety during LC for practicing, experienced surgeons [26]. Sgaramella et al. also stated that CVS is the safest technique to identify the structures of the Calot triangle and, if correctly performed, it has a significant impact on preventing intraoperative complications [27].

9.2 A modern inconsistency

Calot's triangle, also known as the cystohepatic triangle, is a well-known feature of hepatobiliary system that is recognized and dissected during safe cholecystectomy. In various modern textbooks, the borders of Calot's triangle are defined to be the inferior surface of the liver superiorly, the cystic duct laterally and the common hepatic duct medially. Yet the triangle described by Jean-Francois Calot in his original doctorate thesis in 1891 had a different superior border: the cystic artery! (**Figure 9**).

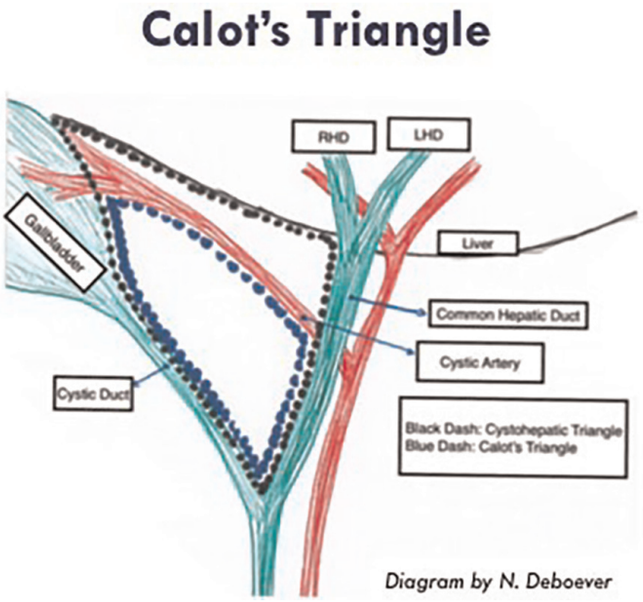

Figure 9.
Calot's triangle; source: Nathaniel Deboever, Sydney university surgical society.

This discrepancy continues to be a commonly encountered source of confusion in modern medicine [28].

10. Concept of "time out"

The concept of intraoperative timeout aims for safety during the procedure. This involves reorientation and reassessment of relevant structures to improve exposure before starting dissection.

The initial intraoperative timeout is designed to establish a foundation of safety for the surgeon. This involves a comprehensive process of identifying important anatomical landmarks and evaluating the necessity for specific actions such as grasping, retraction, gallbladder decompression, and clearing the cystohepatic triangle. The objective is to optimize the visual exposure before initiating dissection. The subsequent intraoperative timeout serves the purpose of determining whether the critical view of safety (CVS) has been successfully achieved [29]. However, the formal adoption and subjective evaluation of the critical view of safety in surgical practices have been commonly reported as suboptimal [30]. This lack of widespread implementation and reliance on subjective assessments may contribute to the ongoing issue of bile duct injuries not showing a decline [31]. Mascagni and colleagues implemented a 5-second long intraoperative timeout to verify the CVS before dividing the cystic duct. The 5-second rule timeout was significantly associated with an increased CVS achievement rate. This led to an approximately threefold increase in the average CVS achievement rate from 15.9 to 44.1% and peaked to 70% (excluding bail-out procedures) [32].

The simple steps to be followed are to stop, wait for some time, reassess the orientation and anatomy, look out for B-SAFE, and then act accordingly. It should be used:

1. Before beginning dissection in hepatocystic triangle.

2. Whenever the anatomy is not clear.

3. After attaining CVS and before dividing cystic duct and artery (define, decide, and then divide) [29].

11. Intraoperative cholangiogram

The controversy of using operative cholangiogram during LC still exists. Some surgeons are performing this Dundee technique on regular basis while others have stopped using it or use it selectively when the dissection is difficult. There is lack of experience in cannulating cystic duct. The surgeon is unable to carry cannulation expeditiously, and interpreting the result of IOC it accurately. There are following benefits of routine intraoperative fluorocholangiography during LC:

- To look out for unsuspected diseases: benign or malignant.
- Surgeon gets familiar with CBD cannulation, which is essential for stone clearance during laparoscopy.
- Early identification of CBD injury so that primary repair can be done intraoperatively.

Near-infrared fluorescence cholangiography (NIRF-C) is a new technique for visualizing CBD intraoperatively. Indocyanine green (ICG), which is a water-soluble dye is injected intravenously before starting the procedure (**Figure 10**) [34]. Ishizawa et al. were the first to report the use of indocyanine green fluorescence as imaging

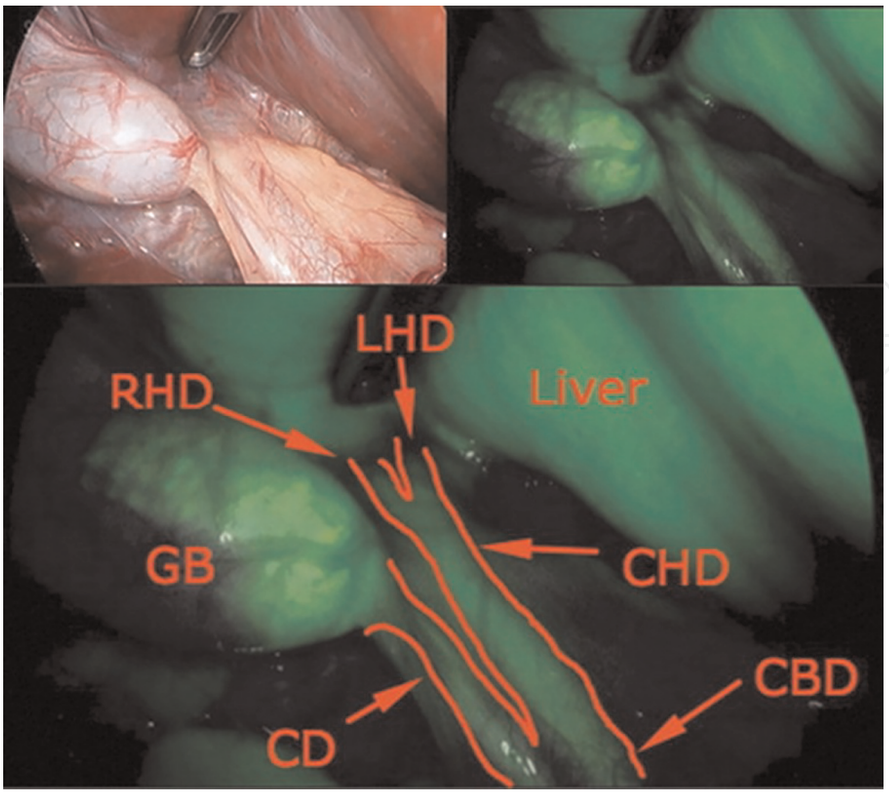

Figure 10.
Intraoperative cholangiogram. Source: Calabro [33].

technology in 2009. In 2010, the author again published a series of 52 patients where they used ICG NIRF-C while LC and established that this method can be used to detect the biliary anatomy while dissecting Calot's triangle [35]. In a study of 108 cases, the following structures were identified: cystic duct in 90%, common hepatic duct in 48%, common bile duct in 84%, and at least 2 of 3 biliary structures were identified in all cases even when the tissues were inflamed, especially the cystic duct-common bile duct junction.

12. Six strategies surgeons can be employed to accept a universal culture of safety for cholecystectomy to and diminish the risk of bile duct injury. (adapted from 'The SAGES safe cholecystectomy program')

- Use the critical view of safety (CVS) method of identification of the cystic duct and cystic artery during laparoscopic cholecystectomy.
- Perform an intraoperative timeout during laparoscopic cholecystectomy prior to clipping, cutting, or transecting any ductal structures.
- Understand the potential for aberrant anatomy in all cases.
- Make liberal use of cholangiography or other methods to image the biliary tree intraoperatively.
- Recognize when the dissection is approaching a zone of great danger and halt the dissection before entering the zone. It is better to finish the operation by a safe method rather than trying to perform cholecystectomy if the gallbladder is too risky to reach.
- Get help from another surgeon when the dissection or conditions are difficult.

The above-stated are the six strategies that can employed to adopt a universal culture of safety for cholecystectomy to and minimize the risk of bile duct injury [36].

13. The D-line segment IV approach

Although we know that attaining the critical view of safety (CVS) is useful to avoid vasculobiliary injury during laparoscopic cholecystectomy (LC), it is not always possible because of severe acute cholecystitis because of technical snags. In such cases, segment IV of the liver and its diagonal line (D-line) can be used as a practicable landmark for implementing difficult LC. The D-line is a vectoral landmark that connects the right dorsal and left ventral corners of segment IV, which is where the gallbladder is first dissected to achieve CVS without misidentification. In a study done by Kitamura et al. reported that dissection can be stopped along the D-line. It acts like an endpoint for dissection so as to prevent misidentification of the cystic structure [37]. Another study by Fujioka et al. reported D line method can be used to achieve critical view of safety in all the patients with anomalous bile duct [38].

14. Clipping and extraction of gallbladder

In order to prevent slippage of clip and ensuring no other structure is being clipped accidently, both limbs of clip applicator should be visualized and only then clip should be applied (**Figure 11**).

Clips should be applied perpendicular to the structure and not obliquely. Cautery should not be used near a clipped structure.

The extraction of the gallbladder is carried out within a tear-resistant bag through the operating port. Nevertheless, in many instances, cost-effective bags made from gloves are also employed. The gallbladder should be taken out in a bag as this prevents loss of stone inside the abdomen as well as port site contamination. There are studies showing that 0.5–1% of patients undergoing cholecystectomy for gallstones have infective or malignant spread to the port site when the bag is not used to extract the gallbladder [17].

15. Bailout procedures

A bailout procedure is performed if a CVS cannot be achieved due to scarring or severe fibrosis. When come across with a difficult gallbladder, it is not always compulsory to try and achieve the goal of complete cholecystectomy while risking the safety of procedure with potential of biliary/vascular injury. Instead, a substitute procedure (bailout techniques) can be executed that allows the surgeon to complete the procedure in a safe manner.

The five bailout strategies for a difficult gallbladder are: (1) Abandon the procedure; (2) convert laparoscopy to an open procedure; (3) tube cholecystostomy; (4) subtotal cholecystectomy (STC, open/laparoscopic); and (5) fundus first cholecystectomy (**Figure 12**). The surgeon chooses the bailout technique while performing the cholecystectomy. The choice of procedure depends on the clinical condition and the expertise of the surgeon. Aborting the procedure altogether is the safest bailout strategy (**Figure 13**) [39].

15.1 Fundus first dissection

This dissection begins from the fundus region of gallbladder and is helpful in difficult open or laparoscopic cholecystectomy where calot's anatomy is not clear. The

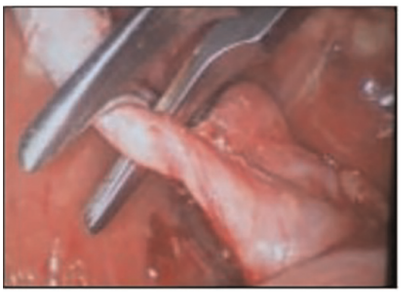

Figure 11.
Proper placement of clips; source: Safe cholecystectomy a to Z by Dr. VK Kapoor Dec 2021 [17].

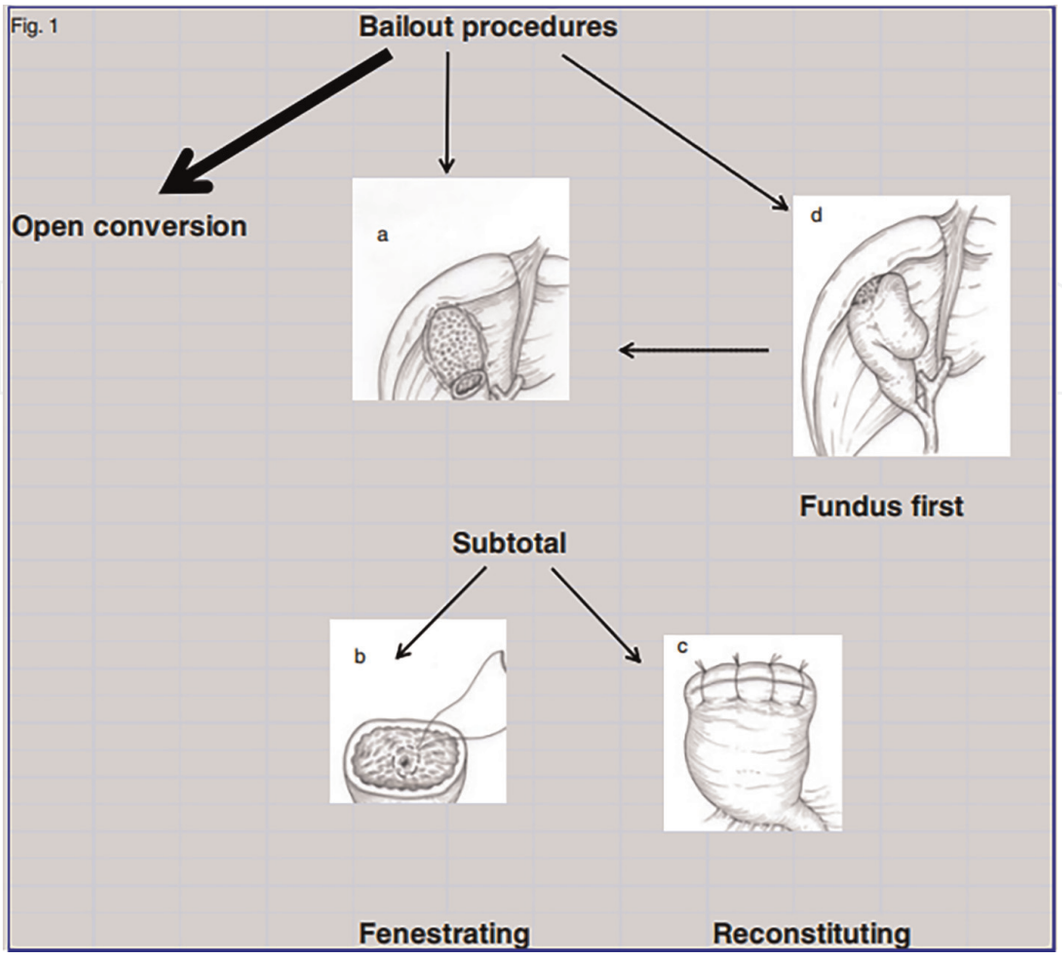

Figure 12.
Bailout procedures; source: Tokyo guidelines 2018 surgical management of acute cholecystitis [36].

dissection is carried till GB neck and concluded by leaving a part of gallbladder to prevent any injury to the common hepatic duct (CHD) and the common bile duct (CBD). This technique is proven to be a safe out pass for Mirizzi's syndrome. Before implementing this technique, surgeon should be well versed with the normal anatomy as well as aberrations that could possibly be encountered at hilar plate due to inflammation of gallbladder and hepatocystic triangle. The surgeon should stay close to gall bladder while dissecting. Dissection should be as close to gallbladder as possible. This technique has reduced the number of conversions of laparoscopic cholecystectomy to open and guides for subtotal cholecystectomy if difficult anatomy makes further dissection unsafe [19].

16. Shield of McElmoyle

The concept of the shield of McElmoyle is of great importance. It was described in 1954 as a shield of cystic duct, part of the body, neck, and infundibulum is left in situ where Calot's triangle cannot be safely dissected. There should be no attempt to dissect structures lying cephalad and medially [40]. McElmoyle's method, described as a modification of cholecystectomy for challenging gallbladders,

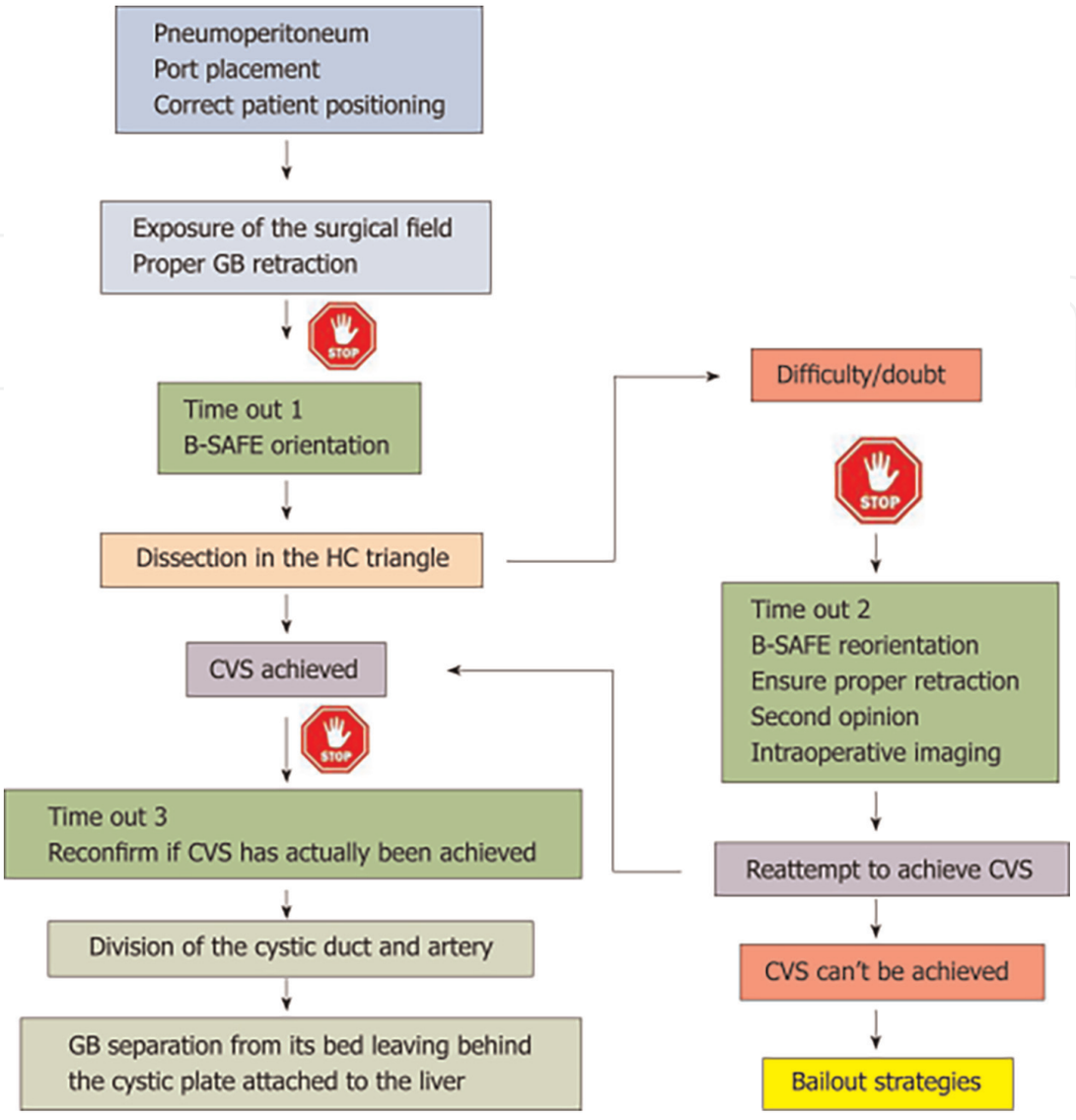

Figure 13.
Flowchart showing overall scheme of performance of laparoscopic cholecystectomy with the culture of safety concept. GB: Gallbladder; B-SAFE: Surgical landmarks; HC triangle: Hepatocystic triangle; source: Gupta V et al. safe laparoscopic cholecystectomy [17].

encompassed the following core elements along with two supplementary components [40, 41]:

1. The part of gallbladder wall is left behind while excising the peritoneal wall. Portion of the neck, infundibulum, and body which lies toward left and medially to liver bed.

2. Hemostasis is achieved by suturing the remaining wall edge.

3. Destruction of mucosa of remaining wall should be done by chemical or electrical cauterization.

4. Splitting the cystic duct and fulgurating its mucosa within 5 mm of the CBD with or without opening the common duct.

This allows the surgeon to conclude cholecystectomy and preventing injury to any major structures while dissection in difficult gallbladders. This concept is known for more than six decades but very little work has been published about its application and result. It can be the basis of bail-out procedures where subtotal cholecystectomy is done [42].

17. Role of artificial intelligence

Intraoperative landmark indication systems are developed to prevent BDI in LC. Although the average precisions for each landmark are low, valid indications of the landmarks can be confirmed. The prototype system was fruitfully used in an authentication experiment. One can state that the practice of intraoperative landmark indication systems will reduce the incidence of BDI, and will eventually grow the safety of LC. Errors in visual perception lead to misinterpretation of anatomy and this is the main cause of complications during the procedure. A subfield of AI, which is deep learning, can supposedly be used to deliver real-time guidance intraoperatively.

In a study by Way et al. findings revealed that a significant 97% of major biliary injuries (BDIs) were attributed to human visual perception errors concerning the cystic duct and artery. The recommended solution highlighted the necessity for technological advancements to counteract these errors [43]. Another study by Liu et al. showcased comparative results using SurgSmart (AI). This AI exhibited notably higher intersection-over-union (IoU) and accuracy (IoU $\geq$ 0.5) in recognizing anatomy, even in the presence of severe inflammation, surpassing the performance of both experienced surgeons (n = 36) and trainees (n = 32). The AI demonstrated an accuracy of 0.94 ($\pm$0.05), sensitivity of 0.69 ($\pm$0.20), and specificity of 0.94 ($\pm$0.03) in identifying Go zones. For No-Go zones, these metrics were 0.95 ($\pm$0.06), 0.80 ($\pm$0.21), and 0.98 ($\pm$0.05), respectively. The AI's proficiency in identifying liver, gallbladder, and hepatocystic triangle were rated at 0.86 ($\pm$0.12), 0.72 ($\pm$0.19), and 0.65 ($\pm$0.22), respectively [44, 45]. Although there is no substitute of classical teaching, training, and experience, these upcoming modalities may have application in future. To improve surgical safety, surgical-technical partnerships should be encouraged to progress and assess deep learning models [46].

Conflict of interest

The authors declare no conflict of interest.

Key points:

- Stopping rules during cholecystectomy.
    - Wide cystic artery seen entering the gallbladder should be presumed as hepatic artery and dissection should be carried out before clipping.
    - Careful dissection should be done if more than two structures are seen in Calot's triangle.

- Care should be taken while cystic duct dissection if strong pulsations are present beneath it as this is the location of common duct.
- The limbs of clip applicator should be able to encircle the structure. If the large-sized clip is not able to occlude the lumen of the structure that could mean it is not cystic duct, rather it is common bile duct.
- The ductal structure that could be traced behind duodenum is common bile duct.
- The presence of lymphatic and fibrofatty tissue around the duct indicates it is common duct.
- Any bile seen in abdomen when the gallbladder is intact should be traced.

- Always stay close to the gallbladder or hug the gallbladder. To allow an easy location of the cystic duct, the dissection should always start at the infundibulum of the gallbladder.
- Use of electrosurgical devices should be used wisely, especially during dissection in the Calot's triangle. Spray mode should never be used. In case of cauterizing a bleeding point, single-point cauterization should be done at low wattage.
- The surgeon should stay close to the GB while using cautery in the Calot's triangle. Cauterization should not be done after clips have been applied as metal clips can conduct the electric current to the CHD/CBD leading to thermal damage.
- The liver bed can be cauterized using spray mode to achieve hemostasis. The care should be taken to keep the metal tip in view so that it does not cause any damage to the structures, such as bowel, CHD, or CBD.
- Needle aspiration should be done if mucocele of gallbladder is encountered. Endoloop or large clips should be used to occlude the site of leak.
- Do not apply clips blindly in case of bleeding as this might lead to panic reaction. This only spell disaster. The immediate action to halt bleeding should be compression.
- Gallbladder may be used to give direct compression on the bleeding site if this is in the gallbladder bed. In case of bleeding from the cystic artery, gauze can be used to compress the area and once the bleeding is controlled, careful diathermy of the bleeding point can be done. Clips are rarely required.
- In case of difficult anatomy, where the Calot's triangle cannot be isolated properly, a fundus first approach may be used to reach the junction of gallbladder and cystic duct.
- Clips on the artery should always be double for extra safety.

- A short cystic duct can be lengthened after dissecting and dividing the cystic artery flush with the gallbladder and teasing out fibrous bands which kink and shorten the duct.
- Laparoscopic cholangiography should not be used as a substitute for vigilant dissection. It should be used to exclude or confirm the presence of CBD calculi.
- Overconfidence and an easy case may spell threat.
- Patient's outcome from complications is best if detected during first surgery and corrective measures are taken during the same sitting.
- Conversion to open cholecystectomy is not a failure but very judicious and wise decision of the surgeon to prevent iatrogenic injuries to bile ducts and surrounding viscera, thus minimizing the morbidity of the patient.
- Adequate formal training should be provided in minimal invasive surgery, preferably as a part of course during post-graduation or afterward as an observer but not merely depending on the workshops over weekends.
- Proper selection of initial cases - thin-built female patient with a short history of biliary colic only, no history of acute cholecystitis, and thin-walled distended gallbladder on ultrasound.
- Proper informed consent (including chances of conversion and higher risk of bile duct injury).
- Double clips on the retained side of the cystic duct and cystic artery.
- Ligature, hemoclip, endoloop, and stapler can be used to ligate a wide cytic duct.
- Standard-sized common bile duct can easily be presumed as a cystic duct.
- Very soft (normal) liver, fatty liver, and cirrhotic liver can easily be injured during retraction.
- Fundus first is a useful technique in difficult cases.
- Partial cholecystectomy should be opted in case of difficult gallbladder.
- Surgeon should not panic in case of bleeding instead pressure with a gauze or the mobilized gall bladder can be put to control the bleeding.
- Desperate attempt to clip or coagulate a bleeding point without proper vision in a pool of blood can lead to disasters.
- Stumps (cystic duct/cystic artery) for proper placement of clips and any bile leak/bleed should be reexamined.
- Gallbladder bed should be irrigated and examined for any bleed/bile leak (from a cholecysto-hepatic duct).

- Existence of bile should alert the surgeon to stop and locate for the source of bile - gallbladder or bile duct.
- Extraction of gallbladder under vision to make sure that there is no bile/stone spill.
- Spilled bile should be sucked out, spilled stones should be looked for and removed.
- All 10 mm port sites aponeurosis should be closed.
- All gallbladders, even if they look grossly normal, should be sent for histopathology so as not to miss an incidental gallbladder cancer.
- The patient should be pain-free, sitting up comfortably in the bed, should be having her breakfast and wanting discharge the next day after cholecystectomy. The vitals should be stable and abdomen should be soft; if not, observe the patient for another day.

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