Principles of Emergency and Trauma Laparoscopy

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Learning Goals

- Learn the nomenclature on laparoscopy in emergencies
- Understand the indications and contraindications of laparoscopy for emergencies and trauma
- Recognize the maneuvers of surgical exploration in emergency laparoscopy and trauma

55.1 Introduction

Laparoscopy has been positioned over decades as a useful technique in various surgical procedures of different specialties, in some procedures it has come to be considered the gold standard; however, until few years ago it has been given the role in the emergency surgery [1] and trauma [2]; and it is in this last area where it has found an initial role as a diagnostic tool, but its therapeutic usefulness has been questioned. The first description of the use of laparoscopy (coelioscopy) in trauma was in 1925 to diagnose hemoperitoneum due to abdominal contusion [3]. In recent publications there is a tendency to use laparoscopy beyond as only as a superficial visual purpose, and it has been called ***Exploratory Laparoscopy*** [4–6] as a diagnostic tool keeping similarity to the systematic laparotomy of traditional open surgery. It is well known that laparoscopic surgery is associated with reduced pain, earlier discharge, and quicker return to work. It has at the same time reduced complications associated with traditional open surgery, such as wound infections and incisional hernia [7].

Certainly, it will be necessary to specify some terminology concepts for the proper use of the term laparoscopy. According to the British dictionary [8], refers that **laparoscopy**, also called **peritoneoscopy**, is the procedure that allows visual examination of the abdominal cavity with an optical instrument called a laparoscope, which is inserted through a small incision made in the abdominal wall. So, to have a better concept of the use of laparoscopy, we will use the following nomenclature:

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"Diagnostic laparoscopy" (DL) refers to the diagnosis made by general visualization of the abdominal cavity with the laparoscope. It only requires the introduction of a port for the lens through the navel, the visualization is basically superficial since the mobilization of the structures is passive and only depends on the effect of gravity with the positioning table. In trauma and emergency surgery, it basically allows us to superficially visualize the existence of fluid (blood or intestinal content) or obvious inflammatory processes and in trauma, obvious penetrations, perforations of the liver or anterior abdominal wall. "Exploratory laparoscopy" (EL) is the technique in which the visualization of the organs, structures, and spaces of the abdominal cavity is carried out in a visual and instrumented way. The introduction of auxiliary ports for the manipulation and mobilization of the structures is required for the complete evaluation in places where the only superficial visualization is not enough. Additional terms like "therapeutic," "non-therapeutic," or "assisted therapeutic" are used postoperatively and are defined intraoperatively.

"Therapeutic laparoscopy" refers to the strict performance of another minimally invasive surgical procedure that solves a problem. That is, suture of a perforation, resection by a stapler, placement of a hemostatic agent, compression on a bleeding site, and the cessation of bleeding or aspiration of the hemoperitoneum and surgical lavage of the abdominal cavity, placement of drains or exteriorization of loops, etc. It is clear that "purely diagnostic laparoscopy" could not be possible. This requires advanced surgical skills (intracorporeal suturing, hemostasis, resections, stapling, cannulation, and exteriorization) and other requirements in relation to infrastructure, teamwork, and safety standards to perform it. Instead, "non-therapeutic laparoscopy" is the result of a "negative" exploratory laparoscopy [9], it is a confusing term and not very objective in the surgical nomenclature. The term "non-therapeutic exploratory laparoscopy," on the other hand, does not generate confusion, it is precise and elegant within the surgical nomenclature. It is easy to understand that a formal systematic examination of the entire abdominal cavity (organs, spaces, and structures) was performed without the need for any alternate procedure.

Publications on emergency laparoscopy and good practices [10], as well as the guidelines and consensus [11] they emphasize that any endorsement for a laparoscopic approach is only valid for surgical units with experience and sufficient expertise in minimal access surgery.

55.2 Diagnosis

The diagnosis of the different non-traumatic acute inflammatory pathologies includes not only to find the clinical findings, but also uses complementary image studies to establish the possible cause of the acute abdominal pathology. The use of laparoscopy is not only considered a diagnostic surgical technique, but also it is the visualization that also offers and allows us to have the opportunity to expand its use as a therapeutic tool.

In the next paragraphs we will give an overview of the indications and contraindications of laparoscopy in surgical abdominal emergencies and indications of use of laparoscopy in traumatic injuries.

55.3 Indications and Contraindications of Laparoscopy in Surgical Emergencies

In 2006, the European Association for Endoscopic Surgery (EAES) developed guidelines to define that subgroups of patients should undergo laparoscopic surgery instead of open surgery for acute abdominal pain [12]. Five years later, these guidelines [13] were reviewed by a group of SICE (Italian Society of Endoscopic Surgery) experts under the auspices of EAES to achieve the following objectives: (1) establish the preferred diagnostic procedures,

patient selection, if applicable, and the suitability of the laparoscopic approach responsible for the configuration of acute abdominal disease; (2) evaluate the indication, morbidity, length of hospital stay, costs, and recovery time of laparoscopic treatment for acute abdominal situations; and (3) define optimal laparoscopic practice for each abdominal emergency and provide recommendations that reflect good practice. The indications were the result of key statements each with a grade of recommendation (GoR) followed by a commentary in order to explain the rationale and the level of evidence (LE) behind the statement. The non-traumatic medical pathologies and their level of recommendation are shown below.

55.3.1 Acute Appendicitis

Patients with symptoms and diagnostic findings suggestive of acute appendicitis should undergo exploratory laparoscopy (GoR A) and, if the diagnosis is confirmed, laparoscopic appendectomy (GoR A). Complicated appendicitis can be approached laparoscopically, with significant improvement of the surgical site (SS) infection rate. Regarding appendiceal stump closure, stapling has been found to reduce operative time and superficial wound infections [14] (LE 1a) (Fig. 55.1).

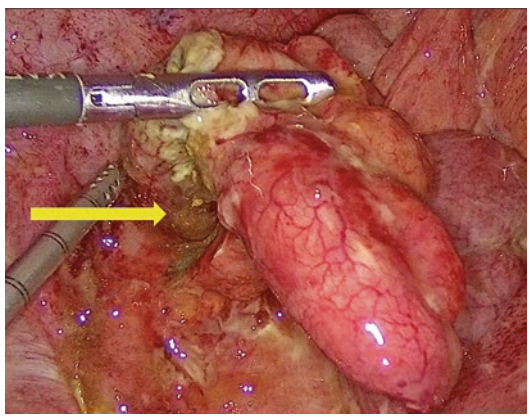

Fig. 55.1 Acute perforated appendicitis. The yellow arrow shows the perforation site

55.3.2 Acute Cholecystitis

Patients should be treated by laparoscopic cholecystectomy (GoR A). Severe cases that include gangrene, empyemic, or perforated cholecystitis and advanced age are not contraindications for laparoscopic cholecystectomy (GoR B) despite a threefold higher conversion rate. Surgery should be performed as soon as possible after the onset of symptoms (GoR A). Early laparoscopic surgery should be offered also to elderly patients (GoR B). In patients with severe comorbidities, conservative treatment or percutaneous cholecystostomy, followed or not by early or delayed surgery, may be alternatives to reduce surgical or anesthetic risks (GoR C). Subtotal cholecystectomy appears to be an acceptable alternative in patients with intense inflammation and increased risk of damage to important structures (LE 2a) [15] (Fig. 55.2a–c).

55.3.3 Acute Pancreatitis

Laparoscopic cholecystectomy should be performed as soon as the patient has recovered in mild gallstone-associated acute pancreatitis during the same hospital admission (GoR B). In the other hand, in severe gallstone-associated acute pancreatitis, laparoscopic cholecystectomy should be delayed until there is sufficient resolution of the inflammatory response and clinical recovery (GoR B). In cases of CBD (common bile duct) stones in which an emergency Endoscopic Retrograde Cholangio Pancreatography (ERCP) is indicated, clearance should be obtained by preoperative ERCP or by laparoscopic removal of bile duct stones during cholecystectomy (GoR A) or by combined laparoscopic endoscopic procedure (Transgastric) [16]. When pancreatic necrosis requires surgical treatment (Fig. 55.3) for clinical signs of sepsis or multiorgan failure, necrosectomy (Fig. 55.4) can be performed by laparoscopic debridement through an inframesocolic [17] (Fig. 55.5) or retroperitoneal approach. Open surgery should be reserved to patients not responding to minimally invasive treatment (GoR B). Laparoscopy is

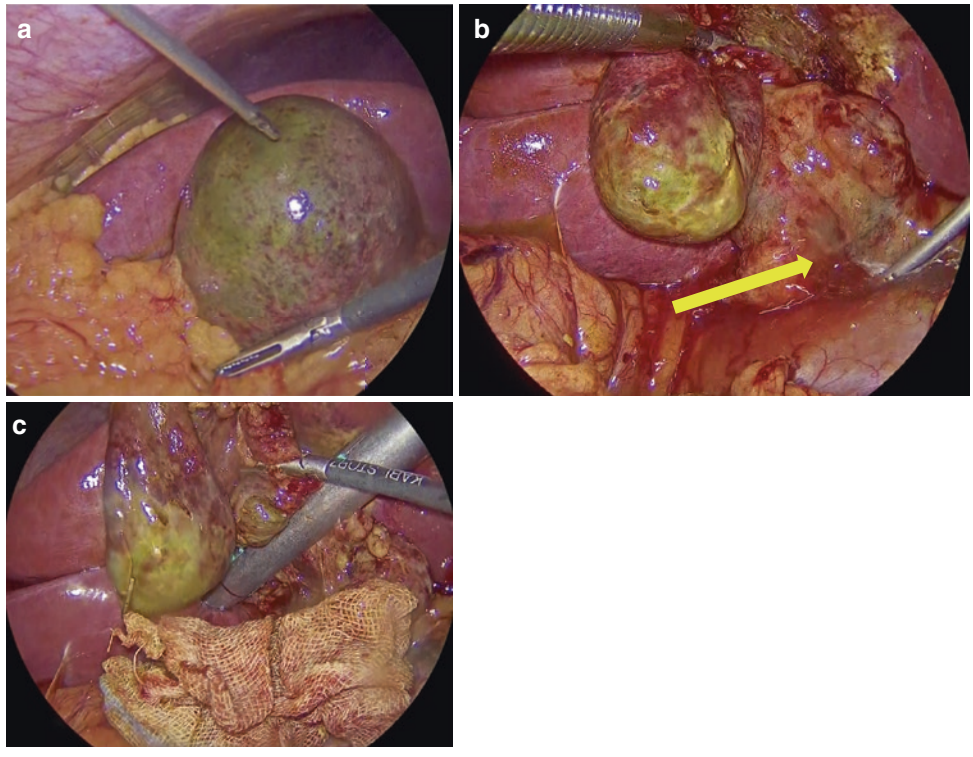

Fig. 55.2 Acute cholecystitis. (**a**) Gallbladder necrosis, (**b**) Retrograde dissection. Yellow arrow shows the difficult Calot's triangle dissection. (**c**) Stapled cholecystectomy

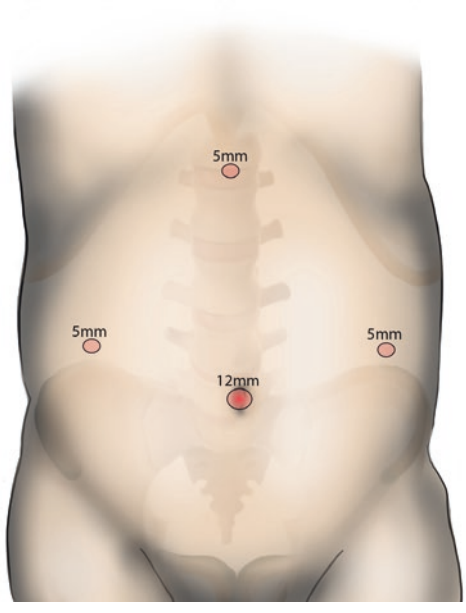

Fig. 55.3 Trocar placement for pancreatic necrosectomy

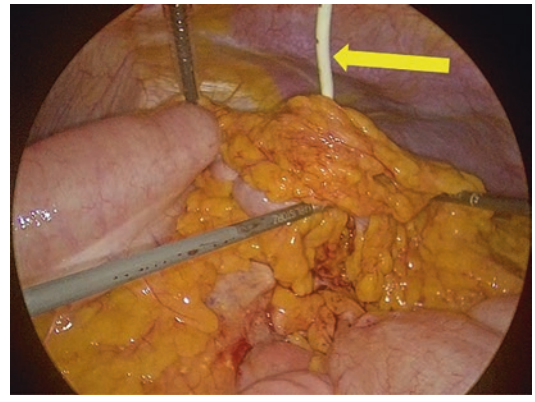

Fig. 55.4 The yellow arrow shows the failed percutaneous drainage, days before the surgical necrosectomy

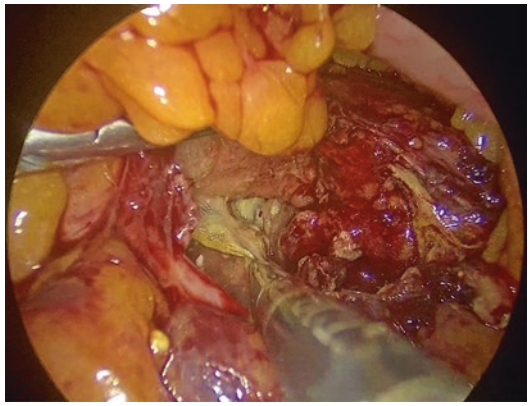

Fig. 55.5 Transmesocolic (infracolic) pancreatic necrosectomy

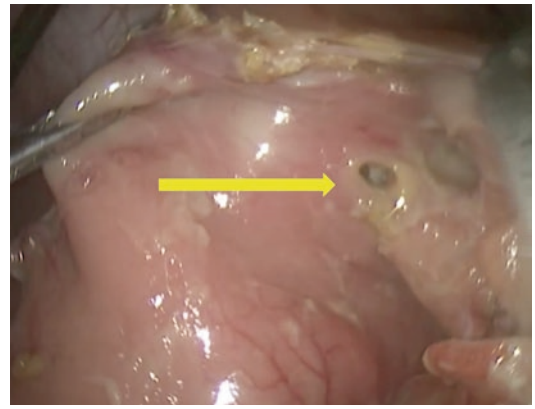

Fig. 55.6 Perforated peptic ulcer. Yellow arrow shows the 0.8 mm perforation in the posterior face of the stomach

totally contraindicated in cases with abdominal compartment syndrome.

55.3.4 Perforated Peptic Ulcer

Laparoscopy is a useful diagnostic tool to detect a perforated peptic ulcer (PPU) when preoperative findings are not conclusive, especially if a laparoscopic treatment is likely (GoR A). Laparoscopy is a possible alternative to open surgery in the treatment of perforated peptic ulcer (GoR B). However, failing to identify a PPU represents one of the most frequent causes of conversion to laparotomy (LE 1a). Decontamination of the peritoneal cavity by washing after treatment of PPU is a fundamental step in the surgical procedure and it can be done by laparoscopy (LE 1a) [18]. A decrease in the incidence of complications has been found with the use of laparoscopic repair compared with open surgery, such as septic abdominal complications, less associated pulmonary infection, complications of the abdominal wall, postoperative ileus, and mortality rate [19] (Fig. 55.6).

55.3.5 Acute Mesenteric Ischemia

Acute mesenteric ischemia (AMI) presents a high mortality rate, usually due to arterial occlusion in 50% of cases, in 35% by nonocclusive arterial ischemia and 15% by venous occlusion and prognosis is frequently related to the timeliness of diagnosis. Since laparoscopy does not offer adequate diagnostic accuracy notwithstanding the use of fluorescein and ultraviolet light, it does not offer significant advantages in acute mesenteric ischemia besides a potential role as a bedside and second-look procedure (GoR C) (LE 4) [20]. However, despite the recommendations, some anecdotal cases of severe acute abdominal pain with suspicious of segmentary bowel ischemia can benefit from the laparoscopic procedure (Fig. 55.7).

55.3.6 Acute Diverticulitis

There is no role for diagnostic laparoscopy in this condition, because easy diagnosis includes blood count, inflammatory markers, and CT scanning. Laparoscopic approach with lavage and drainage is indicated in complicated diverticulitis when percutaneous drainage failed and when indicated for clinical deterioration (GoR B). Laparoscopic surgery has been utilized in the setting of diverticular perforation with associated peritonitis depending on the general conditions of the patient and on the skill of the operator (GoR C). Elective resection of the ill segment decreases the risk of conversion and increases the rate of primary anastomosis compared to emergency surgery.

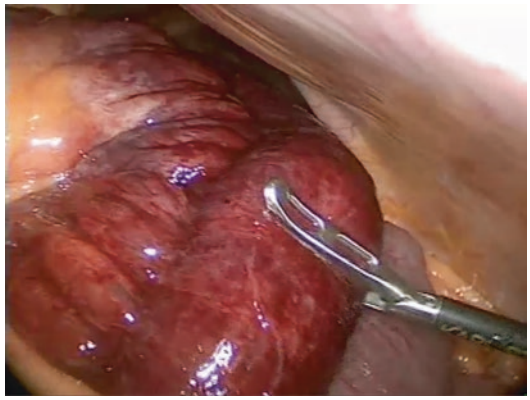

Fig. 55.7 Acute segmentary mesenteric ischemia. The coloring difference of ischemic and healthy bowel can be observed

Associated abscesses can be drained laparoscopically or when the small bowel becomes occluded due to involvement in the diverticular inflammatory process, it can also be resolved in the same way.

55.3.7 Small Bowel Obstruction Due to Adhesions

Adhesions are the leading cause of small bowel obstruction (SBO), which account for about 75% of all SBO. Laparoscopic treatment of small bowel obstruction can be successfully accomplished in selected patients (GoR C). The main concern about a laparoscopic approach to SBO is the high conversion rate: complete laparoscopic treatment has been reported possible in only 50–60% of patients. Some reports have tried to define predictive factors for conversion; a history of two or more surgical abdominal operations, late operation (>24 h post-onset), and a bowel diameter exceeding 4 cm [21]. The SAGES guidelines consider laparoscopy contraindicated in patients with a clear indication for surgical intervention such as massive bowel obstruction, perforated viscus, and hemodynamic instability [22]. A systematic review shows a successful therapeutic laparoscopy rate in the range of 40–88% and a conversion rate ranging from 0 to 52%. As for operative technique, the use of atraumatic graspers is essential, adhesiolysis should be proper and cautious, the principle of gentle traction and countertraction and cutting without energy sources are essential and the contents in the defect should be always accurately checked for blood supply, motility, and integrity (Fig. 55.8). If an enterotomy occurs, it can be repaired laparoscopically, trying to isolate the site, and controlling contamination to adjacent structures, always having the suction device prepared. Supposedly benefits of the laparoscopic approach include faster recovery of bowel motility and shorter hospital stay.

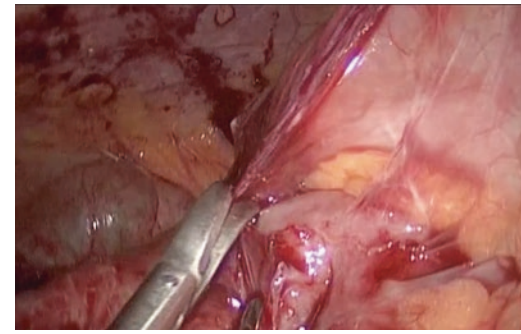

Fig. 55.8 Small bowel adhesions in the 4 quadrants. The principle of gentle traction and countertraction and cutting without energy sources is essential to resolve multiple bowel adhesions

55.3.8 Incarcerated/Strangulated Hernias

In 2010 a meta-analysis confirmed that the outcome of elective LHR is at least equivalent to that of the open approach [23]. Laparoscopic hernia repair surgery, including TEP or TAPP, may be performed for the treatment of nonreducible or strangulated inguinal hernias (GoR B). The laparoscopic approach, in both techniques, is possible for repairing incarcerated hernia considering the knowledge of anatomy and expertise needed to dissect and reduce the sac (Fig. 55.9). There is a poor evidence that laparoscopic repair of noninguinal incarcerated hernias may be performed, and further studies are necessary to validate this approach (GoR D).

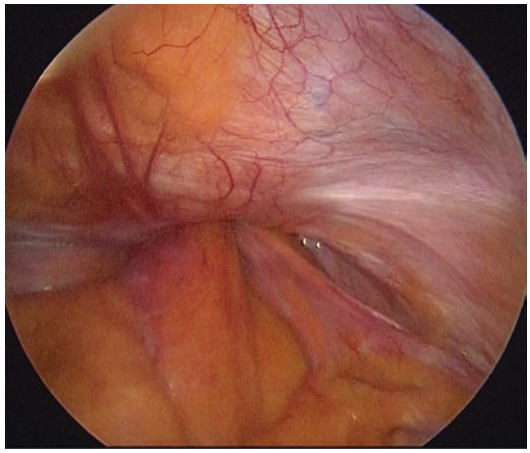

Fig. 55.9 Incarcerated (nonreductible) inguinal hernia from the small intestine

55.3.9 Gynecological Disorders

The most common diagnoses encountered in female patients with acute lower abdominal and/or pelvic pain are ectopic pregnancy (EP), adnexal torsion (AT), endometriosis, pelvic inflammatory disease (PID), and hemorrhagic ovarian cysts. There is a significant amount of high-quality evidence regarding the role of laparoscopic surgery in EP. In the confirmed EP in stable patient laparoscopy should be performed, hospitalization and sick leave times are shorter, and adhesion development reduced when compared to laparotomy. In case of complications with a tubal rupture, salpingectomy can be feasible, and a tube preserving operation can be possible too. When AT, an organ-threatening disease, is suspected, urgent surgical intervention is indicated. Despite the "necrotic" appearance of the twisted ischemic ovary, detorsion is the only procedure that should be performed at surgery. Adnexectomy should be avoided as ovarian function is preserved in 88–100% of cases. Tubo-ovarian abscess is one of the most common types of pelvic abscess. Surgical procedures include laparotomy or laparoscopy with drainage of the abscess, unilateral or bilateral salpingo-oophorectomy, and hysterectomy. However, surgery for tubo-ovarian abscess is often technically difficult and associated with complications [24]. When gynecologic disorders are the suspected cause of abdominal pain, diagnostic laparoscopy (DL) should follow conventional diagnostic investigations, especially US (GoR A), and, if needed, a laparoscopic treatment of the disease should be performed (GoR A). Close cooperation with the gynecologist is strongly recommended (GoR A).

55.4 Surgical Imaging and Assistance in Emergency Laparoscopy Setting

55.4.1 Indocyanine Green Fluorescence

Indocyanine green is a substance used as a surgical dye requiring special equipment that has many applications nowadays. It was first utilized in critically ill patients to determine cardiac output and cerebral perfusion. It gained more functions later as applications in emergency surgery [25].

In laparoscopy we can use Indocyanine green injected intravenously (in a dose of 0.25–0.5 mg/kg) to the patient following with the use of a compatible light filter, in order to visualize the perfused tissue. For instance, we can use it for viewing bowel ischemia and the possible evaluation of its perfusion (Fig. 55.10). We can actually see the arteries coloring green as we inject the dye within the first 30 s after injection, thus, leading to take decision regarding tissue viability.

Also, in an emergency biliary tract surgery setting [26], we can inject the dye prior to incision, preferably 30 min earlier with the purpose of seeing the biliary tract such as the common bile duct turn green with the light filter (Fig. 55.11) resulting in a much easier identification of anatomical structures and resultingly avoiding injuries to those structures.

In conclusion, Indocyanine green has gained acceptance and usage during laparoscopy because of its simplicity and infrequency of complications. It is important to keep in mind that when emergency arises, a surgeon can have this technique in his pocket in order to identify structures when surgery becomes tricky or is difficult to

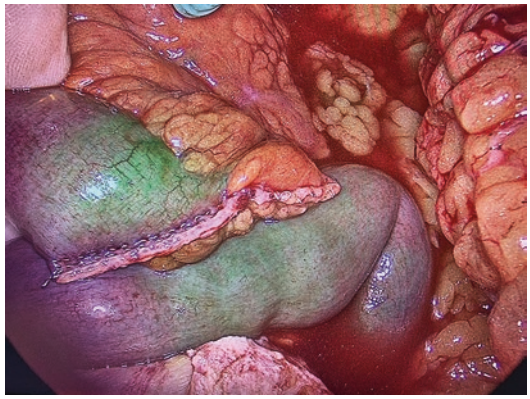

Fig. 55.10 Indocyanine green can use it for viewing bowel ischemia and the possible evaluation of its perfusion

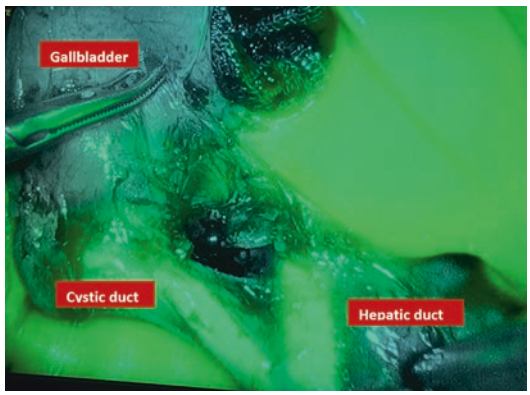

Fig. 55.11 Biliary tract such as hepatic duct turns green with the light filter

evaluate perfusion by performing a real time arteriography.

55.4.2 X-Ray and Fluoroscopy Guidance

The use of X-rays is commonly and widely accepted and routinely used during laparoscopy; more commonly so during biliary tract manipulation and trans-operative cholangiography. As a general principle, when necessary is always beneficial to consider the use of X-rays during surgery. If it is use routinely, we can find associated pathology or intraoperative anatomical findings (Fig. 55.12).

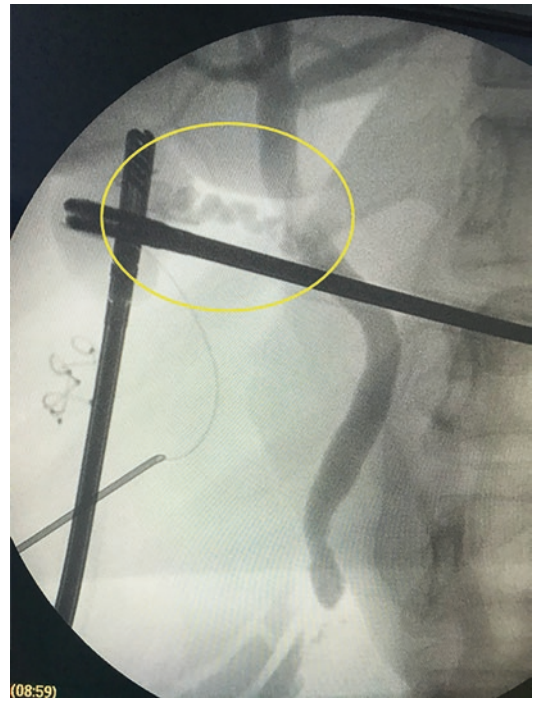

Fig. 55.12 Note cystic duct corkscrew, and dilation of the biliary tract

55.4.3 Endoscopy and Surgery

It is important to keep in mind that when operating on the digestive tract, we always have the endoscopy as a tool, whenever it is available in our hospitals, which in emergency situation (after hours) it is not always available.

We have three types of endo-visualization that can be used to help us during surgery

- Esophagogastroduodenoscopy (EGD) includes the visualization of the esophagus, gastric chamber, and duodenum. During surgery it can be a useful tool to have a clear view of the structures from both sides in a real time. It is easily performed, and it can be done simultaneously with the surgical procedure, as the positions do not intervene with each other. It can be used to evaluate anastomosis, review for perforations in difficult zones to expose during laparoscopy, often posterior walls, most commonly in the duodenum and the posterior wall of the

stomach, which is the most common site for inadvertent perforations in trauma scenarios.
- Colonoscopy enable a clear view of the entire colon and in some occasions the last 20 cm of the ileum. Is also used in emergency settings to evaluate anastomoses and hunt for perforations (less often). It is important to remember that this requires previous bowel preparation via laxatives, otherwise, it is hard to obtain good visibility.
- Endoscopic Retrograde Cholangio Pancreatography (ERCP): This procedure allows exploration of the biliary tract, used in emergency setting for one of two scenarios: exploration for injuries in the biliary tract (iatrogenic or otherwise), which can allow a real time treatment for placement of stents or prosthetics. Secondly, the extraction of gallstones from the biliary ducts, which is achievable either by a common ERCP or by a rendezvous technique, includes the passing of a guide wire through the cystic duct in order to find it through the sphincter of Oddi, facilitating access to the biliary tract.

55.5 Indications and Contraindications of Laparoscopy in Traumatic Emergencies

Laparotomy for abdominal trauma used to be negative or nontherapeutic in approximately one-third of patients. The major advantage of laparoscopy as identified in these studies was the obviation of unnecessary laparotomy in approximately 60% of cases [27]. However, relevant injuries went undetected in 1% of all laparoscopies, particularly after blunt trauma affecting solid organs or hollow viscus. In hemodynamically unstable patients, emergency surgical exploration of the abdomen may be lifesaving. In this situation, delaying definitive therapy by laparoscopy is contraindicated. Bleeding from minor injuries to the liver or the spleen can be controlled through laparoscopic maneuvers. Diaphragmatic lacerations and perforating stab wounds of the gastrointestinal tract can also be sewn or stapled.

After penetrating abdominal trauma, laparoscopy may be useful in hemodynamically stable patients with documented or equivocal penetration of the anterior fascia (Gor B). Laparoscopy should be considered in hemodynamically stable blunt trauma patients with suspected intra-abdominal injury and equivocal findings on imaging studies or even in patients with negative studies but with a high clinical likelihood for intra-abdominal injury ("unclear abdomen") to exclude relevant injury (GoR C). To optimize results, the procedure should be incorporated in institutional diagnostic and treatment algorithms for trauma patients (Gor D). In 2014 we published [28] these indications and contraindications listed below.

55.5.1 Indications for Exploratory Laparoscopy in Abdominal Trauma

1. Diagnosis of low-speed bleeding or doubt of complete hemostasis in case of injury of solid organs (liver and spleen) especially when it has been managed nonoperatively.
2. Probable diaphragmatic rupture or penetration due to clinical suspicion, image, and trajectory.
3. Probable hollow viscus injuries and/or mesenteric injuries, in trauma patients with irrelevant clinical examination and indirect signs on CT (most often free fluid in the peritoneal cavity without solid organ injury) in hemodynamic stable patient.
4. Unfavorable evolution of patients with blunt abdominal trauma with inconclusive imaging results who were managed nonoperatively and with probable diaphragmatic injury, intra-abdominal abscesses, post-traumatic secondary bleeding, mesenteric ischemia, or acute cholecystitis.
5. Contradictions between clinical examination and imaging results, which are inconclusive and are in preparation for general anesthesia for extra-abdominal surgery.
6. Temporary inability to perform a CT scan or FAST, but has the possibility to perform an

exploratory laparoscopy, to avoid a useless laparotomy.
7. Post-traumatic complications: diaphragmatic hernia, delayed evidence of post-traumatic complications, perihepatic biliary or hematic collections, post-traumatic hernias, ureteral injuries.
8. Assistance in the surgical management of intestinal diversion to protect perineal pelvic injuries.

55.5.2 Contraindications for the Use of Laparoscopy in Trauma

1. Hemodynamic instability MAP <70 with fluctuations and acidosis and massive transfusion protocol requirements, including septic shock.
2. Multiple injuries.
3. Significant bleeding.
4. Diffuse peritonitis (relative).
5. Immediately life-threatening injuries.
6. Severe head injury (GCS ≤12) without intracranial pressure (ICP) monitoring.
7. Severe chest trauma with respiratory failure.
8. Clinically significant blunt cardiac trauma.
9. Uncorrected coagulopathy.
10. Chronic cardiopulmonary disease (relative).
11. Decompensated liver disease.
12. Inability to tolerate pneumoperitoneum.
13. Difficulties of access to the peritoneal cavity.
14. Multiple previous surgeries (relative).
15. Bowel distension (relative).
16. Pregnancy—third trimester (relative).
17. Lack of surgical experience.
18. Lack of multidisciplinary team and surgical conjunction.
19. Equipment limitations and inadequate infrastructure.
20. Lack of a protocol for Exploratory Laparoscopy for Trauma.
21. Lack of laparotomy instruments and equipment for trauma prepared, open and ready.

GCS = Glasgow Coma Scale.
MAP = mean arterial pressure.

55.6 Treatment

In the surgical emergencies section, we have been able to review laparoscopic treatment from a simple appendicular resection to complex intestinal resections. This requires training in advanced laparoscopic skills that include intestinal mobilization, intracorporeal suturing, energy use, and staplers. Next, we will review some aspects and principles about the basics of the use of laparoscopy in trauma surgery.

55.7 Basics in Laparoscopic Surgery for Trauma

The first two principles to decide to do a full exploratory laparoscopy in surgical emergencies and trauma is the careful selection of patients and have available a highly skilled laparoscopic trauma surgeon. The availability of laparoscopic equipment 24 h a day, 7 days a week (24/7), and adequate support by collaborating and specifically trained surgical nurses and anesthesiologists are another fundamental condition.

55.7.1 Basic Equipment

Basic equipment is required to perform a successful procedure in emergency surgery or in a trauma setting like any other surgical procedure. Considering having available some other additional material that may be needed to perform the procedure without delay with the best performance.

55.7.2 The Operating Room

It should be noted that in many cases of trauma and emergency surgery, especially in the laparoscopic era, you may need adequate space to house all the equipment you will need from the anesthesia workstation and monitors, space enough for assistance, such as a C-arm or endoscope, among others. Therefore, if an operating room were built

from scratch to perform this type of procedures from the user's point of view, the following should be taken into account: Adequate space for proper workflow, for equipment and personnel, with enough space 36–64 square feet (recommended), or adapt it to the equipment it contains, and the most common procedures you perform. Hybrid trauma operating rooms tend to have more space since they harbor larger equipment like angiographic equipment or portable CT-scan machines [29–31]. It is of utmost importance in any operating room to control the environment and patient temperature. The lighting of the operating room ceiling and the lights of the operative field must be cold lights that do not influence the temperature of the patient, they must not cast shadows on the surgical field, or reflections on the monitors, they must be prepared and articulated to be able to convert to open surgery without any problem. The surgical table must be multi-positioning to take advantage of the gravity of the displacement of the organs when mobilizing it, making the surgery more efficient. Remember always that the patient must be strictly restrained to the table.

The monitors must be of very high resolution, preferably 4K, high contrast, commonly 3000:1, since the shadows created within the abdominal cavity give it a perception of depth, with a non-reflective surface and sufficient brightness not to turn off the lights from the ceiling of the operating room. Exploratory laparoscopy for trauma is very dynamic and the surgeon must change sometimes to be able to evaluate the four quadrants and spaces, therefore monitors should be mobile and versatile to adapt to the required visualization and the surgeon's ergonomics to be optimal. The CO_2 insufflator must be configured on volume, flow and pressure in the abdominal cavity. It should not be insufflated above 12 mmHg for any procedure. The flow in operative laparoscopy for trauma must be high, ensuring a constant intra-abdominal pressure avoiding fluctuations and delays in reinflation. The anesthesia area must be spacious, so that in addition to the monitoring and ventilation machine, the anesthesiologist can perform additional procedures such as the placement of a central catheter or invasive blood pressure monitoring [32] (Fig. 55.13).

55.7.3 Laparoscopic Instruments

The surgeon must use its best option as a method of entry and a second option in case it is not possible with the first. Different methods of entry have been compared, there is no evidence of superiority of one over another. Even though there are several techniques for entering the abdominal cavity such as the open technique, the close technique, direct view trocar entry, Veress needle, Hasson technique and radial expanding trocars (STEP). The surgeon must use the technique that dominates and feels more secure and comfortable [33]. The preferred route for exploratory trauma laparoscopy is the open route through the navel. In our experience, the versatility of having lens of 5 mm and 10 mm with 30° provides an advantage of multiple visions. There is currently no place in exploratory laparoscopy for 0° lenses. It is of the utmost importance to keep the lens with adequate clarity cleaning them continuously with anti-fog or warm water solution. It is important to have the suction/irrigation cannula available from the beginning of the procedure, functioning properly, with a great capacity canister and with the pressure irrigation solution ready for use. The electrosurgery unit and the appropriate devices cannot be missing to make hemostatic vessel control of different diameters. The energy should be used with caution, trying not to have complications to the surrounding tissue during handling.

55.7.4 Basic Technique

Within the preparation of the patient for an exploratory laparoscopy, it is imperative to emphasize that before preparation, we have to fasten the pelvis and chest with straps, this allows an active mobilization of the patient during surgery and perform exploration maneuvers helped by the mobilization of organs by gravity. In

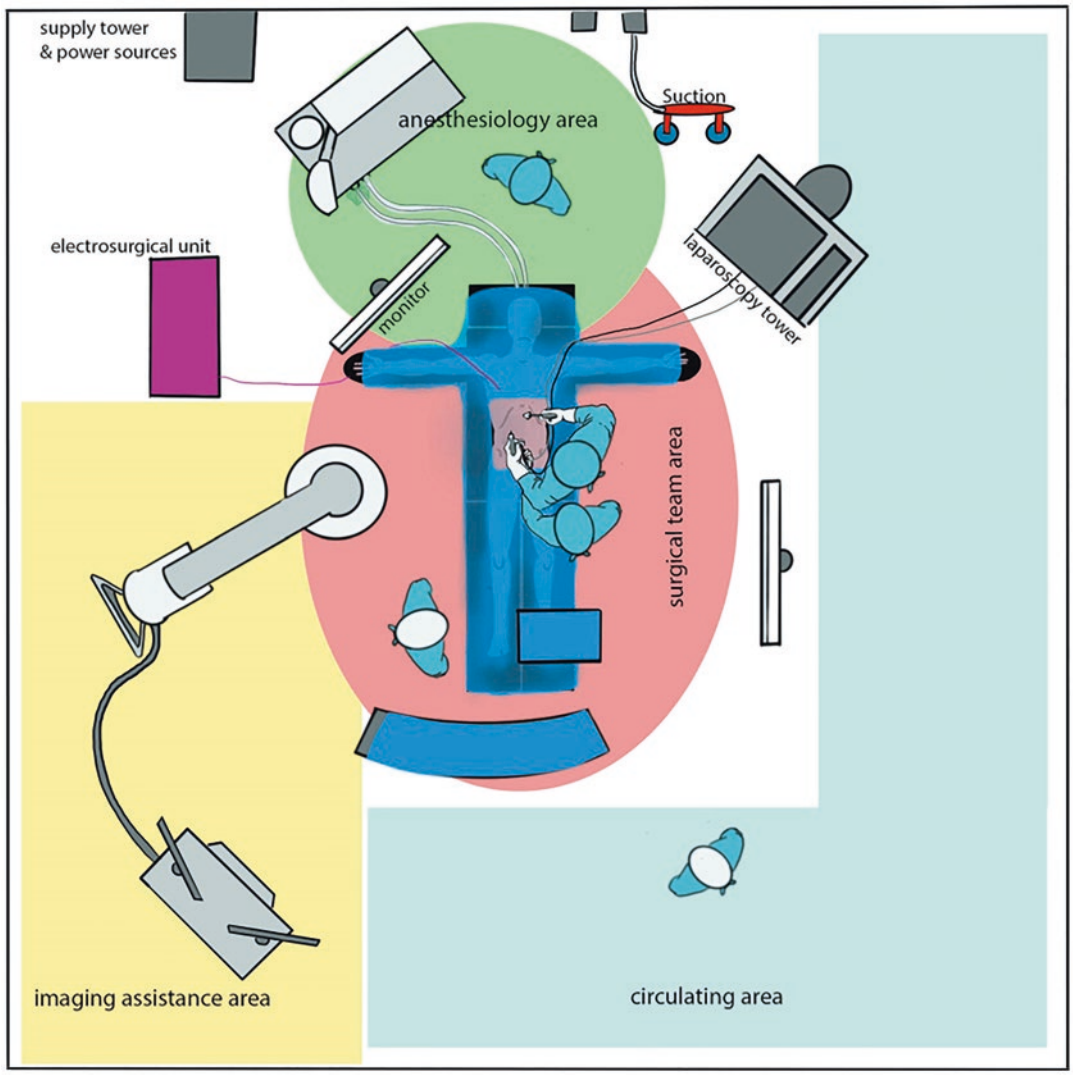

Fig. 55.13 Example of distribution of the laparoscopic operating room

patients where is possible to place in a French position, holding the legs is also important, being careful of taking care of the bone pressure zones. In trauma patients, the open arms position is recommended, these allow anesthesiologists to be able to have peripheral venous control.

55.7.5 Entry Techniques

There are many different entry techniques, and the surgeon should use the technique that feels more comfortable for him. The techniques can be divided into closed and open techniques, the main difference is that in the open technique it carries out an incision in the skin and layers of the abdomen until the peritoneum, and the trocar described by Hasson in 1971 is introduced. In the closed technique, a sharp object is introduced into the abdominal wall thru the peritoneum and subsequently the CO_2 is insufflated, a Veress needle is generally used, but a trocar can also be used with or without the laparoscopic lens, or the STEP technique, that uses a Veress needle with a sleeve that allows you to insufflate and create the pneumoperitoneum and then introduce increas-

ingly large trocars that is radially expanded at the access point. Closed maneuvers are time consuming and not recommended in exploratory laparoscopy for trauma. The main risks and complications of any type of entry technique are visceral, vascular, or solid organs injuries, failed access, and gas embolism.

55.7.6 Trocar Placement

A good rule of thumb is that the instruments and the lens should create a triangle pointing to the area you wish to work in and the trocars should be spread at least the distance of the handgrip from one to another, so the surgeon could work efficiently and still have an ergonomic position, one way to think about this, is imaging a circle around the area you will be working on the center of the circle will be the vertex of the triangle and you can place the trocars on the radius of the circle. The first access is best achieved at the navel with an open technique using a 10/12 mm trocar. We do not recommend the use of Veress needle in trauma patients, some may have a distended bowel and it may cause misleading iatrogenic bowel or vascular injuries.

55.8 Important Issues About Laparoscopy in Trauma Patients

Since the first descriptions of the use of laparoscopy in trauma, its usefulness was valuable in the diagnostic context [34–39] and publications were emerging describing maneuvers for laparoscopic exploration of the abdominal cavity [40, 41] in blunt and penetrating injuries [42].

It is evident that the limitations of monocular vision that existed in the beginning, coupled with poor surgical skills, little technological development, and inexperience in the laparoscopic technique caused that its use was limited. It was not until 1986, when a camera was adapted to the laparoscope, gaving a new dimension to the vision that had existed until then, allowing the sharing of the findings and making the procedures safer. Based on this and with the various technological advances incorporating the 30°- and 45° lens, electrosurgery systems, the variety of instruments and the monitoring and anesthesia techniques that we currently have, they facilitated the procedures and expanded the horizon of laparoscopic possibilities. The benefits of minimally invasive surgery in other surgical areas have encouraged many surgeons to find applications in hemodynamically stable trauma patients, avoiding unnecessary secondary insult with larger wounds and increased morbidity associated with the procedure. In such a way, that exploratory laparoscopy seeks the possibility of being a reliable, feasible procedure that tries to be approved as a tool that allows exploring and repairing the initial injury safely with less morbidity and with a better postoperative recovery.

In recent years the enthusiasm in trauma laparoscopy is less than the post-laparoscopic cholecystectomy era, with fewer publications on laparoscopy in trauma patients. Many factors impact not only in the publications but also in the therapeutic laparoscopy, such as the percutaneous techniques, best imaging systems and protocols that promote the non-operative management, even with the development of laparoscopy techniques and skills in the world. Some examples of these were vision with different graduation angles, versatility of movements, laparoscopes with smaller diameters, cameras with better quality definition, lighting power, constant flow of insufflation without loss of gas, trocars of better quality and bladeless, powerful aspiration systems and more reliable methods of vascular coagulation and sealing with the improvement in electrosurgery systems, methods of better exposure and vascular control with the development and perfection of ultrasonic cutting systems, staplers with articulated movements and number of lines of stapling, various hemostatic agents, adjuvant drugs in the control of bleeding, practical autotransfusion systems and new concepts in relation to the monitoring and management of shock. In this last point, the abandonment of aggressive therapy with intravenous fluids in patients with penetrating trauma and opting for

the concept of delayed resuscitation with fluids and the use of vasoactive drugs, allows us to maintain an adequate perfusion, reducing complications due to excess fluid and pulmonary failure up to 30% [43]. When damage control surgery steps were developed in the trauma laparotomy sequence, with quadrant packing, rapid vascular access methods, exposure maneuvers, and management for various types of injuries, it contributed to saving time for the benefit of this type of patients and performed rapid and protocolized surgery; however, the steps and requirements have not been described for systematic exploratory trauma laparoscopy. For this reason, it is particularly important to describe the initial approach site, the characteristics of the pneumoperitoneum that should be used in cases with multisystemic lesions or in cases of head trauma, the number of trocars and their characteristics, the position of the patient for the correct visualization of certain anatomical spaces, as well as the methodology for exposing an organ injury and its repair. Recently, a publication from the University of Sao Paulo [44] by Kawahara et al. standardize and refine their technique, and describe an algorithm for penetrating injuries that is important to consider. Likewise, they graphically represent the trocar placement site, which does not vary from ours. In their report, they refer to the exploration of the small intestine and the possibility of carrying out a complete exploration of this, coinciding with us. They found series of 75 patients injured with sharps and firearms, a general sensitivity of laparoscopy of 97.61%, and specificity of 100%. Positive and negative predictive values with values of 100% and 97.05%, respectively and accurate of 98.66%. Based on this, since 2014 we developed the ***Systematic Exploratory Laparoscopy in Trauma (SELT)*** technique seeking to standardize the way of performing exploratory laparoscopy in a trauma patient, proposing a way of placing trocars and maneuvers to try to explore practically the entire peritoneal abdomen in hemodynamically stable patients. This includes a checklist for performing the procedure, a list of surgery steps, and specific maneuvers for organ exploration. The surgeon stands on the left to explore the right abdomen (liver, right colon, and small bowel) and on the right to explore the left abdomen (left diaphragm, stomach, spleen, left colon, sigmoid, bladder, and rectum). In the same way, we describe critical points of conversion to traditional trauma laparotomy during laparoscopic exploration.

55.8.1 Critical Points to Conversion

If during the laparoscopic exploration the finding is a retroperitoneum Zone I hematoma, is enough reason to convert to laparotomy at once, as well as expanding hematomas in Zone II even when the patient is hemodynamically stable. In expanding hematomas in Zone III, you can have two options, decide to convert to laparotomy, or only perform open preperitoneal packing and assistance with angioembolization. Any hemodynamic decompensation due to bleeding, previously undetected pulmonary or cardiovascular dysfunction, or decompensation due to abdominal hypertension during SELT procedure, is sufficient reason to open the patient. Insufflation should be stopped in case of abrupt rise in respiratory pressure, blood hypotension, or tachycardia; and a low threshold for immediate conversion to open surgery should be kept in mind. A low threshold for open conversion should be maintained if the surgeon is not confident and missing injuries are suspected.

Di Saverio and colleagues mention that they prefer a preliminary exploration by exploratory laparoscopy and seek if there is any indication for the urgent conversion first, and then continue with the rest of the trocars according to the suspicion of identified injury.

55.9 Technical Aspects of SELT Procedure

To carry out laparoscopic management of the patient correctly and safely with abdominal trauma, it is necessary to have the equipment, complete instruments, and ready to be used immediately to avoid wasting time that could have an impact on a decrease in the quality of

patient care. The preferred laparoscopic equipment should be of high definition and have a light source of at least 300 W, a 20-L insufflator, and a 30°, 5- and 10-mm laparoscope. The instruments should include, in addition to conventional forceps such as graspers and dissectors, atraumatic intestinal forceps, and needle holders. It is essential to have a suction system with conventional and with multiple fenestrations 5- and 10-mm cannulas for a quick and efficient evacuation of the hemoperitoneum. Placement of the first trocar can be performed with open technique. There was not standardized approach to where to place the trocars in the abdominal wall, but any placement must allows functionality, manipulation of practically all the peritoneal organs, options to repair an injury and manipulate the structures, comfort of the team and of course, of the surgeon. At any time, an extra trocar can be placed or one of its positions changed. The abdomen exploration begins with the right upper quadrant like an open approach proceeding clockwise. During the procedure, both hemidiaphragms are required to be explored to rule out injuries that could cause tension pneumothorax, and if present immediately, a pleural tube should be placed [45]. For the evaluation of hemoperitoneum, it is useful to classify it in minimal, moderate, and severe [46] (Table 55.1).

The additional trocars that are necessary according to the findings are placed in an appropriate number and place for the maneuver to be carried out. Preferably, a position contralateral to the injury to be repaired should always be adopted and it is always desirable to have an extra trocar for aspiration. The first maneuver is to exhaustively search for the site or sites that bled, systematizing the search by quadrants. If a large and profusely active bleeding injury is found, there should be no doubt in convert the procedure to open surgery. If the injury is superficial and the bleeding is not profuse, it can be packed with prefabricated roll gauze that allows easy passage through the 10-mm trocars and allows adequate temporary packing and continued exploration of the abdomen searching other bleeding sites and other injuries. The bowel should be entirely and thoroughly explored by run the bowel technique, with two atraumatic intestinal forceps from the ileocecal valve to the duodenal–jejunal flexure, trying to visualize both sides from the intestine and mesenteric and antimesenteric margins.

For the management of intestinal injuries, it is necessary and advisable to have endoscopic staplers. However, it is not mandatory to perform mechanical anastomoses. Depending on the skill of the surgeon, it is possible to perform primary closures and anastomoses manually. Table 55.2 explains the place of the surgeon, the quadrants and the organs that can be explored in each of them, and the positioning of the patient.

Table 55.1 Classification of hemoperitoneum

Minimal hemoperitoneum: small static amount of blood, including in the parietocolic gutter or between the intestinal loops
Moderate hemoperitoneum: obvious 5–10 mm deep blood accumulation in the paracolic gutters and/or pelvis
Severe hemoperitoneum—the widespread accumulation of blood throughout the peritoneal cavity including around the intestinal loops floating in or surrounding by a pool of blood

Berci G, Sackier JM, Pas MP. Emergency laparoscopy. Am J Surg. 1991;161:332

55.9.1 Ready Check list Description

1. Patient monitoring by anesthesia
2. Open surgery equipment available and open for immediate use if needed (strictly required)
3. Laparoscopic equipment available and working
4. Multi-positioning table functioning
5. Nasogastric tube placed
6. Foley catheter placed
7. Endopleural catheter placed (if needed)
8. Patient restraint to prevent falls and injuries from improper posture
9. Automatic staplers and clips available
10. Hemostats available
11. Electrosurgery unit and devices ready to use

Di Saverio [47] recently published some concepts where the "why" of laparoscopy is ques-

Table 55.2 Surgeon position, organs inspection and surgical table position

Surgeon side	Quadrant	Organ inspected	Patient position
Left	Right upper quadrant	Liver, gallbladder diaphragm, stomach, lesser sac, ascending colon, right colon flexure, first 2 portions of duodenum and pancreas, [a]right transverse colon	Fowler position and left tilted
Right	Left upper quadrant	Stomach great curvature, diaphragm, spleen, left transverse colon, left colon flexure, descending colon	Fowler position and right tilted
Left	Right lower quadrant	Cecum, ileocecal valve, and half of small bowel	Trendelenburg and left tilted
Right	Left lower quadrant	Half of small bowel to duodenal–jejunal flexure and Treitz ligament, [b]descending colon, sigmoid, and rectum	Trendelenburg and right tilted

Vega-Rivera F. (2014). Laparoscopia Exploradora Sistematizada para Trauma (LEST). En José de Vinatea (Ed.), Ciencia y práctica en Cirugía Laparoscópica (Primera edición, pp.103–120). Ed. Amolca

[a]The pancreas can be visualized in the first portions, but the body and tail can be explored behind the stomach, cutting the higher omentum

[b]When the small intestine is being explored near the duodenal–jejunal flexure, the mobilization of the patient must be dynamic by changing from the position of Trendelenburg to Fowler to completely visualize the intestine

tioned and refers to certain advantages such as lower inflammation and trauma, high diagnostic accuracy and reduce rate of nontherapeutic laparotomies up to 73% [48], better respiratory management and less postoperative pain, lower rate of adhesions, incisional hernias, and surgical site infection, faster recovery, and less costs [49].

Dos and Don'ts

- Is laparoscopy indicated?
  - It is very important not to start the wrong way, if a laparoscopic procedure seems like a risky bet in terms of the capacity of the surgical team that will face a complex emergent procedure, consider open surgery from the beginning, since it is of paramount importance, do not waste time.
  - Know the resources in the hospital and in the operating room. Make sure the required technology is at your disposal.
  - Perform night surgery? Every good surgeon should keep in mind that the night shift is often understaffed and that not all resources available during the day are equally available at night. Be aware of the things you can safely count on overnight and use this information when deciding to perform laparoscopic procedures in emergency/trauma situations.
- Beginning of surgery
  - It is often common to see trocars misplaced or placed in sites where there is no possibility of therapeutic maneuver. You should always consider, anatomic variations in patients, previous surgeries/existing scars (beware of adhesions of viscera to the abdominal wall), leaving enough space between them (at least 10 cm) and last but not least, the proper trocar diameter for the proper site (i.e., do not insert a 5 mm trocar where needles or gauzes are likely to be inserted, instead choose a 10–12 mm trocar).
  - It is often seen in less trained surgeons to apply more force than needed to break the tension imposed by the abdominal wall when insert-

ing a trocar, especially in obese patients, therefore it is recommended to grasp the upper part of the trocar with all the palm of the hand and always remember to place the index finger distally to avoid forced entry of the blade/tip and never end up piercing healthy tissue, which can often result in complications.
  - NEVER proceed if you are not comfortable with the quality of the image, make sure you view everything with the appropriate resolution, if necessary, make the necessary changes to improve; don't settle for poor image resolution [50].
- During the surgery
  - Whenever possible avoid higher pressures on the pneumoperitoneum, rather work with the least amount of pressure that adequately exposes the surgical site.
  - If you are not a veteran in laparoscopy, consider when alternating instruments (forceps, scissors, needle holders, etc.) that your assistant holding the endoscope visualize the introduction of the instrument into the abdominal cavity to have a safe view of the path that it will take the tip of the instrument to reach the surgical site. Performing this maneuver will result in fewer instrument tips inside the abdominal organs.
  - When using an instrument that carries any type of energy (ultrasonic scalpel, bipolar, monopolar forceps, etc.) always let the instrument do its work before removing or pulling it; By doing so, you will avoid tearing divided or incompletely clotted tissue, resulting in blood loss, or incomplete sealing.
  - If you accidentally open a blood vessel, always keep in mind that the first step is proximal and distal control of the vessel, most often achieved by adequate compression by the quickest means necessary. Do not attempt to use staples when you cannot visualize the vascular ends. If the situation is out of your control, always seek help or convert the procedure to open surgery.
  - Do not be afraid to replace or insert additional trocars when necessary, reconsider repositioning frequently, when you do not have the correct exposure. It is better to place an additional trocar when you have performance problems than to spend too much time with the patient on the surgical table [51].
- After the surgery
  - At the end of the procedure, always remove the trocars with direct endoscopic vision, in this way, you will always avoid postoperative bleeding at the insertion sites. And then, properly evacuate the gas from the abdominal cavity.
  - Trocars larger than 5–8 mm in diameter always require closure of the abdominal wall with suture at the insertion site, regardless of the skin incision.

55.10 Summary

Minimally invasive surgery increases in the context of abdominal emergencies in a wide range of acute conditions and nowadays has in our point of view a place in the algorithm of surgical treatment in the trauma patient. The indications and contraindications are clear and the threshold to convert to open surgery is well defined. The surgical expertise, knowledge, and surgical skills are a fundamental piece to improve the experience in trauma laparoscopy. These procedures must be performed by a well-trained surgeon and his team. The Systematic Exploratory Laparoscopic for Trauma (SELT) needs to gain

more followers and surgical confidence. The only way to get expertise is to practice, without any risk to the patient. We do not believe that this will be easy, but it is feasible and possible. The availability and surgical facility preparedness are indispensable.

Take-Home Messages

- Always prepare yourself and discuss with your peers and surgical team to develop an adequate plan execution prior to the first incision.
- Keep in mind which procedures you are able to perform regarding the equipment available.
- Previously familiarize yourself with laparoscopic techniques in a simulator prior to attempt four first emergency situation.
- Whenever possible, evaluate to delay some procedures in order to avoid operate after hours (e.g., cholecystectomy in the middle of the night); surgery at night is more challenging for many reasons.
- When facing active bleeding, always apply pressure and decide beforehand which hemostatic skills will result for an adequate bleeding control. Every wrong decision becomes the surgery more challenging.
- If you are not well versed in laparoscopic skills, consider other techniques in vulnerable patients because prolonged surgical times have poor outcomes.
- When surgery is done, always take time to assess structures and organs involved until you are completely satisfied with what was done before closure.
- Stick with guidelines and post-operative protocols for patient follow up, in order to detect in early stages when something seems to be wrong.
- If something goes wrong or seems too overwhelming, always ask for help.
- If you make a mistake, never make two! Keep calm and think before take action again.

Questions and Answers

1. What is the correct term, when you only perform a single trocar laparoscopy to observe the peritoneal cavity?
   A. Diagnostic laparoscopy
   B. Exploratory laparoscopy
   C. Therapeutic laparoscopy
   D. Non-therapeutic laparoscopy

Correct Answer: **A**

2. What is the correct term, when you perform a laparoscopic procedure with multiple trocars where you able to observe the peritoneal cavity and mobilize the organs to discard any injuries?
   A. Diagnostic laparoscopy
   B. Exploratory laparoscopy
   C. Therapeutic laparoscopy
   D. Non-therapeutic laparoscopy

Correct Answer: **B**

3. In a routine exploratory laparoscopy, looking to find the cause of an acute abdominal pain, you found an acute appendicitis and perform an appendectomy. What is the correct form to designate the procedure?
   A. Diagnostic laparoscopy
   B. Peritoneoscopy
   C. Exploratory therapeutic laparoscopy
   D. Exploratory non-therapeutic laparoscopy

Correct Answer: **C**

4. A 32-year-old male patient involved in a motor vehicle collision presents to the Emergency Department with blunt abdominal trauma, no additional injury is identified on primary assessment. There is a well healed surgical scar in the right lower quadrant in the abdomen. Relevant trauma history reveals ethanol halitosis, and GCS 13/15. An initial resuscitation attempt is performed with 0.9% NaCl 2000 mL, rendering MAP to 59 mmHg. The surgeon considers proceed with open surgery. Which of the following is a contraindication to perform an exploratory laparoscopy?
   A. Severe head injury
   B. Ethanol halitosis

C. Hemodynamic instability
D. Difficulty assessment of the peritoneal cavity

Correct Answer: **C**

5. A 35-year-old second trimester pregnant female presents to the ER with acute abdominal pain diagnosed by ultrasound as acute cholecystitis, she has a history of thrombophilia, she is with enoxaparin 40 mg subcutaneous once a day, GCS 14/15, MAP 72, normal liver function tests, bowel distension due to intraluminal gas attributed to irritable bowel syndrome. Is there an absolute contraindication for laparoscopic surgery?
   A. Bowel distension
   B. Pregnancy
   C. Thrombophilia treatment
   D. There isn't any

Correct Answer: **D**

6. An otherwise healthy 65-year-old male presents to the ER with a single 2 inch (5 cm) knife stabbing wound in the abdomen on the lower left quadrant, with no apparent active bleeding from the wound, the patient has a GCS 15/15, HR 100/m, MAP 75, abdominal pain near the wound, a CT scan shows approximately 200 mL of free liquid in the pelvic region and no free gas. What procedure should be advisable?
   A. Diagnostic laparoscopy
   B. Exploratory laparoscopy
   C. Exploratory laparotomy
   D. Angiography

Correct Answer: **B**

7. What is the name of the procedure that we use for abdominal trauma in hemodynamically stable patients that allows us to explore by laparoscopy the entire abdomen in an orderly fashion?
   A. Exploratory laparotomy
   B. Exploratory laparoscopy
   C. Systematic Exploratory Laparoscopy in Trauma (SELT)
   D. Systematic Exploratory Laparotomy in Trauma

Correct Answer: **C**

8. Which of the following is an absolute indication for conversion to open laparotomy?
   A. Zone 1 nonexpanding hematoma
   B. Zone 2 nonexpanding hematoma
   C. Zone 3 non expanding hematoma
   D. Zone 3 expanding hematoma

Correct Answer: **A**

9. The SELT procedure requires for the surgeon and his team to relocate and adjust the patient position depending on the area they are exploring. Which of the following would be advisable to explore the spleen?
   A. Surgeon on the right side of the patient with Fowler position
   B. Surgeon on the right side of the patient with Trendelenburg position
   C. Surgeon on the left side of the patient with Trendelenburg position
   D. Surgeon on the left side of the patient with Fowler position

Correct Answer: **A**

10. Which of the following would be advisable to explore the ileocecal valve?
    A. Surgeon on the right side of the patient with Fowler position
    B. Surgeon on the right side of the patient with Trendelenburg position
    C. Surgeon on the left side of the patient with Trendelenburg position
    D. Surgeon on the left side of the patient with Fowler position

Correct Answer: **C**

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