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Safety in Perioperative Period in Laparoscopic Surgery

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ABSTRACT

Laparoscopic surgery has revolutionized the field of surgery, offering significant improvements in patient outcomes such as reduced recovery times, pain, and hospital stays compared to traditional open surgery. However, safety concerns arose with its introduction, prompting the need for advancements in technique and equipment. This article explores critical safety improvements in laparoscopic surgery, simulating a patient's perioperative journey. Key topics include the importance of team briefings, proper patient positioning, ergonomics, optimal laparoscopic setup, safe port insertion techniques, pneumoperitoneum management, instrument handling, and hemostasis. The review highlights the ongoing need for research and consensus in patient safety practices within laparoscopic surgery.

KEYWORDS: Laparoscopy, safety, perioperative period.

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INTRODUCTION

Laparoscopic surgery is considered one of the most significant advancements in surgical practice. It has initiated a revolution in the application of digital and robotic technology in surgical practice. It has significantly reduced patient recovery times in comparison to 'open' surgeries. Remarkably, these advancements have been achieved while simultaneously improving the quality of surgery. Laparoscopic surgery is linked to diminished pain, fewer wound infections, shorter hospital stays, decreased morbidity and mortality, expedited return to work, and enhanced overall quality of life. Initially, the introduction of laparoscopy raised concerns about its safety. Fortunately, as surgical teams have advanced through their learning curves, many of the initially documented complications have become relatively rare.

This article examines critical aspects that may improve the safety of laparoscopic surgery. This article is organized to reflect a patient's experience regarding perioperative considerations.

Perioperative period

Team briefing and surgical safety checklist

An effective team briefing is essential prior to any operation. All team members, including the consultant surgeon, surgical assistants/trainees, anaesthetist, anaesthetic trainee/operating department practitioners, scrub nurse, and circulating nurse, must be present during the team briefing. These sessions facilitate the discussion of potential challenges, prophylactic measures for venous thromboembolism, antibiotic prophylaxis, glycemic control, patient allergies, patient warming, patient positioning, screen placement, necessity for X-ray, and other related matters. We highly advocate for the inclusion of team briefings in the World Health Organization (WHO) "safe-surgery" checklist, as evidence indicates that this practice diminishes human error and adverse outcomes while enhancing communication and collaboration. During discussions of allergies, it is imperative to focus on allergies related to substances typically utilized during or post-surgery. Certain elective procedures may need to be postponed while the patient is referred to suitable specialists for additional testing and allergy confirmation.

Patient positioning

Optimal patient positioning is crucial for the safe execution of laparoscopic surgery. Necessary precautions must be

implemented to guarantee neutral alignment of primary joints and cushioning of pressure points. Some surgeons favor a "French" position, standing between the patient's legs, while others prefer to stand on the patient's right side. Notwithstanding these preferences, fundamental principles of positioning remain unchanged. The patient must be restrained with a strap across the chest and thighs, with or without footrests, contingent upon the anticipated use of the reverse Trendelenburg position during the surgery, to prevent lateral and caudal displacement. Similarly, for pelvic surgery, the patient may require the Trendelenburg position. In such instances, hips and knees must be maintained in a neutral position using secured leg supports with soft cushioning for all pressure points. Shoulder supports can assist in preventing the cephalad displacement of patients. If stationary retractors, like Nathanson's liver retractor, are necessary, they must be securely affixed to the operating table to reduce the risk of intra-operative complications, including liver injuries. One must exercise extreme caution when introducing and removing these retractors. The liver may be firmly attached to adjacent vascular structures, and improper handling may result in traction injuries. Properly transferring the patient on and off the operating table is essential to prevent injuries to both the patient and staff, particularly for obese patients, where air mattresses (e.g., HoverMatt®, HoverTech International, Allentown, PA, United States) may be beneficial.

Preparation for laparoscopy

A considerable proportion of laparoscopic surgeons experience work-related musculoskeletal injuries (up to 70%), making ergonomics particularly relevant to laparoscopic surgery compared to open or robotic surgery. Factors to consider include the patient's position, the height of the operating table, port placement, and the configuration of the laparoscopic monitor. A primary recommendation is that the surgeon, the surgical field, and the monitor should be aligned in a straight line, ensuring triangulation between the camera and the principal operating ports. The monitor's height should be positioned slightly below the surgeon's eye level (ideally between 0 and 150) to prevent strain from extended neck positioning. Surgeon and assistant fatigue may elevate the likelihood of procedural errors; therefore, it is imperative to enhance ergonomics. To address certain ergonomic challenges, contemporary laparoscopic operating rooms are outfitted with permanently mounted, ceiling-suspended multiple flat-screen monitors featuring adjustable angles. The relative deficiency in depth perception (2D view) has been a significant drawback of laparoscopy in comparison to open surgery. To address this, 4K ultra high-definition technology and 3D laparoscopic technology have been implemented, and multiple trials have compared the two. Neither appears to be superior to the other, and a recent consensus statement from the European Association of Endoscopic Surgeons determined that additional rigorous research is necessary to explore the advantages of the 3D laparoscopy system. The elevated cost, coupled with the stress associated with the 3D laparoscopy system and concerns regarding the surgeon's vision, indicates that these systems have not achieved widespread adoption.

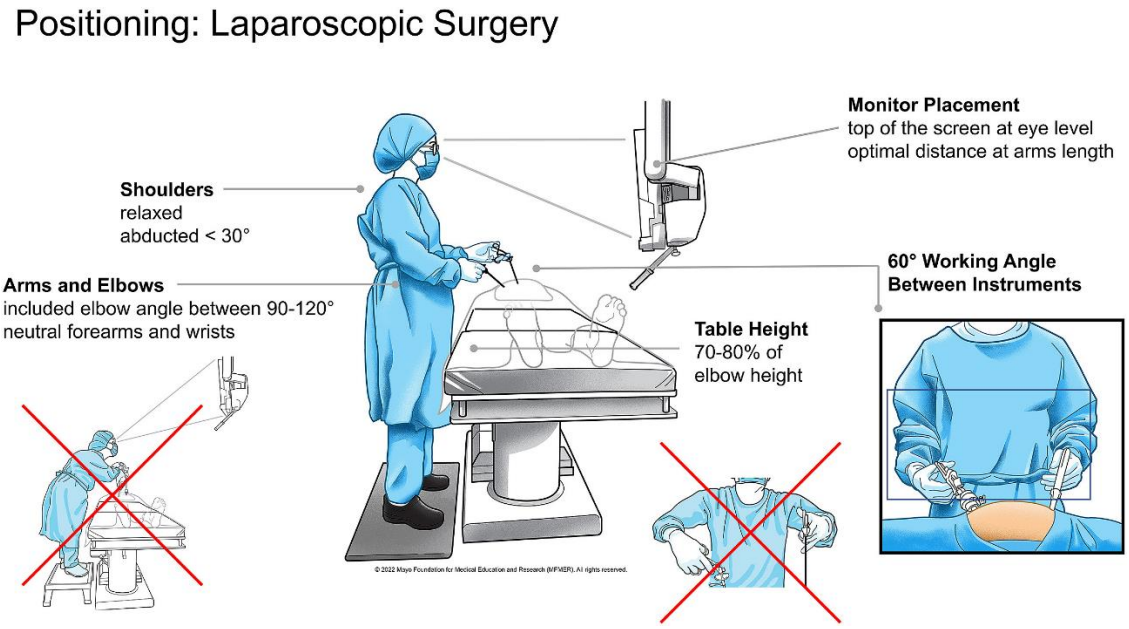

Figure 1. Ergonomics in laparoscopic surgery

Techniques for port placement and insertion

It has been proposed that as much as 50% of significant complications in laparoscopic surgery arise during port insertion. Surgeons must, consequently, be adept in various techniques for creating pneumoperitoneum. The Open Hasson technique, closed Veress needle entry, and optical ports—either with or without prior pneumoperitoneum utilizing a Veress needle—are the predominant methods employed today. A recent Cochrane review indicated that none of these methods are distinguished by complications,

including visceral and major vascular injuries. Nonetheless, Hasson's open technique is linked to the lowest probability of entry failures in comparison to the other two methods. Although numerous surgeons possess a favored technique, the choice of entry method should likely be determined by patient attributes. The open juxta-umbilical approach is efficient and secure for patients of slender to average physique with minimal abdominal wall adiposity and no history of midline laparotomy; conversely, optical port insertion in the left upper quadrant (with or without preceding Veress needle pneumoperitoneum) may be more prudent for individuals with a history of midline laparotomy or obesity. In any closed technique, the initial port should invariably be introduced under optical guidance, with the left upper abdomen (Palmer's point) considered by many surgeons to be the safest location for this procedure.

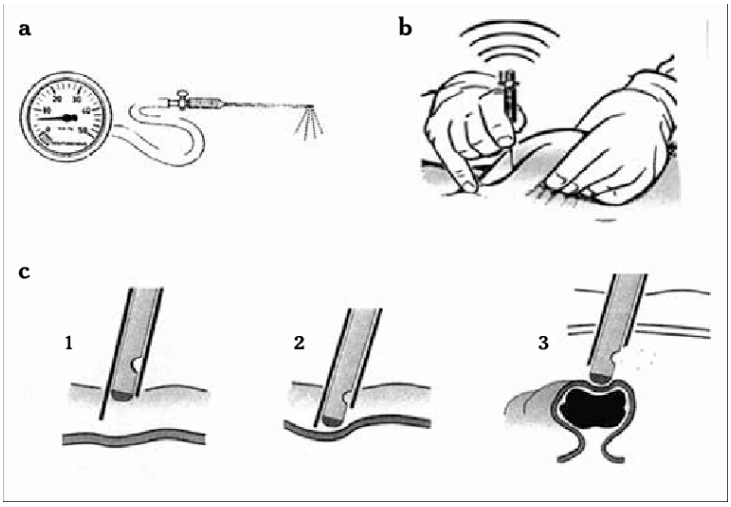

Figure 2. Veress needle

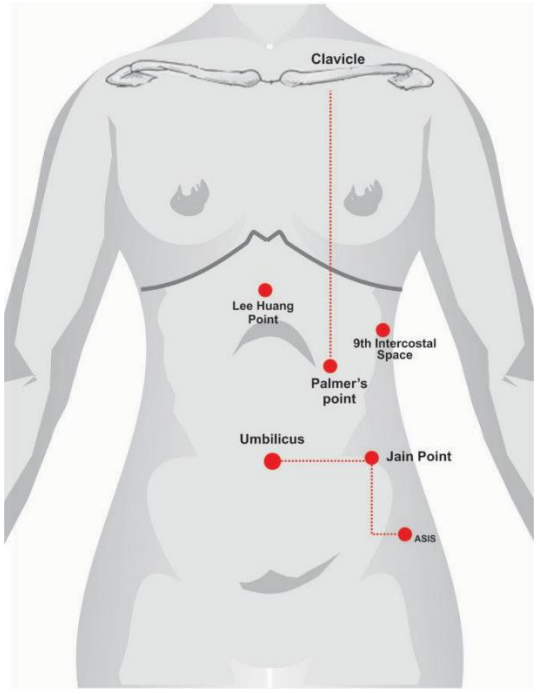

Figure 3. Access for laparoscopy

The dimensions of the primary port (10-12 mm or 5 mm) are contingent upon the surgeon's preference and the nature of the surgical procedure. Some surgeons, for pediatric patients, prefer a 5 mm primary port to minimize tissue trauma. The image quality produced by a 5 mm scope may be inferior to that of a standard 10 mm scope due to a reduced number of optical fibers. The dimensions and placement of subsequent ports are contingent upon the operation and expected instruments employed. Most instruments can be utilized safely through 5 mm ports; however, staplers, large clip applicators, and retrieval graspers typically necessitate 12 mm ports. Surgeons must consider that a curved needle cannot pass through a 5 mm port, whereas a ski-shaped needle can. Curved needles may become lost within the abdominal cavity when efforts are made to extract them via a 5 mm port. Surgeons must consistently monitor any needle during its

insertion and extraction from the abdominal cavity. Larger 15 mm ports are occasionally necessary for thick stapler devices and the extraction of sizable specimens. Nonetheless, according to the authors' experience, this occurrence is infrequent, as the majority of specimens can be extracted via a 12 mm port site with minimal distension. Nonetheless, if a 15 mm port is utilized, the port site must invariably be closed, regardless of the patient's body mass index. All subsequent port placements, following the primary port insertion, must be conducted under direct visualization to prevent damage to the underlying viscera. Injury to the inferior epigastric vessels is identified as the most prevalent cause of port site hemorrhage. In slender patients, transillumination can mitigate the risk of unintentionally damaging these vessels.

There are two categories of trocars: bladed and non-bladed, which are utilized for subsequent port placements. The available data comparing the two types is limited; however, non-bladed trocars are likely linked to reduced trocar-site bleeding, with no significant difference in visceral injury. We believe that surgeons should exclusively utilize blunt-tipped non-bladed trocars in laparoscopic procedures, as they are less prone to causing unintentional injuries to epigastric vessels and internal organs. All ports must be positioned in accordance with the triangulation principle to enhance ergonomics. Upon the insertion of all ports, a thorough examination of the peritoneal cavity is essential to detect any unintentional injuries or unforeseen anomalies. Standard laparoscopic ports measure 100 mm in length and are appropriate for the majority of conventional laparoscopic procedures. Nonetheless, extended-length (150 mm) ports may be required to access patients with substantial abdominal walls. The utilization of suitably sized ports mitigates the risk of recurrent port displacement and fascial damage resulting from multiple insertions. Balloon tip ports, when accessible, can avert port displacement.

Pneumoperitoneum

Optimal pneumoperitoneum is essential for secure laparoscopic surgery to guarantee sufficient visualization. However, it may also exert detrimental effects, particularly on the cardiovascular system. Effective communication with the anaesthetist is crucial at the commencement of insufflation. The insufflation rate and intra-peritoneal pressure are critical factors for each procedure. A swift increase in intra-abdominal pressure may lead to hemodynamic instability due to bradycardia or other potentially fatal cardiac arrhythmias, particularly in elderly individuals and those with pre-existing cardiac conditions. A gradual insufflation rate, particularly at the onset of the procedure, may mitigate such occurrences. An intra-abdominal pressure (IAP) exceeding 12 mmHg is classified as intra-abdominal hypertension, which adversely impacts the cardio-respiratory system primarily due to diaphragmatic splinting and hypercarbia induced by carbon dioxide.

Generally, the minimum feasible intracranial pressure (IAP) should be upheld, and an IAP exceeding 15 mmHg is infrequently necessary. Moreover, optimal relaxation of the abdominal wall may enhance the surgical field visibility. The patient's positioning may exacerbate the detrimental effects of pneumoperitoneum. In the Trendelenburg position, the pressure of the viscera on the diaphragm may result in a decrease in functional residual capacity.

Secure management of the camera

The camera serves as the surgeon's visual instrument. In contrast to outdated low-resolution scopes, contemporary laparoscopes deliver high-resolution images that facilitate the seamless execution of intricate and delicate procedures. The assistant operating the camera is tasked with delivering a clear, focused image to the surgeon. The assistant must be familiar with operative procedures and, preferably, the specific techniques employed by each surgeon. Proper training and experience are essential to this. The camera is positioned at the end of the scope with a fixed angle between 0° and 70°, while certain models with a flexible tip permit full 0° to 180° visualization (LTF-V2 Deflectable Tip Laparoscope, Olympus America Inc., Melville, New York). The recognition of these angles is crucial for assistants. The camera operator must maintain the surgical field at the center of the screen with minimal disturbance.

During the insertion and withdrawal of sharp instruments, such as a diathermy hook and scissors, the camera should be employed to prevent any accidental injuries to the viscera. Prior to utilization, white balancing must be performed to attain a digital image with accurate colors. White surfaces, like pristine swabs, reflect light, thereby enhancing the image, whereas dark surfaces, such as blood, absorb light and impair visibility. Consequently, the assistant should endeavor to evade blood-stained and reflective surfaces. The surgeon should concurrently strive to maintain a tidy surgical field. Fogging frequently occurs in laparoscopy, particularly at the onset of the procedure, due to the temperature disparity between the cold scope and the warm peritoneal cavity. Pre-warming with warm water or a liquid scope warmer (WarmORTM, The O.R. Company, Antioh, TN, United States) and utilizing anti-fog solutions (FREDTM, United States Surgical, North Haven, CT) are among the available methods for preventing fog formation.

The elevated intensity of the light can produce considerable heat at the laparoscope's tip. This can incinerate the drapes and potentially harm the patient's skin if proper precautions are not observed.

Instruments utilized in laparoscopy

The accurate selection and appropriate utilization of laparoscopic instruments are essential for the safe execution of laparoscopic surgery. A comprehensive description of all laparoscopic instruments is beyond the scope of this article. We wish to emphasize several key aspects of frequently utilized instruments. Tissue graspers, laparoscopic scissors, clip applicators, needle holders, staplers, and suction devices are frequently utilized instruments in laparoscopic procedures. The selection of the instrument is contingent

upon various factors, including the tissue type (delicate versus robust), instrument characteristics (traumatic versus non-traumatic), and anticipated function (dissection versus retraction). Tissue graspers may be classified as traumatic or non-traumatic based on the surface attributes of the jaw blades and the force exerted by the surgeon. Maryland's forceps are a traumatic instrument that should not be employed to manipulate delicate structures, such as the small or large intestine. Johan's non-traumatic forceps should be utilized for the bowel. It is important to remember that even atraumatic graspers can cause tissue damage if not manipulated delicately. Likewise, Maryland's forceps are effective for blunt dissection and grasp tissues, including hemorrhaging vessels, with their tapered tips. Sharp instruments, including laparoscopic scissors and diathermy hooks, must always be utilized under direct visualization. Articulated instruments provide enhanced dexterity akin to that of robots, achieving a greater degree of freedom at a reduced cost.

Specialized instruments

Laparoscopic staplers of suitable length and staple height must be utilized according to the tissue type. Despite the demonstrated safety and robustness of contemporary tri-staplers, meticulous attention to detail is imperative. The surgeon must be proficient in the specific stapler employed and possess a comprehensive understanding of various cartridge types. Prior to deploying a stapler in Upper Gastro-Intestinal (UGI) surgery, it is essential to conduct a routine check and communicate with the anaesthetist to prevent the inadvertent entrapment of the orogastric tube, temperature probe, or nasogastric tube within the stapler. All of these have been documented as never events. The routine application of nasogastric tubes and temperature probes should be eschewed, particularly in upper gastrointestinal surgery.

Powered staplers and flexible stapler devices (ECHELON FLEXTM, Johnson and Johnson, United States) have demonstrated promising outcomes in laparoscopic surgery. Standard-length instruments are sufficient for the majority of operative procedures, including most bariatric surgeries. Nonetheless, patients with severe obesity may require extra-long instruments. Surgical interventions necessitating access to the gastro-oesophageal junction, such as hiatal hernia repair or bariatric surgery, require a liver retractor. Various types are accessible and may be utilized according to the surgeon's preference and availability (Nathanson Liver Retraction System, Cook® Medical, United States; PretzelFlex Surgical Retraction System, Surgical Innovations, United Kingdom). Nevertheless, meticulous attention is necessary to prevent tissue damage, particularly to the liver. Laparoscopic ultrasound is a valuable instrument, particularly in hepatopancreatic and biliary procedures, as it aids in lesion localization and diminishes the occurrence of complications. Recent applications of Indocyanine Green for fluorescence-guided laparoscopic surgery have demonstrated initial promising outcomes in hepatobiliary surgery, colorectal surgery, and surgical oncology. It is beneficial for tumor localization, lymph node mapping, intraoperative angiography, and cholangiography. Nevertheless, the protocols and techniques require standardization and validation through additional research.

Energy instruments in laparoscopy

Contemporary energy instruments have advanced the evolution and enhancement of laparoscopic surgery. Monopolar diathermy is the fundamental energy device employed in contemporary practice, frequently utilized for tissue dissection and hemostasis via hook or Maryland forceps. Monopolar diathermy, in comparison to other devices, is recognized for its considerable lateral thermal spread, necessitating careful use near sensitive structures like the bowel. Furthermore, unintentional injuries resulting from fractured insulation and capacitance coupling arising from the use of metal or hybrid ports represent additional complications linked to monopolar diathermy. Routine examination and utilization of plastic ports are effective methods for averting these potentially catastrophic complications. The authors advise against the use of metal ports for this reason. Surgeons or other team members may inadvertently activate the cutting pedal during the procedure, as the pedals are located on the floor and frequently obscured by drapes. We advise lowering the default cutting setting to zero, as it is infrequently required in standard laparoscopic procedures.

Bipolar diathermy frequently serves as a secure alternative when monopolar diathermy poses risks, such as proximity to sensitive tissues due to reduced lateral thermal dispersion, or when contraindicated, for instance, in patients with cardiac pacemakers. Numerous sophisticated energy devices exist and employ various technologies. LigasureTM (Medtronic Technologies, Dublin, Ireland) employs bipolar energy combined with pressure to occlude blood vessels measuring up to 7 mm. HarmonicTM (Ethicon Technologies, Raritan, NJ, United States) and SonoSurgTM (Olympus Technologies, Tokyo, Japan) employ high-frequency ultrasonic waves to produce heat, resulting in tissue coagulation and dissection with markedly reduced lateral thermal spread relative to monopolar devices. These devices are safe for use in patients with cardiac pacemakers, for whom monopolar diathermy is contraindicated. While in use, the active blade of these devices must remain within direct sight to avert any accidental harm to underlying tissues. Research indicates that the temperature at the device's tip can exceed 100 °C and may persist for up to 20 seconds post-usage. Consequently, contact with sensitive tissues should be avoided immediately following use, and surgeons should permit a cooling period before reapplication. ThunderbeatTM (Olympus Technologies, Tokyo, Japan) is a device that integrates high-frequency ultrasonic waves with bipolar diathermy, facilitating tissue dissection and vessel sealing up to 7 mm. Burns associated with energy devices may not be

immediately evident and can lead to delayed perforations with severe repercussions.

Laparoscopic tissue dissection

Tissue dissection during laparoscopy presents a formidable challenge, even for seasoned surgeons, owing to the limited haptic feedback. Laparoscopic scissors are frequently employed for sharp dissection, whereas advanced energy devices may be utilized in areas anticipated to bleed. Devices with pointed tips, such as Maryland forceps, are effective for dissecting tissue planes. Suction devices or laparoscopic pledgets may also be employed to establish tissue planes.

Hemostasis in laparoscopy

Any discrete bleeding vessel must be identified, isolated, and adequately controlled prior to advancing to the subsequent step of the procedure. Diathermy is the predominant technique employed for hemostasis and is recommended for vessels of capillary caliber. Laparoscopic clips or Hem-o-lok® (Teleflex®, Morrisville, NC, United States) ligating clips are designated for specific, identified vessels. For substantial vessels like the splenic artery or ileocolic pedicle, we recommend employing either locking clips, such as Hem-o-lok® (Teleflex®, Morrisville, NC, United States), or vascular staplers (1.0 mm to 2.0 mm Endo GIA™, Medtronic, Minneapolis, United States, and Ethicon, Johnson & Johnson Medical, Belgium).

Hemorrhaging from damaged or inflamed tissue, such as the liver bed following a challenging cholecystectomy or the pelvis during rectal resection, can be challenging to manage. Topical haemostatic agents, including gelatins, collagens, thrombin, fibrin sealants (e.g., BioGlue®, Cryolife Inc., Kennesaw, GA, United States), and synthetic adhesives, can occasionally be utilized for control. Certain agents, such as Surgicel (Ethicon, Johnson & Johnson Medical, Belgium), may induce a severe inflammatory response and result in abscess formation. Periodically, ligating or transfixing the pedicle with sutures offers the most reliable control. It is our conviction that all laparoscopic surgeons ought to possess the capability to perform laparoscopic suturing. All energy devices can inflict damage on adjacent structures due to lateral thermal dispersion; therefore, it is essential to maintain constant visual oversight of the instrument during operation. After the application of metal clips, additional diathermy must be avoided, as it induces tissue shrinkage beneath, resulting in the loosening and slippage of the clip. Furthermore, the metal clip may facilitate the transmission of diathermy current to surrounding tissues, potentially causing thermal injury.

Laparoscopic suturing and anchoring techniques

Laparoscopic suturing is a fundamental competency for all laparoscopic surgeons. The selection of appropriate needle size, suture length, and proper needle manipulation at various angles are crucial factors for safe laparoscopic suturing. Moreover, commercially available pre-prepared laparoscopic knots with loops (ENDOLOOP®, Johnson & Johnson Medical, Belgium) serve as a rapid solution for specific procedures such as laparoscopic appendicectomy. Particular anchoring devices (e.g., ProTackTM, Medtronic Ltd., United Kingdom, and Securestrap®, Johnson and Johnson Medical, Belgium) may be employed for mesh fixation in laparoscopic hernia repair. Nonetheless, they may be linked to complications including chronic pain or erosions. Recently, absorbable tackers have been introduced to mitigate the likelihood of these complications (AbsorbaTackTM, Medtronic Ltd., United Kingdom).

Delays during the procedure and consultation for a second opinion

Laparoscopic surgery can be physically and mentally taxing for the surgeon, potentially resulting in fatigue and mistakes. We advocate for brief intermissions during extended or challenging procedures for the entire team. If the operation is not advancing as anticipated, a second opinion from an experienced colleague may prove invaluable. Surgeons should not perceive conversion as a failure.

Conclusive examination

At the conclusion of the procedure, surgeons must verify sufficient hemostasis and assess for any unintentional bowel damage. We also advise maintaining optimal blood pressure and minimizing pressure during haemostasis assessment. A haemostasis assessment conducted with low blood pressure and high-pressure pneumoperitoneum may provide a misleading sense of security.

Surgeons ought to contemplate the closure of all internal defects and 15 mm port incisions. Most 10-12 mm port sites should be closed, except in patients with severe obesity, where many surgeons advise against closing blunt 10-12 mm port sites, particularly when the ports have been angled during insertion. Following the withdrawal of ports, all port sites must be examined for bleeding, and sufficient hemostasis must be guaranteed. Surgeons must verify the surgical tally with nurses and conduct a thorough "time out" to confirm that all intended procedures have been executed. The operating count must encompass surgical specimens and specimen retrieval bags, as it is not unusual for surgeons to retain a specimen or retrieval bag intraabdominally during laparoscopic procedures for subsequent removal. Upon completion of the procedure, it is advisable for the surgeon to take a moment to contemplate the operation, particularly to ascertain whether all intended interventions were executed; all foreign objects, including tonsil swabs, retrieval bags, previously implanted foreign bodies such as gastric bands, and specimens, have been extracted; and all necessary ports have been sutured.

CONCLUSION

This review outlines essential factors for the safe execution of laparoscopic surgery. We have endeavored to encapsulate them in Table 1 for the readers' convenience. A substantial portion of our recommendations is grounded in experience and requires scientific scrutiny. Consensus-building among

experts in this critical domain of patient safety is also necessary.

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