



# Safety considerations in laparoscopic surgery

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## Abstract

Laparoscopic surgery has many advantages over open surgery. At the same time, it is not without its risks. In this review, we discuss steps that could enhance the safety of laparoscopic surgery. Some of the important safety considerations are ruling out pregnancy in women of the childbearing age group; advanced discussion with the patient regarding unexpected intraoperative situations, and ensuring appropriate equipment is available. Important perioperative safety considerations include thromboprophylaxis; antibiotic prophylaxis; patient allergies; proper positioning of the patient, stack, and monitor(s); patient appropriate pneumoperitoneum; ergonomic port placement; use of lowest possible intra-abdominal pressure; use of additional five-millimeter (mm) ports as needed; safe use of energy devices and laparoscopic staplers; low threshold for a second opinion; backing out if unsafe to proceed; avoiding hand-over in the middle of the procedure; ensuring all planned procedures have been performed; inclusion of laparoscopic retrieval bags and specimens in the operating count; avoiding 10-15 mm ports for placement of drains; appropriate port closures; and use of long-acting local anaesthetic agents for analgesia. Important postoperative considerations include adequate analgesia; early ambulation; careful attention to early warning scores; and appropriate discharge advice.

**Key Words:** Laparoscopy; Laparoscopic surgery; Minimally invasive surgery; Key-hole surgery; Patient safety; Safe surgery; Safe laparoscopy

**Core Tip:** Check for pregnancy in women of the childbearing age group. Make an alternative advanced plan with the patient regarding unexpected intra-abdominal circumstances. Consider adequate thromboprophylaxis and antibiotic prophylaxis. Intraoperatively, surgeons should ensure correct patient positioning and placement of stack and monitor(s). Establishing pneumoperitoneum safely, proper use of energy devices/staplers, use of lowest possible intra-abdominal pressure, avoidance of 10-15 millimetre ports for placement of drains; and a thorough “time out” at the end are some of the other important intraoperative considerations. The operating count by nurses should include specimens and retrieval bags. Important postoperative considerations include analgesia, early ambulation, and careful attention to early warning scores.

## INTRODUCTION

Laparoscopic surgery could be regarded as one of the greatest advances in the field of surgery. It has brought with it a revolution in the use of digital and robotic technology in surgical practice. It has radically shortened the patient recovery times compared to the ‘open’ operations. Even more remarkably, these gains have been made whilst simultaneously enhancing the quality of surgery[1,2]. Laparoscopic surgery is associated with less pain, fewer wound infections, reduced hospital stay, reduced morbidity and mortality and early return to work and improved overall quality of life [3,4]. However, when laparoscopy was first introduced there were concerns regarding its safety[5,6]. Fortunately, with time as surgical teams have progressed over their learning curves, many of the initially reported complications have become relatively infrequent[7].

In this article, we review some of the key areas that could enhance the safety of laparoscopic surgery. We have structured this article to simulate a patient's journey into preoperative, perioperative, and postoperative considerations.

## PRE-OPERATIVE PLANNING

### *Patient selection*

Patient selection plays a key role in enhancing the safety of laparoscopic surgery[8,9]. In addition to the risks associated with a general anaesthetic, laparoscopy is associated with risks due to increased intra-abdominal pressure (IAP) and in some cases extreme patient positioning[10]. There is no absolute contraindication to laparoscopic surgery but patients with significant medical comorbidities should be treated with caution just like any other surgery. Some patients may be suitable for laparoscopic surgery but not the corresponding open procedure and this should be discussed with the patient in advance. The morbidity and mortality of the open surgery may be too high (such as frail patients or those suffering from severe obesity) and surgeons may need to either back out without performing any procedure (such as when faced with extensive adhesions or a cirrhotic liver or a huge liver) or perform a different procedure to the one planned (such as a subtotal cholecystectomy instead of a total cholecystectomy; or sleeve gastrectomy in place of Roux-en-Y gastric bypass). An advanced discussion with patients and their families regarding these aspects can help surgeons take the most appropriate course of action in such challenging circumstances.

Another potentially serious issue could be surgery without the knowledge that the patient is pregnant. Though this has implications for all pregnant women and the unborn baby, the implications are even more severe after operations such as bariatric and metabolic surgery[11]. All women in the childbearing age group should, therefore, be offered a routine urine pregnancy test at preassessment to rule out pregnancy[12].

Additionally, laparoscopic surgery may be challenging in a patient who has previously undergone an open abdominal operation especially an emergency laparotomy. In these patients, safe access to the peritoneal cavity may be difficult[8]. Surgeons should generally try to avoid areas where intra-abdominal adhesions are

likely to be maximum for pneumoperitoneum and first port insertion. For example, authors would suggest optical pneumoperitoneum in left upper quadrant as the entry point in patients who have had a previous midline laparotomy.

Like any other surgery, non-urgent procedures may be deferred to allow for patient optimisation. This may include treatment of underlying co-morbidities, smoking cessation, or assisted weight loss. Similarly, patients with obesity could be offered appropriate liver shrinking diet to facilitate cholecystectomy and bariatric procedures [13].

### **Procedure selection**

Over the last couple of decades, an increasing variety of operations are being performed laparoscopically[14-16]. In many cases, the laparoscopic approach has become the norm. For instance, it is difficult to believe that gastric bypass for obesity was once performed using an open approach. A similar expansion of laparoscopy is also being observed in emergency surgery in haemodynamically stable patients[17,18]. Laparoscopy has also been reported to be safe with reduced risks of nontherapeutic laparotomy and mortality in patients with blunt abdominal trauma[19]. Though its role in penetrating abdominal trauma is less clear, some surgeons believe it may be useful as a screening tool for identifying patients who would require laparotomy[20]. Procedures can be laparoscopic (such as gastric bypass for morbid obesity), or hybrid-combined open and laparoscopy (such as anterior resection for rectal cancer) depending on the underlying pathology and experience of the surgeon.

### **Review of pre-operative investigations**

The main drawbacks of laparoscopic surgery are reduced tactile and depth perception, which could be critical in many surgical procedures (*e.g.*, segmental colectomy for small malignant polyps)[21]. Where feasible, we suggest endoscopic procedures for such lesions and, if surgery is required, preoperative endoscopic tattooing could help intraoperative identification of the pathology[22,23]. A preoperative review of radiological imaging with an experienced radiologist can also be helpful.

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## **PERI-OPERATIVE CONSIDERATIONS**

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### **Team brief and safe surgery checklist**

A good and effective team brief is crucial before any operation. All members of the team including the consultant surgeon, surgical assistants/trainees, anaesthetist, anaesthetic trainee/operating department practitioners, scrub nurse, and circulating nurse should be present during the team brief. These sessions provide an opportunity for discussion of any anticipated difficulties, measures for prophylaxis of venous thromboembolism, antibiotic prophylaxis, glycaemic control, patient allergies, patient warming, patient positioning, location of the screen, need for X-ray, *etc.* We strongly recommend team briefings are done as part of the World Health Organization (WHO) "safe-surgery" checklist, which has been shown to reduce human error and adverse effects while improving communication and teamwork[11,24]. While discussing allergies, particular attention should be paid to allergies to something that would normally be used during or after surgery. Some elective procedures may need to be deferred while patient is referred to appropriate specialists for further testing and confirmation of allergies.

### **Patient positioning**

Proper patient position is essential for the safe performance of laparoscopic surgery. Appropriate precautions must be taken to ensure neutral positioning of major joints and padding of pressure points[25,26]. Some surgeons prefer a "French" position (surgeon stands between the legs of the patient) whereas others prefer standing on the right side of the patient. Regardless of these preferences, basic principles of positioning remain the same. The patient must be secured with a strap over the chest/thighs with or without footrests (depending on whether reverse Trendelenburg position is anticipated during the surgery) to avoid lateral and caudal slippage[11]. Likewise, for pelvic surgery, the patient may need to be in Trendelenburg position. In these cases, hips and knees should be kept in a neutral position in secured leg supports with soft cushions for all pressure points. Shoulder supports can also help prevent cephalad sliding of patients. If stationary retractors are required, such as Nathanson's liver retractor, they should be fastened securely to the operating table to minimize intra-operative adverse events, such as liver injuries[27]. One should use utmost care while

introducing and removing these retractors. The liver may be densely adherent to underlying vascular structures and careless lifting may lead to traction injuries. Moving the patient on and off the operating table should be carried out properly to avoid patient and staff injuries especially for patients with obesity where air mattresses (such as HoverMatt®, HoverTech International, Allentown, PA, United States) may be useful[28].

### **Laparoscopy setup**

A significant number of laparoscopic surgeons suffer from work-related musculoskeletal injuries (up to 70%)[29], and as such ergonomics are more pertinent to laparoscopic surgery than probably open or even robotic surgery. The patient's position, height of the operating table, port position, and laparoscopic monitor setup are some of the important factors to consider in this regard[30,31]. One key suggestion is that the surgeon, the operating field, and the monitor should be in a straight line with triangulation between the camera and main operating ports. The height of the monitor should be just below the surgeon's eye level (preferably 0 to 150) to avoid sprain due to prolonged neck extension[32,33]. Fatigue amongst the surgeon and assistant may increase the risk of error during the procedure, and hence every effort should be made to improve ergonomics. To overcome some of these ergonomic challenges, modern laparoscopic theatre suites are equipped with permanently installed ceiling suspended multiple flat-screen monitors with adjustable inclination[34]. Relative lack of depth perception (2D view) has been a major disadvantage with laparoscopy compared to open surgery. To overcome this, 4K ultra high definition technology[35] and 3D laparoscopic technology have been introduced[36], and several trials have compared the two[35,37]. Neither seems superior to the other, and a recent consensus statement from the European Association of Endoscopic Surgeons concluded that further robust research is required to investigate the advantages of 3D laparoscopy system[38]. Higher cost as well as the stress of the 3D laparoscopy system and issues with surgeon's vision mean that these systems are not yet in widespread usage[39].

### **Port positioning and insertion techniques**

It has been suggested that up to 50% of major complications in laparoscopic surgery occur at the time of port insertion[4]. Surgeons should, therefore, be proficient with different techniques for establishing pneumoperitoneum. Open Hasson technique[40], closed Veress needle entry (named after Janos Veres)[41] and optical ports (with or without prior pneumoperitoneum using a Veress needle) are the most common methods currently used. A recent Cochrane review showed none of these approaches stand out in terms of complications such as visceral injuries and major vascular injuries[42]. However, open Hasson's method is associated with the least chance of entry failures compared to the other two modalities[42]. Even though many surgeons have a preferred technique, the selection of entry technique should probably be based on patient characteristics. For example, the open juxta-umbilical approach is safe and quick for thin to averagely built patients with less abdominal wall fat and with no previous midline laparotomy; whereas optical port insertion in left upper quadrant (with or without prior Veress needle pneumoperitoneum) might be safer for patients with previous midline laparotomy or obesity[43]. In any closed technique, the first port should always be introduced using optical guidance and left upper abdomen (Palmer's point) is regarded to the safest place for this purpose by many surgeons[44].

The size of the primary port (10-12 mm or 5 mm) also depends on the surgeon's preference and type of surgery. For example, some surgeons prefer a 5 mm primary port for paediatric patients to minimize tissue trauma. However, the quality of the picture obtained through a 5 mm scope can be inferior to a standard 10 mm scope due to fewer optical fibres. The size and position of subsequent ports depend on the operation and anticipated instruments in use. Most of the instruments can be safely used through 5 mm ports, but staplers, large clip applicators, retrieval graspers usually require 12 mm ports. Surgeons should also bear in mind that a curved needle will not go through a 5 mm port whereas a ski-shaped needle will. Curved needles can be lost intra-abdominally in an attempt to retrieve them through a 5 mm port[11]. Surgeons should always follow any needle during insertion and removal from the abdominal cavity. Occasionally, larger 15 mm ports are required for thick stapler devices as well as to extract large specimens. However, in the authors' experience, this is rare as most specimens can be removed through a 12 mm port site with some stretch. However, if a 15 mm port is used, the port site should always be closed irrespective of the patient's body mass index. All subsequent port placements, after the primary port insertion, should be under direct vision to avoid injury to the underlying viscera. Injury to inferior epigastric vessels is reported to be the commonest cause of

port site bleeding[45,46]. In thin patients, transillumination can help reduce the chance of inadvertently injuring these vessels.

There are two types of trocars: Bladed and non-bladed that are available for subsequent port placements. The data on comparing the two types are very limited, but non-bladed trocars are probably associated with less trocar-site bleeding with no difference in visceral injury[47]. It is our view that surgeons should only use blunt-tipped non-bladed trocars in laparoscopic surgery as they are less likely to result in inadvertent injuries to epigastric vessels and viscera. All ports should be placed according to the triangulation principle for the better ergonomics[48]. After all the ports are inserted, a gross inspection of the peritoneal cavity is important to identify any inadvertent injury or any unexpected finding. Standard laparoscopic ports are 100 mm in length and suitable for most regular laparoscopic procedures. However, extra-length (150 mm) ports may be necessary to gain access to patients with thick abdominal walls. Usage of appropriate length ports helps to prevent repeated port displacement and fascial injury caused by repeated insertions. If available, balloon tip ports can prevent port displacement.

### ***Pneumoperitoneum***

Optimal pneumoperitoneum is vital for safe laparoscopic surgery to ensure adequate visualization. But, it can also have adverse effects especially on the cardiovascular system[49-51]. Good communication with the anaesthetist is important at the start of insufflation. The rate of insufflation and intra-peritoneal pressure are the key considerations for each procedure[52]. A rapid rise in IAP rise could result in hemodynamic instability from bradycardia or other life-threatening cardiac arrhythmias especially in elderly patients and those with pre-existing cardiac disease[49,50,53,54]. An initial slow rate of insufflation especially at the beginning of the procedure could minimize such events. IAP > 12 mmHg is considered intra-abdominal hypertension with adverse effects on the cardio-respiratory system mainly due to diaphragmatic splinting and carbon dioxide-induced hypercarbia[52].

As a general rule, the lowest possible IAP should be maintained, and an IAP > 15 mmHg is very rarely required. Additionally, good abdominal wall relaxation could improve surgical view[50]. The patient's position could further exaggerate these adverse effects of pneumoperitoneum. For example, in the Trendelenburg position, pressure of viscera on the diaphragm can lead to a reduction in the functional residual capacity[50,51].

### ***Safe handling of the camera***

The camera is the eye of the surgeon! Compared to old low-resolution scopes, modern laparoscopes provide high-resolution images enabling the smooth performance of complex and delicate procedures[55,56]. The assistant holding the camera is responsible for providing a clear, focused image to the surgeon. It is important that the assistant knows operative steps and ideally also, the manoeuvres unique to each surgeon. Appropriate training and experience are key to this[57]. The camera is located at the tip of the scope with a fixed angle ranging from 0° to 70°[53], and some with flexible tip allow complete 0 to 180° visualization (LTF-V2 Deflectable Tip Laparoscope, Olympus America Inc., Melville, New York). The familiarity of these angles is important for assistants. Additionally, the camera holder must try to keep the surgical field in the centre of the screen with minimal turbulence.

Sharp instruments such as a diathermy hook and scissors should be followed with the camera during insertion and withdrawal to avoid any inadvertent injuries to the viscera. Before usage, white balancing should be done to achieve a digital image with true colours. White surfaces, such as clean swabs reflect the light enhancing the image, while dark surfaces such as blood, absorb the light and compromise the view. Therefore, the assistant must try to avoid blood-stained and reflective surfaces. The surgeon at the same time should attempt to keep the surgical field tidy. Fogging is a common problem in laparoscopy especially at the beginning of the procedure due to the temperature difference between cold scope and warm peritoneal cavity. Pre-warming with warm water[58-60] or liquid scope warmer (WarmORTM, The O.R. Company, Antioch, TN, United States), anti-fog solutions (FREDTM, United States Surgical, North Haven, CT) are some of the options available for preventing fog formation.

The high intensity of the light can generate significant heat at the tip of the laparoscope. This can burn the drapes and even skin of the patient if due care is not taken.

### **Instruments in laparoscopy**

Correct selection and proper usage of laparoscopic instruments are vital for safe performance of laparoscopic surgery. Describing all laparoscopic instruments is out of the scope of this article. However, we would like to highlight some of the key aspects of commonly used instruments. Tissue graspers, laparoscopic scissors, clip applicators, needle holders, staplers, and suction devices are some of the commonly used instruments in laparoscopic practice. Choice of the instrument depends on multiple factors such as nature of the tissue (delicate *vs* tough), characteristics of the instrument (traumatic *vs* non-traumatic), expected function (dissection *vs* retraction). For example, tissue graspers can be traumatic or non-traumatic depending on the surface characteristics of the jaw blades of the force used by the surgeon. Maryland's forceps are a traumatic device, which should not be used to handle delicate structures such as the small or large intestine. Instead, Johan's non-traumatic forceps should be used for the bowel. It is worth bearing in mind that even atraumatic graspers can lead to tissue trauma if not handled gently. Similarly, Maryland's forceps are useful for blunt dissection and hold tissues (such as bleeding vessels) with their pointed tips. Sharp instruments such as laparoscopic scissors and diathermy hook should always be used under direct vision. Articulated instruments offer "robot-like dexterity" with an improved degree of freedom at lower cost[61,62].

### **Special instruments**

Laparoscopic staplers of appropriate length and staple height should be used depending on the tissue[63-65]. Although modern tri-staplers are shown to be safe and robust, utmost care should be exercised with attention to detail[66,67]. The surgeon needs to be familiar with the type of stapler they are using, and also have good working knowledge of different type of cartridges. Before firing a stapler in Upper Gastro-Intestinal (UGI) surgery, a routine check and communication with the anaesthetist are mandatory to avoid inadvertently catching the orogastric tube or temperature probe, or nasogastric tube within the stapler. All of these have been reported as never events[68]. Routine use of nasogastric tubes and temperature probes should be avoided, especially in UGI surgery.

Powered staplers and flexible stapler devices (ECHELON FLEXTM, Johnson and Johnson, United States) have also shown some promising results in laparoscopic surgery[69,70]. For most operative procedures (including most bariatric surgery) standard length instruments are adequate. However extra-long instruments may be needed in some patients with severe obesity[71]. Surgical procedures requiring access to gastro-oesophageal junction such as hiatal hernia repair or bariatric surgery require a liver retractor. Different types are available and can be used based on the surgeon's preference and availability (Nathanson Liver Retraction System, Cook® Medical, United States and PretzelFlex Surgical Retraction System, Surgical Innovations, United Kingdom). However, utmost care is required to avoid tissue injury especially to the liver[27,72,73]. Laparoscopic ultrasound, yet another useful tool especially in hepato-pancreatic and biliary operations can be helpful to localise lesions and reduced the incidence of complications[74-76]. More recently, use of Indocyanine Green for fluorescence-guided laparoscopic surgery has shown some initial promising results in hepatobiliary surgery, colorectal surgery, and surgical oncology. It can be useful in tumour localisation, lymph node mapping, and intra-operative angiography as well as cholangiography[77-79]. However, the protocols and technique need to be standardized and validated with further research.

### **Energy devices in laparoscopy**

Modern energy devices have facilitated the progress and development of laparoscopic surgery. Monopolar diathermy is the most basic energy device used in current practice utilized commonly for tissue dissection and hemostasis through hook or Maryland's forceps. Compared to other devices, monopolar diathermy is known to cause significant lateral thermal spread, which requires cautious application close to delicate structures such as the bowel[80,81]. Additionally, inadvertent injuries due to cracked insulation, capacitance coupling due to the usage of metal or hybrid ports are other complications associated with monopolar diathermy[82-84]. Regular inspection and usage of plastic ports are effective means of preventing these potentially disastrous complications. The authors recommend avoiding metal ports for this reason. Surgeons or other team members can also accidentally step on the cutting pedal during the procedure as pedals are on the floor and often hidden under the drapes. We recommend reducing the default cutting setting down to zero as it is rarely needed during routine laparoscopic surgery.

Bipolar diathermy is often a safe alternative when monopolar diathermy is risky *e.g.* close to delicate tissues due to minimal lateral thermal spread or is contraindicated *e.g.* patients with cardiac pacemakers[74]. Several advanced energy devices are available and utilize different technology[80,85]. Ligasure™ (Medtronic Technologies, Dublin, Ireland) uses bipolar energy with pressure to seal blood vessels up to 7 mm. Harmonic™ (Ethicon technologies, Raritan, NJ, United States), and SonoSurg™ (Olympus Technologies, Tokyo, Japan), use high-frequency ultrasonic waves to generate heat, thereby causing tissue coagulation and dissection with significantly lower lateral thermal spread compared to monopolar devices[80]. These devices can be safely used even in patients with cardiac pacemakers, in whom monopolar diathermy is contraindicated[86]. During usage, the active blade of these devices should be kept under direct vision to prevent any inadvertent injury to underlying tissues. Studies demonstrate heat at the tip of the device can lead to temperatures as high as > 100 °C and can last up to 20 s after usage[87]. Therefore, tip contact with vulnerable tissues should be avoided immediately after usage and surgeons should allow some time for it to cool down before using again. Thunderbeat™ (Olympus Technologies, Tokyo, Japan) is another device that combines both high-frequency ultrasonic waves and bipolar diathermy, which allows tissue dissection as well as sealing of vessels up to 7 mm[88]. Energy devices related burns may not be immediately apparent and result in late perforations with disastrous consequences[89,90].

### **Tissue dissection in laparoscopy**

Tissue dissection in laparoscopy can be a challenging task even for experienced surgeons due to a relative lack of haptic feedback. Laparoscopic scissors are often used for sharp dissection, whilst advanced energy devices could be used where tissues are expected to bleed. Pointed tip devices such as Maryland's forceps are useful to open-up the tissue planes. Suction devices or laparoscopic pledgets can also be used to create tissue planes[91].

### **Hemostasis in laparoscopy**

Any discrete bleeding vessel should be identified, isolated, and properly controlled before proceeding to the next step of the procedure. Diathermy is the most frequently used modality for hemostasis and is advocated for a capillary-sized vessel. Laparoscopic clips or Hem-o-lok® (Teleflex®, Morrisville, NC, United States) ligating clips are indicated for defined, named vessels. For larger vessels such as a splenic artery or ileocolic pedicle, we suggest using either locking clips *e.g.*, Hem-o-lok® (Teleflex®, Morrisville, NC, United States) or vascular staplers (1.0 mm to 2.0 mm Endo GIATM, Medtronic, Minneapolis, United States, and Ethicon, Johnson & Johnson Medical, Belgium).

Bleeding from raw or inflamed tissue *e.g.*, liver bed after a difficult cholecystectomy or pelvis during rectal resection can be difficult to control[91-93]. These can sometimes be controlled with topical hemostatic agents such as gelatins, collagens, thrombin, and fibrin sealants (BioGlue®, Cryolife Inc., Kennesaw, GA, United States), and synthetic glues[94,95]. Some of these agents *e.g.*, Surgicel (Ethicon, Johnson & Johnson Medical, Belgium) can cause an intense inflammatory reaction, and lead to the formation of an abscess[96-99]. Occasionally, ligating or transfixing the pedicle with sutures provides the most secure control. We believe all laparoscopic surgeons should be able to carry out laparoscopic suturing. All energy devices can cause injury to nearby structures due to lateral thermal spread and as such, it is vital to keep the instrument completely under vision during use[80,85]. Once metal clips are applied, further diathermy should be avoided as it causes shrinkage of tissues underneath with subsequent loosening and slippage of the clip, and the metal clip could lead to the spread of the diathermy current to adjacent tissue causing thermal injury[82,83,100].

### **Laparoscopic suturing and anchoring**

Laparoscopic suturing is an essential skill for all laparoscopic surgeons. Selection of correct needle size, length of the suture, proper handling of the needle at various angles are vital considerations for safe laparoscopic suturing. Additionally, pre-prepared laparoscopic knots with loops (ENDOLOOP®, Johnson & Johnson Medical, Belgium) are commercially available as a quick option for certain procedures as laparoscopic appendectomy. Specific anchoring devices (such as ProTack™, Medtronic Ltd., United Kingdom, and Securestrap®, Johnson and Johnson Medical, Belgium) can be used for mesh fixation during a laparoscopic hernia repair. However, they can be associated with complications such as chronic pain or erosions[101,102]. More recently, absorbable tackers have been introduced in an attempt to reduce the



odds of these complications (AbsorbaTack™, Medtronic Ltd., United Kingdom).

### ***Timeouts during the procedure and second opinion***

Laparoscopic surgery can be physically and mentally demanding for the surgeon and could easily lead to fatigue and errors[103,104]. We recommend short breaks during long or difficult procedures for the whole team. If the operation is not progressing as expected, a second opinion from an experienced colleague could be invaluable[105]. Surgeons should not regard conversion as a failure.

### ***Final check***

Towards the end of the procedure, surgeons should ensure adequate hemostasis and check for any inadvertent bowel injury. We also recommend ensuring adequate blood pressure and reducing the pressure while checking for hemostasis. A hemostasis check with low blood pressure and high-pressure pneumoperitoneum may be falsely reassuring.

Surgeons should consider closing all internal defects and 15 mm port sites. Most 10-12 mm port sites should also be closed except in patients with severe obesity where many surgeons do not recommend closing blunt 10-12mm port sites especially when ports have been angled during placement[106,107]. After the withdrawal of ports, all port sites should be checked for bleeding and adequate hemostasis must be ensured. Surgeons should finally check the operating count with nurses and do a proper "time out" to ensure all planned procedures have been performed. The operating count should include surgical specimens and specimen retrieval bags as it is not uncommon during laparoscopic surgery for surgeons to leave a specimen/retrieval bag intraabdominally during the surgery for later removal[11]. At the end of the procedure, we recommend a mental pause for the surgeon to reflect on the procedure - especially consider if all planned procedures have been performed; all foreign bodies such as tonsil swabs, retrieval bags, removed previously placed foreign bodies such as gastric bands, and specimens have been removed; and all ports that needed closing have been closed.

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## **POST-OPERATIVE CONSIDERATIONS**

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Laparoscopic surgery has transformed post-operative care and reduced the length of in-hospital stay to the extent that many surgical procedures can be undertaken as day cases[108,109]. This is probably because of minimal physiological disturbances and stress with laparoscopy[110]. Early discharge is beneficial for patients and should be routine after in-hospital care is no longer needed.

### ***Analgesia***

Pain management plays a vital role in recovery post-laparoscopy as in any other type of surgery. We recommend effective multi-modal analgesia[111] following any laparoscopic surgery including the infiltration of long-acting local anaesthetic agents at port sites. Deep breathing exercises and chest physiotherapy can reduce respiratory complications[112].

### ***Thromboprophylaxis***

Appropriate thromboprophylaxis is crucial for laparoscopic surgery because of the higher IAP[113]. A recent study by our group identified failure to prescribe the correct thromboprophylaxis as one of the commonest serious clinical incidents after bariatric surgery[11]. A combination of mechanical and pharmacological thromboprophylaxis should be used. We recommend continuing to use the calf compression devices in the immediate post-operative period till the patient is ambulatory, and compression stockings even after discharge till the patient has resumed near-normal levels of mobility. Low molecular weight heparin is an effective pharmacological thromboprophylaxis usually started preoperatively and continued for variable duration post-operatively for those at highest risk.

### ***Enhanced recovery after surgery***

We would strongly advocate incorporating an Enhanced Recovery After Surgery (ERAS) programme[114-116]. For certain specialties and procedures, separate ERAS protocols have been developed[117-120].

**Table 1 Summary of various safety considerations throughout the patient journey when undergoing a laparoscopic procedure**

Stage of surgery	Safety considerations	
Pre-operative	Patient selection	Rule out pregnancy for elective procedures in women of child bearing age group
		Optimization of risk factors
	Procedure selection	Elective surgery
		Emergency general surgery
Pre-operative investigations	Abdominal trauma	
	Supplementary procedures (e.g., endoscopic tattooing)	
Intra-operative	Before start	Review of radiological investigations
		Effective communication and surgical check list
		Ensure correct patient, correct procedure, correct site
		Consider allergies, antibiotic prophylaxis, DVT prophylaxis, and glycaemic control
	During surgery	Safe and appropriate patient positioning
		Ensure comfortable and effective laparoscopy set-up
		Safe pneumoperitoneum and ergonomically favourable port positioning
		Use lowest possible pneumoperitoneum pressure
		Accurate selection and handling of instruments (e.g., camera, energy devices)
		Meticulous tissue dissection and hemostasis
		Regular evaluation of operative steps
At the end of the surgery	Low threshold for seeking second opinion	
	Check for hemostasis with reduced intra-abdominal pressure and adequate blood pressure	
Post-operative	Early recovery	Proper closure of port sites
		Multimodal analgesia
		Thromboprophylaxis
		Clear plan for oral intake and patient's routine medications
	Complications	Use Enhanced Recovery Protocols for elective surgery
		Early recognition of warning signs and prompt intervention
		Tachycardia not reliable as an early warning sign for patients on Beta blockers
	Discharge advices	Appropriate training of nursing staff and early escalation. Use Early Warning Scores
		Clear discharge documentation for patient and their primary care doctor
		Patient education on complications and anticipated recovery times

DVT: Deep vein thrombosis.

### **Management of diabetes**

Poor perioperative glycaemic control is shown to be associated with increased infection rate and mortality across many surgical specialties[121-123]. Therefore, it is highly recommended to have a strict policy for peri-operative glycaemic control, especially in patients on insulin[124].

### **Patient's routine medications**

Many patients admitted for elective surgery may be on regular medications for a variety of medical conditions, which may need to be withheld peri-operatively. Incorrect management of patients' regular medications[12] can lead to avoidable harm [125]. Close collaboration with physicians, pharmacists, and specialist nurses can help. For medications that are commonly omitted perioperatively such as antiplatelets and anticoagulants, it is good practice to have clear local perioperative guidelines/ protocols, to minimize errors. Surgeons should clearly document when these can be

restarted safely after surgery and in what dosages in their operation notes. It is equally important to ensure patients' regular medications such as antihypertensives are prescribed correctly especially in the post-operative period. A thorough review by a pharmacist at pre-assessment and/or on the ward after surgery can help prevent these errors.

### **Post-operative complications and management**

It is important to ensure that the junior doctors and nursing staff are appropriately trained to identify a complication early. Tachycardia is often the first sign of an unwell patients. However, its limitations as an early warning sign in patients who are on Beta-blockers should be understood. Shoulder tip pain and port site pain are frequently reported after laparoscopic surgery. Diaphragmatic irritation due to retained carbon dioxide can trigger referred pain to shoulders, which can last up to a few days post-operatively[126-128].

Overall, laparoscopic surgery is associated with reduced abdominal pain and discomfort. Surgical teams should take excessive pain and regular use of opiate analgesia more than 24 h after surgery seriously. Such a patient could be developing an early complication such as bowel perforation or bile leak after cholecystectomy and a Computed Tomography scan may be falsely negative[129]. We recommend having a low threshold for re-laparoscopy.

### **Discharge advice**

Surgical teams should provide clear information to patients and their carers about the expected recovery times after surgery. They should also be advised regarding warning symptoms and who to contact in such cases. This is crucial as laparoscopy has reduced the length of stay in the hospital, and patients will usually be home when complications develop. Unwell patients should have rapid access to senior surgical input during the early postoperative period.

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## **CONCLUSION**

This review presents some of the key considerations in the safe performance of laparoscopic surgery. We have attempted to summarize them in [Table 1](#) for readers. Many of our recommendations are based on experience and need to be examined scientifically. There is also a need for consensus-building amongst experts in this crucial area of patient safety.

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