The principles of safe laparoscopic surgery

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Abstract

The well-established benefits of laparoscopic surgery over open surgery and the rapid technology developments have meant that in just over 30 years laparoscopy has become the first-line modality for performing a host of operative procedures. The objective of this paper is to give a broad overview of laparoscopic surgery, to include: (1) patient positioning and how this aids surgery; (2) methods of establishing pneumoperitoneum, including the open Hassan and closed Veress needle techniques; (3) gas insufflation; (4) maintaining good vision during surgery and how this can be achieved; (5) insertion of additional ports; (6) a description of available laparoscopic instruments and their uses; (7) limitations of laparoscopy; and (8) closure of port sites. Despite its advantages, serious iatrogenic complications have been reported with laparoscopic surgery and the vast majority of these are avoidable. For this reason the paper places a particular emphasis on safety during laparoscopic surgery and steps that should be taken to ensure this.

Keywords Keyhole; laparoscopic surgery; laparoscopy; safety

Introduction

The significant benefits offered by the minimally invasive approach of laparoscopic surgery have consequently seen a rapid development in the principles, practice and technology used in this field. In just over 30 years, the laparoscopic approach has become the first-line approach to many general surgical operations. The first laparoscopic appendicectomy was performed on May 30, 1980 by a German gynaecologist called Kurt Semm. During the early 1980s, news of Semm's laparoscopic appendicectomy spread throughout the world. Erich Mühe was particularly interested in the possibility of performing additional operations using the laparoscopic technique and by 1984, Mühe had worked out the details of an operative laparoscope that he called the 'Galloscope'. On September 12, 1985, he carried out the first laparoscopic cholecystectomy and the concept of 'minimally invasive surgery' was born.[1]

Unfortunately Eric Mühe did not publish his work and consequently was not recognized for performing the first laparoscopic cholecystectomy. Phillipe Mouret, who was a gynaecologist, documented the first laparoscopic cholecystectomy in 1987.[2] Finally in 1999, Eric Mühe was recognized for his pioneering work and was invited by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) to give the Storz Lecture that he titled 'The First Laparoscopic Cholecystectomy'.[3]

The widespread adoption of the 'laparoscopic cholecystectomy' resulted in marked improvements in equipment. With increasingly refined technology, it became possible to perform more complex procedures that consequently led to the first report of a laparoscopic colorectal operation being performed in 1991.

The use of laparoscopic surgery with the incorporation of additional programmes such as the 'Enhanced Recovery Program' has resulted in extremely short lengths of postoperative stay. Whereas 10 years ago the average stay following a colorectal resection was 10 to 14 days, papers have been published showing that patients can be discharged safely 23 hours after their surgery.[4]

Despite all the benefits, laparoscopy carries inherent risks. The aim of the paper is to draw attention to these with potential ways of preventing them.

Principles of safe laparoscopic colorectal surgery

Safe laparoscopic surgery invariably comprises a number of crucial stages, namely:

- positioning of the patient
- gaining access to the abdomen
- insufflation of gas
- maintaining good vision
- placement of additional ports
- use of appropriate laparoscopic instruments and ligation devices
- the limitations of laparoscopy
- closure following laparoscopy.

Positioning

Initial safe positioning of the patient is necessary. The nature of the operation and region of the abdomen being operated on will influence the position required. Examples are given below.

- Right hemicolectomy and appendicectomy require supine positioning. An adherent mattress such as a large gel or suction mattress is required to prevent patient slippage during head down and right side up positioning, which allows a good view of the caecum, terminal ileum and the ileocolic artery.
- Left-sided colonic resections require the Lloyd Davies position, again with some form of securing mattress, as the head down tilt required is steep as shown in Figure 1. Shoulder supports must be well padded to prevent nerve injury.
- Laparoscopic cholecystectomy requires the patient to be supine and in the reverse Trendelenburg (head up) position, with some left-sided tilt to allow good access to the gallbladder and Calot's triangle.
- Emergency diagnostic laparoscopy, commonly performed to investigate lower abdominal pain in females, requires the Lloyd-Davies position as this allows access to the

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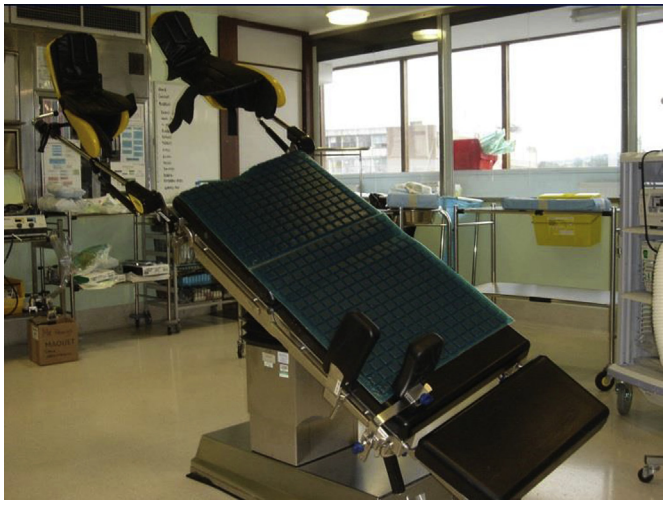

Figure 1 Table position for steep Trendelenburg.

female pelvic organs should the cause of pain be gynaecological.

Gaining access to the abdomen

Entry into the abdomen is performed using either an open or closed technique.

- The open 'Hassan' technique can be likened to the now infrequently used 'diagnostic peritoneal lavage' approach. While there are minor surgeon-dependant variations in this approach, the technique itself has become standardized. The approach commences with a small vertical skin incision (±1 cm) below or above the umbilicus depending on the position of the patient's umbilicus in relation to the territory being operated on. The cicatrix of the umbilicus is then elevated using a clip and dissection is performed to expose the abdominal fascia at the base of the cicatrix. The abdominal fascia can then be raised with sutures placed on either side of the midline or with a second clip in order to maximize the distance from the underlying intra-abdominal organs. The fascia and peritoneum is then incised in a controlled and progressive manner in order to maintain a truly open technique as opposed to bluntly pushing in instruments, which can easily cause injury. A 10 mm trochar and port is generally inserted through this opening, though with the advent of smaller scopes 5 mm ports can now be used instead.

  Inserting the trochar through the fascia has significant potential for iatrogenic injury and reports of aortic or inferior vena caval injury unfortunately occur more frequently than they should. Damage to the underlying structures can be minimized by elevating the fascia, ensuring the technique is truly open and by pointing trochars down to the pelvis away from the main vessels on insertion.

  There are several variations to the described method. Some are due to surgeon choice and others are driven by specific surgical indications.
- Closed method — A Veress needle can be used to create a pneumoperitoneum prior to port insertion. The Veress needle has a spring-loaded, inner blunt stylet positioned centrally within an outer cannula that has a bevelled end. As the Veress needle is pushed through firm tissue, pressure on the tip pushes the blunt stylet into the shaft of the outer cannula, allowing the outer needle to cut through. As the needle passes through the firm layer, the blunt tipped inner stylet springs out and serves to protect any abdominal viscera from iatrogenic injury by the sharp cannula. Once the Veress needle is in the abdominal cavity, the abdomen is filled with gas before the port is inserted.

Patients that have had previous surgery are prone to adhesion formation and carry an increased risk of visceral injury on entry into the abdomen. Special techniques may be required in such circumstances to permit safe entry. One common technique involves an open cut down at a safe site away from scars, such as Palmers point in the left upper quadrant. An alternative method of entry involves the use of a visual port. The laparoscope is mounted into this port, which is then carefully twisted through the layers of the abdominal wall and into the peritoneal cavity under direct laparoscopic vision.

Insufflation of carbon dioxide

The abdomen is distended with carbon dioxide in order to create a working space and provide the necessary visualization for the surgery to be performed. Carbon dioxide is used due to its inert, non-flammable properties. In addition, its solubility allows for excretion via the respiratory route. The abdomen is insufflated with carbon dioxide up to a pressure of 12 mm of mercury (mmHg). It is important to be aware that this pneumoperitoneum can cause cardiovascular compromise manifested as hypotension or bradycardia, through a reduction in venous return to the heart. In such a circumstance the pneumoperitoneum should immediately be released and not recommenced until the anaesthetist states that it is safe to do so.

Good vision

A clear sharp image is essential for safe surgery. The light, which originates from an external light source, is passed to the laparoscope by a fiber-optic cable. The light source can cause serious burns very quickly. It is imperative that the light source does not come in contact with the patient or the drapes when it is on. The safest way to prevent any thermal injury is to switch on the light only after it has been connected to the scope. The laparoscopes used can vary in size and can be either 5 mm or 10 mm in diameter. The 10 mm cameras in general give a better image although the new 5 mm scopes continue to improve.

Camera fog can be very disruptive to the flow of surgery. The fog forms due to condensation on the relatively cold lens. Techniques to avoid fogging include:

- placing the scope in warm water prior to insertion into the abdomen
- using a topical agent to the end of the scope to help reduce condensation.

Laparoscopes come with either a flat end referred to as a zero degree scope or with a bevelled end known as a 30-degree scope. The latter are useful as they have the advantage of being able to view the target area from different angles. This is particularly important in confined working spaces, such as in the pelvis during anterior resection where good views can otherwise be

difficult to achieve. It is important to use the correct camera to ensure that the view is not compromised in any way for the required surgery, thereby minimizing the risk of inadvertent injury.

An external camera is mounted on the laparoscope and feeds the image to a television screen. Picture quality has significantly improved with the development of high-definition screens, which are now in regular use. The screen should be placed at an appropriate height and in the direction of the line of operating.

Insertion of additional ports

Following the introduction of the first port, additional 5 to 10 mm ports are placed to allow the insertion of instruments. The size of these ports is governed by the operation and instruments being used. These remaining ports are inserted under direct laparoscopic vision. It is wise to introduce a green 21-gauge needle at the planned point of port insertion and infiltrate with local anaesthetic — this serves to ensure that ports are placed in the correct position and that they are introduced away from structures that must be avoided such as the inferior epigastric arteries. The bladder is another organ particularly at risk with supra-pubic port insertion. Injury to the bladder with the supra-pubic port is well documented and carries serious consequences if missed.[5] Preoperative catheterization helps to avoid iatrogenic bladder injuries.

Exact port positions need to be determined on a case by case basis and modified depending on anatomy, pathology and complicating factors such as adhesions.

Instrumentation

Tissue graspers, scissors and energy devices are routinely used in laparoscopic surgery. Laparoscopic graspers are broadly classified into either atraumatic or toothed graspers. Atraumatic graspers such as the Johanns graspers are smooth instruments that are used for handling delicate tissues such as bowel. A variety of toothed graspers are available for manipulation and retraction of more resilient tissues such as the gallbladder, which must be retracted cephalad during laparoscopic cholecystectomy. Even with the use of appropriate instruments, careful handling of all tissue is imperative to avoid iatrogenic injury. Inadvertent enterotomies do not occur infrequently and the surgeon must always be aware of the dangers of using excessive force during tissue manipulation particularly when the tissues are friable.

As with open surgery, laparoscopic tissue dissection is performed using sharp and blunt techniques. Laparoscopic scissors such as the Metzenbaum or hook scissors allow sharp dissection. New energy devices such as the harmonic ultracision have become the energy devices of choice in performing major surgery in view of their efficiency and haemostatic properties, and whereas diathermy can interfere with pacemakers, the harmonic scalpel has the advantage of being safe in this circumstance. The instrument does, however, become extremely hot and must therefore always remain in the visual field and must not touch the bowel.

Laparoscopic dissectors such as the Maryland or Peterlin instrument allow blunt dissection. These instruments dissect by spreading tissues apart, and as such often have curved tapered tips. Regardless of the dissection technique used, adequate retraction is crucial for successful and safe tissue dissection in laparoscopic surgery.

Laparoscopic clip applicators allow the ligation of tubular structures such as blood vessels and ducts. They are often required in commonly performed surgeries such as laparoscopic cholecystectomy where they are necessary for ligation of the cystic duct and artery, but are also used in laparoscopic colorectal resections for ligation of the colonic blood supply. The clips are either metallic or plastic in nature. The metallic varieties are compressed together around the structure and rely on the tensile strength of the clip to maintain pressure. If they are misplaced they can readily be removed. Plastic clips (Hemolock®) lock together around the tubular structure. Should plastic clips need to be removed, a special instrument is required. Safe clip placement requires the tips to be visible during application. This prevents accidental incorporation of unwanted structures into the clip.

Suture ligation can either be performed laparoscopically with pre-tied endoloops or with intra-corporeal knot tying. The development of laparoscopic stapling devices has greatly expanded the spectrum of surgeries that can be performed laparoscopically. They are most commonly used for the division of viscera or the formation of stapled anastamoses. Such stapling devices are either straight or roticulate to allow their use in tighter spaces, such as in the pelvis when dividing the rectum during anterior resection. The surgeon must always check and double check that only the tissue to be divided is within the jaws of the stapling instrument prior to firing. The only way of being absolutely certain of this is to clearly visualize the tips of each jaw.

The limitations of laparoscopy

Although a wide array of surgeries are feasible laparoscopically and its advantages over open surgery are well-established, the technique is not without its limitations.

Limited field of vision: in contrast to the panoramic view seen in open surgery, only a small area of the surgical field is visualized for long periods of laparoscopic surgery. Injuries caused by laparoscopic instruments can occur outside of this field and go unrecognized as a consequence. Particular care must be exercised when inserting and removing laparoscopic instruments.

Poor depth perception: laparoscopy produces a two-dimensional image making depth perception challenging. The surgeon is reliant on other cues to gauge depth such as changes in light intensity, motion parallax, shadowing or learnt memory. Three-dimensional laparoscopic technology is currently under development to overcome problems with depth perception.

Loss of tactile sensation: the inability to touch tissues can make abnormalities difficult to detect, for example the 'hardness' of a cancer identified by palpation. Furthermore, the degree of force being exerted on tissues by laparoscopic instruments can be difficult to establish in the absence of tactile sensation, resulting in potential trauma.

The fulcrum effect: as a result of the fulcrum affect, the ends of the operating instruments move in the opposite direction to the

surgeon's hands. As such laparoscopic surgery can feel counter-intuitive and this is partially responsible for the associated steep learning curve.

Closure following laparoscopy

Deep fascial layer closure should be undertaken for all port sites that are 10 mm or greater in size in order to prevent the development of port site hernias. The risk of this complication with 5 mm ports is low and consequently these are not closed. During closure it is important that the fascia is lifted away from any underlying bowel using heavy forceps or a retractor in order to prevent inadvertent injury. Due to the depth of the fascia from the skin surface a J-shaped needle should be used to aid closure.

The skin over larger ports is generally closed with an absorbable continuous subcuticular suture. The 5 mm ports are closed with either a single interrupted subcuticular suture, ensuring that the knot is deep to the skin surface, or with steri-strips alone. Standard dressings are then applied.

Laparoscopy is increasingly being used in all facets of abdominal surgery. It is important to remember, however, that laparoscopy is a tool and not a religion. Safety must remain the priority and if concern exists, conversion to open surgery should be considered. ◆

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