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Symposium

Cholecystectomy: What's new?

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Introduction

'Big surgeons, big incisions', is what we were taught during our surgical training. The words stressed the importance of adequate operation field in order to perform a quality operation. Surgical practice is now experiencing a paradigm shift from open to minimally invasive procedures motivated both by the surgeons' desire to explore newer avenues and the patients' desire for cosmesis aided by emerging technology. From the conventional four port laparoscopic cholecystectomy we seem to be migrating towards three and now even single port surgery. Suitable technology is being developed and rapidly discarded as well in the search for something new and better. One may give it many names but these remain only slight modifications of the same procedure. Truly speaking what matters the most is what you do inside and that has remained unchanged – only the access varies. Possibly in the near future we will see a generation of surgeons with degrees of MS (GS, LS, AS) to be deciphered as Masters in General Surgery, Laparoscopic Surgery and Acrobatic Surgery.

History

Even though the first open cholecystectomy was performed in 1882, it took a century to perform the first laparoscopic cholecystectomy by Philippe Mouret in 1987.^{1,2} The development of laparoscopic surgery is an example of an emerging technology that has significantly changed the way surgeons operate today. In its infancy, laparoscopy was beset with numerous obstacles to its progress. Over the last two decades the four port laparoscopic cholecystectomy (LC) has become the standard of care for gall bladder disease. Surgery through natural orifices is a new surgical technique in developmental

and experimental phase both in animals and humans. The potential advantage lies in absence/further concealment of scars and reduced pain and discomfort. The most natural point of access for surgeons is to use already existing scars, such as the naval, to introduce the instruments that facilitate laparoscopic procedures. This approach was first used in 1997 by Navarra et al. in a laparoscopic cholecystectomy using two periumbilical incisions that were later joined to remove the gallbladder.³ Although Single incision laparoscopic surgery (SILS) is not as revolutionary a concept as the initial introduction of laparoscopy, it is being evaluated and adopted by many. It is still beset with numerous concerns regarding higher costs, longer operating time, and, among many, a feeling of disbelief regarding its potential advantages.

A completely new dimension is currently evolving in the form of natural orifice transluminal endoscopic surgery (NOTES). The goal is to perform intraperitoneal operations safely through a natural orifice obviating the need for any skin incision. This could help reduce surgical pain, decrease anesthesia and analgesia, shorten recovery time, avoid hernia formation and adhesions, and eliminate any surgical site infection and visible scarring. Ever since Kalloo's first report on transgastric peritoneoscopy in a porcine model in 2004, this dramatic surgical revolution has triggered many surgeons and endoscopists to study this new technique.⁴ This complex technique involves breaching the wall of the stomach, colon, vagina or bladder by endoscopic means to gain access into the peritoneum to perform the endoscopic therapy. In recent years, several NOTES surgery has been performed even on humans, such as transvaginal cholecystectomy, transgastric appendectomy, transvaginal appendectomy and transvesical peritoneoscopy. As with the laparoscopy revolution, NOTES caused a stir amongst surgeons and many scrambled to learn the new technique, more in anticipation of change rather than benefit.

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Single Incision Laparoscopic Cholecystectomy (SILC)

Nomenclature

Single incision laparoscopic surgery (SILS), single port laparoscopic cholecystectomy (SPLC), laparoscopic single site surgery (LESS), embryonic natural orifice transumbilical endoscopic surgery (e-NOTES), transumbilical endoscopic surgery (TUES), covert laparoscopic cholecystectomy are different names for similar procedures.

Basic operative principles

The several described techniques for SILC vary principally in the number of trocars used. These can be roughly categorized as the 2-, 3-, and 4-trocar techniques. In all of these techniques, the endoscope is introduced through 1 trocar, with 1-3 working instruments through the others. Increasing the number of instruments allows better retraction and greater flexibility in instrumentation, but also increases the conflicts between instruments and may reduce dexterity with any single instrument. A reduction in the number of instruments allows more freedom of movement and fewer instrument conflicts, but also reduces the number of instruments available to assist with retraction. Typically, retraction instruments are then replaced with suture, hooks, or magnets. Any of these techniques can be performed using multiple separate trocars or with a newer multitrocar or multiport device. Kuon Lee and coworkers also described a less expensive multiport technique using an abdominal retractor and a glove.⁵ Patient and surgeon position is as for conventional procedure. Alternatively, the patient can be placed in modified lithotomy (split-leg) position with the surgeon working from between the patient's legs. This position is more ergonomic for the surgeon, but adds to patient preparation time.

Trocar insertion

When using multiple individual trocars, they should have low-profile heads in order to minimize interference. The first step is to evert the umbilicus by pulling the deepest point of the umbilical scar (inner ring) out of its inward position. A 1.5- to 2-cm transumbilical incision performed in a vertical fashion without extension beyond the limits of the umbilical folds. By incising the umbilical fascia, direct access is obtained into the abdomen. One 5-mm low-profile trocar is used, and after pneumoperitoneum is created, a second trocar is inserted 5 mm above the previous port. Additional trocars may be placed inferior or lateral to the other ports.

Alternatively, a number of commercially available disposable multiple-port single incision platforms are available though at a cost. These have different means of insertion, depending on the manufacturer. Typically the umbilicus is everted and incised as above. A modified Hasson technique is used to make a 1.5- to 2.5-cm fascial incision, followed by insertion of the multiport. Although the fascial incision is larger with a multiport system, the single fascial defect is less stressed and easier to close than multiple smaller fascial defects in close proximity.

A flexible-tip endoscope can facilitate the view but is not indispensable, and using a long scope with or without a 90° adaptor is sufficient. Regular scopes can be also used, but these will clash more with the other instruments.

Instruments

Introduction of multiple instruments through a single incision invariably results in some conflicts between instruments. Additionally, because all instruments enter at the same location, they approach the target tissue at the same angle, reducing triangulation. Because of this, multiple manufacturers have introduced angled or articulating instrumentation. These reduce conflicts and allow for improved triangulation. However, they are more expensive and are often not as robust as conventional straight instruments. There is a significant learning curve for using these articulating instruments. Often the surgery is done using conventional instruments, adding an articulating grasper or dissector only if needed. Dissection, cutting, and clipping are performed with conventional instruments.

In the 3- and 4-trocar techniques, multiple instruments are inserted through a single point of access. It is often most effective to cross the instruments at the fulcrum point. Therefore, the right hand controls the left instrument, used for retracting the infundibulum laterally. The left hand controls the right instrument, used for dissection. This crossed hands technique has a significant learning curve.

In order to further reduce conflicts outside the patient, it is very helpful to use an extra long (bariatric length) 5-mm, 30° telescope. A standard light cord that projects straight up from the telescope will get in the way. Having a camera with a light cord that comes off the back is helpful. Alternatively, a 90° adapter will allow the light cord to be kept out of the way. A number of flexible laparoscopes are now available, which further allow the telescope to be kept out of the way of the instruments. These are quite expensive, and have a learning curve of their own, but once mastered they are a helpful addition to the operating suite.

Retraction

In the 4-trocar technique, a standard straight grasper is placed on the dome of the gallbladder, which is lifted towards the head as in standard LC. In the 2- and 3-trocar techniques, however, no instrument is available to retract the gallbladder cephalad. Instead, suture retraction on the fundus of the gallbladder using a nonabsorbable monofilament 2-0 suture on a straight needle is used. This is passed through the fundus of the gallbladder, secured using a lasso, titanium clip, pledget, or rubber stopper, and then brought transabdominally just below the costal margin.⁶ The suture is then grasped by the assistant and used to "puppet" the gallbladder. Because this typically does not retract the gallbladder cephalad as in standard LC, additional sutures may be used in the body or infundibulum of the gallbladder.

In the 3-trocar technique, a grasper is used for lateral retraction of the infundibulum. In the 2-trocar technique, an additional suture is passed through the infundibulum and used for retraction. It can be helpful to pass this infundibular suture transabdominally through the subxiphoid space,

through the gallbladder, and then out transabdominally in the lateral space, creating a sling. This allows the infundibulum to be flipped to permit dissection on the front and back of the triangle of Calot.

Some surgeons have voiced concerns that puncturing the gallbladder to obtain retraction may increase the chances of bactobilia and bile peritonitis, particularly if operating in the setting of acute cholecystitis.⁷ The use of magnets to retract without piercing the gallbladder has been described by Dominguez and associates and it is a very promising retraction technique.⁸

Dissection

The dissection is carried out until the critical view of safety is obtained, using a standard technique with a 5-mm dissector and conventional laparoscopic instruments or roticulating instruments. Once the critical view of safety is obtained, the cystic duct and artery are clipped using 5 mm clip applicator and cut, or ligated if they are too thick.

A 5-mm trocar is exchanged for a 10-mm trocar, and the specimen is placed inside of a bag and removed from the abdominal cavity. When using multiple individual trocars, the fascial incisions may be connected. The fascia and the skin are closed with absorbable sutures.

Potential advantages of SILC

Newer techniques, such as NOTES and SILC, were developed to reduce postoperative pain and improve cosmesis after a LC. In a comparative study by Navarra and colleagues involving 100 patients (74 LC, 6 NOTES, and 20 SILC), postoperative pain ratings were the same; although, a statistical analysis was not possible as a result of differences in the treated cases.⁹ Other studies showed no differences in postoperative pain and analgesia requirement.^{10,11} The main advantage seen with SILC is the hidden scar, because the entry point is the umbilicus. If the umbilical hernia rate is not increased, the cosmetic result, with an incision smaller than 2 cm, is the primary benefit with this procedure.

Possible disadvantages of SILC

SILC is not ergonomic for the surgeon, who must adapt to a new method of positioning, retraction and instrumentation. As the camera and instruments are introduced through the same port, the traditional laparoscopic principal of triangulation is lost. The operator often works in positions where his or her right hand is controlling the left-sided instrument on screen and vice versa. This reversed view can make movements less intuitive than in conventional laparoscopic surgery. Instruments often interfere with each other within the abdomen and extracorporeally, where attachments such as the camera light lead often restrict movement.

In a recent systematic review, Antoniou and colleagues identified 29 studies, including a total of 1166 patients, and found an incidence of wound complications of 21% (25/1,166) and 0.09% for incisional hernia (1 patient), but the follow-up period has been very short for some patients, so the authors suggest that these data be approached with caution.¹² When inserting a multiport or accommodating several ports in

a single incision, the development of skin flaps raises the chance of seromas or hematomas, and the pressure of the ports and the length may play a role in the formation of hernias. Curcillo and colleagues published their experience in 297 patients with no abdominal hernias.¹³

Although the studies comparing the operative time between SILC and LC have shown a more prolonged time for the SILC group, the time decreases when experience is gained.^{9,12} The use of a multiport also does not alter the operative time.

SILC is technically more difficult than a standard LC, but it can be performed in a safe manner with excellent cosmetic results. There should be a very low threshold for placement of additional standard ports as necessary, which should be considered prudent technique and not a failure or “conversion.” There are numerous case reports of SILC but few randomized trials comparing SILC and standard LC. The clinical benefits of SILC are therefore unclear.

Natural Orifice Transluminal Endoscopic Surgery (NOTES)

The term NOTES describes novel endoscopic interventions on internal organs performed through natural orifices. In this new approach, endoscopes enter the abdominal and thoracic cavities via any single or combination of natural orifices—mouth, urethra, vagina, and anus. Depending on the orifice, rigid or flexible equipment can be used. The lower “short-ways” (bladder, colon or vagina) allow the easy passage of rigid or flexible instruments into the abdominal cavity, but the upper “long-ways” (esophagus and stomach) require flexible equipment.

The main goal for NOTES is avoiding skin incisions. Other theoretical advantages include: decreased post-operative pain, reduction/elimination of general anesthesia, performance of procedures in an outpatient or even office setting, and possibly cost reduction. Moreover, eliminating skin incision avoids associated complications such as wound infections and hernias, as well as reduction in hospital stay, faster return to bowel function, improved cosmetic outcomes, and increased overall patient satisfaction.

Types

‘Totally’, ‘Pure’ or ‘True’ NOTES refers to procedures done only with transluminally placed flexible or rigid tools, without laparoscopic assistance to gain access to the peritoneal cavity. With the currently available instruments, there is a high degree of difficulty. Most of the procedures require assistance from instruments placed through other ports. This assistance is used to ensure safety at entry, assist in retraction, dissection and off-axis visualisation and to provide secure closure of the entry site. The term ‘Hybrid’ NOTES is used to describe such procedures that involve any type of transabdominal assistance.

Entry routes

NOTES procedures are frequently performed with existing endoscopic techniques and a number of accessories, such as

snare, endoscopic biopsy forceps, endoscopic grasping forceps, endoloops and endoscopic clips.

1. Transgastric route

To date, most of the published clinical case reports relate to the transgastric route. The anterior wall of the stomach is usually the ideal incision site for access to the peritoneal cavity.

2. Transvaginal route

Currently, transvaginal access is the preferred approach in humans because this route obviates the risk of intestinal content leakage.

3. Transcolonic and transvesical route

These routes though novel have been rarely explored.

All of these routes have their own advantages in NOTES procedures. Although the transgastric route is regarded as the easiest way to get into the abdominal cavity, and initially, many NOTES experiments were done via the transgastric route, a drawback limiting the use of the transgastric route is the lack of a secure and reliable way to close the gastrotomy, which is an essential step in the procedure. The transcolonic route is similar to the transgastric route except that the former has an increased risk of contamination due to the faecal bacterial load. The transvesical route allows straight access to the upper abdominal organs such as the gallbladder, which is mechanically more advantageous than the transgastric approach.¹⁴

Current challenges of NOTES

Although the potential benefits of NOTES represent a new frontier of surgery, many technological challenges still exist. NOTES will not receive widespread adoption for clinical application until these problems are solved.¹⁵

1. **Surgical platform.** The endoscopes that we use nowadays only offer small instrument and suction channels, which makes retraction and dissection of tissues difficult. Therefore, a new platform that is larger, stronger and will eventually allow entry of articulated, instruments through large working channels is necessary.
2. **Pneumoperitoneum.** Endoscopic insufflation is more difficult to manage and measure than a standard laparoscopic approach.
3. **Spatial orientation.** Orientation can be a challenge for NOTES in the peritoneum, because the triangulation used by surgeons during laparoscopy is impossible. Some organs appear relatively easy to find, such as the uterus and ovaries, while others are somewhat surprisingly difficult to localize (gallbladder and spleen)
4. **Triangulation of instruments.** To date, in NOTES experience, when the target tissue is reached, retraction and dissection are virtually impossible due to the lack of the triangulation of endoscopic instruments, which provides efficient grabbing and dissection capabilities.

5. **Closure technique.** Among the challenges of the NOTES technique, closure and suture techniques are thought to be critical in view of perforation and infection risks, especially for the transgastric and transcolonic routes.

6. **Perioperative complications.** To date, the perioperative outcomes have been favorable in most reported studies. However, as closure technique is not mature enough, intra-peritoneal infection remains a primary concern for NOTES.

ROBOTICS

Existing surgical robots operate rigid instruments on the master / slave principle and currently allow extraluminal manipulations and surgical procedures. Frequent collision of the robotic arms raises the issue of appropriateness of robots for SILC or NOTES. To be compatible further refinement of ergonomics, dexterity and precision manoeuvrability is required.

Conclusion

It is important that new surgical techniques are supported by strong evidence to demonstrate their benefits to the patient. In the case of SILC for cholecystectomy, studies so far have demonstrated that it is a safe and efficacious method of surgery. It may be safe in experienced hands but not in the hands of surgeons in training. Further prospective randomised clinical trials are now needed to validate the advantage of this new and attractive technique.

After the familiar laparoscopic surgical techniques, NOTES has become the next worldwide focus of minimally invasive therapy. The novel surgical procedures, with fast recovery and without general anesthesia, visible scarring, postoperative hernia formation and adhesions, are attractive for most surgeons and endoscopists. Although the novel procedure is far away from being mature and many technical problems have to be overcome before its widespread application in clinical cases, NOTES is undoubtedly a promising procedure for the future. More clinical studies and creation of new NOTES-specific instruments will make NOTES a reality.

Conflicts of interest

None identified.

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