Current state of single-port transumbilical surgery in urology: Challenges and applications

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Abstract

Context: Laparoscopic surgery in urology is considered to be an important advance, although it is not exempt from some morbidity associated to the use of multiple trocars and specifically to the extraction of the specimen. In order to decrease this morbidity and improve esthetics, other techniques are being developed, such as natural orifice transluminal endoscopic surgery (NOTES) and laparoendoscopic single-site surgery (LESS). It is aimed to review the current status of laparoendoscopic single site surgery in urology.

Acquisition of evidence: A nonsystematic review has been carried out by means of the bibliographic search using the terms LESS and Urology from 2007 to 2012. The current LESS experience in urology is described, and its principal indications and the different single site devices and instruments available on the market are described.

Synthesis of evidence: LESS surgery arose as one more step in the constant evolution of minimally invasive surgery in an attempt to improve esthetics, reduce surgical trauma and decrease pain and the post-operative complications associated to the conventional laparoscopy with multiple trocars. Since it was first described in 2007, the experience has been increasing exponentially and the LESS technique, whether assisted or not by robot, is becoming consolidated for a large spectrum of urological indications (both in oncological and reconstructive surgery) on a much greater scale than the NOTES technique. Even though most of the existing data are not randomized and very rarely comparative, with the selection bias that this represents, it seems clear that the esthetic benefit and analgesic control associated to the LESS surgery is real and reproducible. The complications associated to it are greater in cases of major oncology surgery and are due more to the technique itself then to the approach.

Conclusions: Although the real benefit of the LESS surgery in urology cannot be appropriately quantified, the cosmetic improvement, less pain and greater patient satisfaction with their wound are clear. Appropriate training in this type of procedures in centers having large volumes...
The evolution of minimally invasive surgery

For many urological procedures, the laparoscopic access has proven effective in reducing postoperative morbidity, mean length of stay, and time of incorporation into working life, and in improving the esthetics of the scar, all without compromising the oncological and functional results of conventional open surgery. However, various complications associated to the use and disposal of trocars during laparoscopic surgery have been described.

In order to reduce these complications and, therefore, decrease the morbidity of laparoscopic surgery and improve the esthetics, other techniques are being developed, such as laparoendoscopic surgery through natural orifices (Natural orifice transluminal endoscopic surgery [NOTES]) and laparoendoscopic single site surgery [LESS].

NOTES, in its strictest sense, means not using any abdominal port. Thus, we avoid an external scar and its associated morbidity.

The evident disadvantages of this type of surgery involve the complete loss of triangulation, partial loss of visibility, insufficient traction, and important conflict of space.

The application of a 3.5-mm accessory port was not considered incompatible with the term NOTES, but a step further in the development of this technique and it has been called hybrid NOTES. The first series of NOTES was reported in 2004 by Kalloo et al. performing transgastric liver biopsies. Several urological groups initially used a variety of terms, such as E-NOTES, SILS, OPUS, SPA, SPL, and SIL, to describe the technique now better known as LESS or laparoendoscopic single-site surgery. LESS presents all the advantages of NOTES, such as improved esthetics and decreased abdominal trauma, without the added difficulties of passing through a natural orifice (stomach, rectum, vagina, bladder). Even so, access in LESS still requires skin incision. From a cosmetic point of view, the ideal approach in LESS is carried out transumbilically, either through a single-port access with several instrumentation channels, a single skin incision in which several separate
ports are inserted, a single skin incision in which various ports are placed through various fascial incisions or even several small transumbilical incisions.

The navel, due to its topographical situation, is one of the most suitable places for the practice of LESS, as it allows for access to both renal and retroperitoneal surgery, as well as to processes of the bony pelvis. Moreover, strictly speaking, it is an embryonic NOTES (E-NOTES), since the navel is a natural embryonic opening and the scar of an umbilical surgery can be completely hidden in the natural scar itself, which means surgery "without incision", or rather without apparent incision or with no incision visible. The aim of this paper is to assess the current and foreseeable future of urologic surgery "without incision".

Urologic surgery has always been in the first line of minimally invasive surgery in the last decades of the history of medicine. Transurethral resection, extracorporeal shock wave lithotripsy, retrograde intrarenal surgery, ureterorenoscopy, and percutaneous nephrolithotomy are some excellent examples of this evolution. The kidney tumors previously requiring high morbidity incisions, such as lumbotomy, are treated routinely in most centers by means of laparoscopy. It is not surprising, then, that the specialty that was better prepared to give impetus to these new minimally invasive techniques has been urology.

**Single-site urological transumbilical surgery**

Currently, the term LESS encompasses the concept of minimally invasive surgery performed laparoscopically through a single port placed by a single incision, using both conventional laparoscopic instruments and new instruments with a degree of deflection (curved) or flexible.

The first description of a real LESS procedure was performed in the gynecological field around 1972 and it consisted of a tubal ligation. Through a 1-cm infraumbilical incision, a laparoscopy optic was inserted to identify and cauterize each fallopian tube. The cosmetic benefit of this technique led to the gynecologists to explore more complex procedures, including total hysterectomy with double adnexectomy in 1991. General surgeons also began to explore the benefits of this technique by performing appendectomies and cholecystectomies. In 1999, they developed a new variant to conduct cholecystectomies by a single skin incision and 2 fascial ones, enabling them to accommodate two 5-mm trocars through the same incision.

The first case of LESS urological surgery described in humans was performed through a flank incision, through which, and through an R-Port single port (Advance Surgical Concepts, Wicklow, Ireland) nephrectomy of an atrophic kidney was completed. The first transumbilical urological procedure with LESS was described by Ramal et al. in 2007, performing a nephrectomy through a single incision but with multiple trocars. The experience has increased exponentially and the LESS technique with the new single-port devices, either disposable or reusable, is emerging as an excellent choice for a wide range of urological indications.

One option is to practice radical nephrectomy through a 7-cm pararectal incision by means of a single GelPort® port (Applied Medical, Rancho Santa Margarita, USA). The Pfannenstiel incision has also been explored for radical nephrectomies and nephroureterectomies by means of a GelPort. These accesses have shown viable options to umbilical incision; however, most of the single-port urological experience was made through the navel because this wound is much less invasive, it means a lower impact of the umbilical aponeurotic midline incision, and prevents muscle injury, which significantly reduces the incision pain and the morbidity associated with it.

However, as with many new surgical platforms, LESS has faced significant ergonomic challenges, some of which are still present. Most problems are avoided with a specific training program and they are lessened with practice and with the proper knowledge of the instruments.

In conventional laparoscopy, the arrangement of several trocars allows for correct triangulation to exert traction–countertraction tissues, avoiding the intracorporeal clashing of the instruments. The clashing, both intra-and extracorporeal, is the main problem with this technique (Fig. 1).

The technical and equipment challenges have been very effectively described by Sawyer and Ponsky, who emphasize rapid innovation and at the same time highlight the difficulties inherent to the technique, among which are the limitation of a reduced visual field in which all the instruments are in parallel.

In fact, at the beginning of this technique, the surgeons performed the procedure with conventional laparoscopic instruments through a single skin incision accompanied by several fascial incisions. Articulated clamps, endobag, and standard endoclips were used, along with a 5-mm and 45° rigid optic. A significant clashing of intra and extracorporeal instruments and a significant learning curve were described. Adrenalectomy was also carried out through a 2-cm skin incision and various fascial ones, which came together to remove the piece. The authors had in this case limited maneuverability, with tearing of the fascia, lack of vision, and difficulty for vascular control.

With the aim to overcome these difficulties, we have developed new platforms that rely on a single skin and
fascial incision, with the potential to accommodate up to 3 or 4 instruments simultaneously (Triport®, QuadPort®, Advance Surgical Concepts). Another solution under the same philosophy is to carry out a single skin and fascial incision to allow for the introduction of several instruments using the Alexis system associated to GelPoint Advance Access Platform (Applied Medical, Rancho Santa Margarita, CA, USA), which allows for the use of conventional laparoscopic instruments by conveniently distancing the instruments from the surgical field, thus facilitating triangulation (Fig. 2). However, this device has the disadvantage of its disposable character due to the economic implications that this entails.

A newly developed device is KeyPort® (Richard Wolf GmBH, Knittlingen, Germany). It is a reusable device with 3 channels and with a suitable ergonomic shape for its optimal transumbilical placement, with perfect attachment to the aponeurosis, without the need for anchorage points or to use other self-retention systems. Moreover, it has 3 channels that permit the introduction of both rigid instruments and with different degrees of rotation and deflection (Fig. 3). The reusable nature of this device involves a great advantage in economic terms. In addition, the working instruments designed for this system are Duo-Rotate; that is, they incorporate an intelligent double rotation system which allows for high precision and versatility of movement, as well as the correct traction of the tissues.

The use of minilaparoscopy accessory ports (3–3.5 mm) is the ideal complement to LESS, facilitating angulation and performing the sutures with minimum cosmetic impact. This assistance has been postulated as a bridge to save the step of conventional laparoscopy to LESS. In certain procedures, it may be necessary to place minilaparoscopy instruments without a trocar for liver retraction or puppet sutures for bladder or colon retraction. Such assistance does not usually leave a scar.

Trading houses and available devices

Karl Storz

This house has 2 devices marketed for single port surgery, X-Cone, and EndoCone (Fig. 4). The first consists of 2 half metallic frames and a silicone sealing unit with 4 inlets. Storz recommends using an instrument with curved distal end and a straight instrument in combination with a 5.5-mm extra-long optic, with an angle of 30° and a length of 50 cm. The insertion procedure is more complicated than other devices. In case of performing too large an incision, there is a loss of gas and if, conversely, it is smaller, a muscle tear can occur by bringing the half frames together. The instrumental change is quick and easy, but the maximum diameter is 13 mm. In order to remove the piece, it is necessary to withdraw the complete sealing unit. The second model is comprised by only 2 pieces: an EndoCone trocar sheath without obturater and a cap provided with various holes for the passage of instruments and 2 for optic. It is often used in combination with non-rotatable curved instruments (Fig. 5). It is easily introduced, although it has no blunt obturater to ensure safe introduction. The management and exchange of the instruments are quick and easy, and it also makes it possible to work with up to 15 mm. It

Figure 2 Umbilical skin and fascial incision to conduct radical cystectomy (A). The Alexis retraction system (B) is placed, to which the GelPoint disposable port (Applied Medical) (C) is coupled, which allows for the introduction of various instruments and conventional laparoscopic lens (D).

Figure 3 Reusable KeyPort® port (Richard Wolf) with 3 channels and ergonomic shape for transumbilical placement. It may be employed alone or with a 3.5-mm accessory trocar, through which minilaparoscopy instruments are inserted.
is a stable platform without pneumoperitoneum leakages. Due to its robustness, the durability is great, although it may prove heavy and unbalanced.

**Covidien**

This company pioneered the single port with the SILS-Port® system (Single Incision Laparoscopic Surgery Port). It is an expendable device composed of a cellular plastic base with 3 channels for the introduction of rigid trocars, although it also offers special disposable rotatable and adjustable instruments (Roticulator) that are managed intuitively but with the drawback that the jaws always remain in the same position (Fig. 4). The introduction of the device is quite simple if we are helped with a curved forceps. The exchange of the instruments is quick and easy, being able to work with instruments of up to 15 mm. The platform is stable, although pneumoperitoneum leaks can occur, especially when applied with robot-assisted surgery. For the extraction of the piece, we have to completely remove the port.

**Olympus**

Olympus has 2 single-use systems marketed, TriPort® and QuadPort® (Fig. 4). The first one has 3 valves for 5-mm instruments and a 10-mm valve, together with a connector for CO₂ insufflation and another one for fume extraction. The system is introduced through a special applicator and is fixed around the navel with the aid of a sleeve system. This sleeve serves as a working channel and to protect the wound. TriPort® has two 5-mm accesses and a 15-mm one. QuadPort® has 4 channels (5, 10, 12, and 15 mm). The greatest accesses can be adapted for 5-mm instruments through the corresponding sealing caps. This company also has curved specific instruments for single-use LESS (HiQLS), which are introduced with the help of a special trocar. The management and change of tools are quick and easy as it is a stable system, without gas leak. Removing the cap, any surgical piece can be safely and easily extracted, without removing the entire device. Its disposable nature implies a high cost.

**Applied Medical**

The most flexible solution in single-port surgery is probably the single-use GelPoint system, with sleeve-separator system (Alexis) similar to the Olympus one and a gel cap (Figs. 2 and 4). This gel cap makes it possible to place several trocars of any size at any point of the gel pad, so that the instruments can be introduced to achieve the most favorable angle for triangulation. All the Applied Medical instruments are fungible, some of which are pre-curved (Fig. 5). The introduction of the device is carried out in 2 steps: first the sleeve is inserted with the help of a flexible insertion ring, and then the GelPoint cap is placed. The management and exchange of the instruments is very simple and quick, and the free selection of diameters and positions of the trocars allows for great freedom of movement. It is a very stable system, with no loss of gas. Removing the gel cap, we can extract any surgical specimen safely and easily.

**DaLim Surginet**

This South Korean company has presented one of the latest disposable systems in the field of single-port systems, OctoPort® (Fig. 4). It is a fungible platform consisting of a flexible silicone funnel system that holds the system firmly to the abdominal cover. Then, adapters are applied as needed. Large sealing caps (10–15 mm) are set to the desired diameter of the instrument by means of smaller caps or changing their position. This manufacturer does not offer special instruments for LESS. The insertion of the device is done in several steps; first, we insert the base of the silicone ring, then the silicone ring, and finally the cover is fixed. The management of the instruments is quick and easy thanks to the adapter-reducer and the flexible sealing caps. The system is stable, without loss of
pneumoperitoneum. Removing the cap, we extract the surgical piece.

Richard Wolf

The latest system to be marketed is the KeyPort® by Richard Wolf, a reusable system which consists of 3 parts: trocar sheath, trocar, and silicone sealing unit with 3 inlets with valves (Figs. 3 and 4). The sheath has 2 thread pitches that facilitate umbilical insertion and that, in turn, give stability to the system preventing a gas leak. The tip of the distal end of the trocar is blunt andatraumatic. The obturation unit has a valved inlet for 5-mm instruments, another one for 5–15-mm instruments, and a third one for the passage of the optic. It also presents a connector for CO₂ insufflation. The 3 main inlets are equipped with a sealing cap and they also have additional integration valves to prevent the loss of gas when not using a working tool. Richard Wolf has designed a wide range of new specific instruments for LESS that have curved and inserted sheath tubes that allow for a wide degree of freedom, both outside and inside the abdominal cavity, thus avoiding the external crush and the internal crossing of the instruments (Fig. 5). Additionally, the inserted instruments have a DuoRotate system that makes it possible to get a translational movement of the sheath and complete it with individualized rotation, and it requires their tip. The introduction of the device is very quick and easy thanks to the thread of the trocar sheath. The change and management of the tools are quick and easy, allowing for the use of instruments of up to 15 mm. The tightness of the system is optimal thanks to the valves and the thread of the trocar sheath. Moreover, the extraction of the surgical specimen is performed quickly and safely, opening and closing the sealing unit.

Main procedures performed

An impressive number and variety of urological procedures has been carried out successfully through the different single umbilical port platforms. There is accumulated experience in multicenter studies on the morbidity and complications of this type of surgery. We know that these complications are higher in cases of major cancer surgery, although they are more due to the technique itself than to the laparoendoscopic approach itself.

The procedures on the kidney are the most reported. As for the kidney cancer procedures, cryoablation, partial nephrectomy, and radical nephrectomy have been described. Most authors use a fine accessory port for liver retraction, without compromising the esthetic result of LESS. A number of partial nephrectomies have also been safely described without vascular clamping. Renal reconstructive procedures such as pyeloplasty, ureteral replacement with ileum, and ureteroneocystostomy with psic bladder have also been conducted. Pyeloplasty with LESS shows results similar to laparoscopic pyeloplasty, but with shorter hospital stay and fewer analgesic requirements. Pielonephrectomy on horseshoe kidney has also been reported, with excellent results and ureterolithotomy and colposacropexy.

Figure 6 Excellent cosmetic results in a patient with umbilical-access KeyPort® radical prostatectomy without any residual scarring.

Experiences are less frequent in the adrenal gland, probably due to the difficulty to reach the renal upper pole and the need to properly expose the gland, especially on the right side. When comparing the laparoscopic approach and LESS, both techniques are similar in the conversion rate, surgical time, bleeding, hospital stay, and complications, but the umbilical LESS group had fewer analgesic requirements. The transplantation field has been very prolific in the area of LESS. Transumbilical live donor nephrectomy implies an excellent cosmetic result for the donor, a shorter recovery period, and less need for analgesia.

Complex procedures have also been described, such as major oncologic pelvic surgery. Our center has initiated a radical cystectomy program with LESS with orthotopic neobladder and is also conducting the largest series of LESS radical prostatectomy in the literature, with very encouraging initial results, both oncological and functional, excellent pain control, and cosmetic outcome (Fig. 6), and with very low economic cost due to its reusability.

However, it is clear that transumbilical surgery has several disadvantages that the surgeon has to weigh. The first is the impossibility of a correct triangulation, so it is necessary to use specific instruments to solve this problem, being indispensable to carry out a specific training, even in surgeons with extensive prior experience in laparoscopic surgery. Moreover, the need for specific instruments involves an initial outlay to start a program with this technique, although the emergence of recent reusable devices makes it much more economically affordable. To date, there has been no cost-effectiveness analysis on the implementation of LESS in urology.

Conflict of interest

The authors declare that they have no conflict of interest.

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