Single-Port Access Laparoscopic Hysterectomy: A New Dimension of Minimally Invasive Surgery

ABSTRACT

The fundamental idea is to have all of the laparoscopic working ports entering the abdominal wall through the same incision. Single-incision laparoscopic surgery is an alternative to conventional multiport laparoscopy. Single-access laparoscopy using a transumbilical port affords maximum cosmetic benefits because the surgical incision is hidden in the umbilicus and reduces morbidity of minimally invasive surgery. The advantages of single-access laparoscopic surgery may include less bleeding, infection, and hernia formation and better cosmetic outcome and less pain. The disadvantages and limitations include longer surgery time, difficulty in learning the technique, and the need for specialized instruments. This review summarizes the history of SPAL hysterectomy (single-port access laparoscopy), and emphasizes nomenclature, surgical technique, instrumentation, and perioperative outcomes. Specific gynecological applications of single-port hysterectomy to date are summarized. Using the PubMed database, the English-language literature was reviewed for the past 40 years. Keyword searches included scarless, scar free, single-port/trocar/incision, single-port access laparoscopic hysterectomy. Within the bibliography of selected references, additional sources were retrieved. The purpose of the present article was to review the development and current status of SPAL hysterectomy and highlight important advances associated with this innovative approach.

Key words: Hysterectomy, minimal access surgery, single-port access laparoscopy

INTRODUCTION

The latest advancements in terms of techniques expertise and surgical instrumentation have allowed single-access surgery to become even more minimal. This led to the development of a multitude of surgical approaches collectively known as laparo-endoscopic single-site surgery (LESS) and involves more recently coined terminology including natural orifice transluminal endoscopic surgery (NOTES), single-access laparoscopic surgery (SALS), single-port access laparoscopy (SPAL), and one-port umbilical surgery (OPUS).

Initial trials, conducted in animal models, were accompanied by the development of dedicated custom-made instrumentation. Preliminary advances were made with the use of SPAL in urologic and gastrointestinal surgery, and only recently, many reports describing the application of SPAL also in gynecology have been published. These data on which the reports are based demonstrated that even though the SPAL approach was clearly feasible, the operating time was significantly longer compared to conventional laparoscopy. In order to further evolve the concept of SPAL and to standardize its application in gynecology, the design of a set of specific laparoscopic instruments is of key importance.
DEVICES IN GYNECOLOGY SURGERY

In the gynecological literature there are reported a number of studies using a wound retractor and a glove for single access in the umbilicus. A small wound retractor (Alexis; Applied Medical, Rancho Santa Margarita, CA) is inserted into a wound opening transumbicularly [Figure 1]. The wound retractor comprises a distal ring, a proximal ring, and a cylindrical connecting sleeve. Once it is fixed in the opening site, it laterally retracted the sides of the wound opening. This makes the small vertical incision a wider, rounder opening. A surgical glove with 2-3 sheaths that are inserted through cut edges of distal finger tips and tied with elastic bandage to prevent leakage of carbon dioxide is draped around the rim of the wound retractor. The elastic nature of the glove enables it to obtain a good purchase on the ring and achieve an airtight seal, which maintains the pneumoperitoneum. The multiple fingers of the glove function as a multiport for laparoscopic instruments and a camera.

A Seoul group has used a new device, Octo Port (DalimSurgNet, Seoul, Korea) that is a newly developed laparoscopic multichannel access device that allows multiple instruments to pass simultaneously through one incision and ensures pneumoperitoneum regardless of whether a laparoscopic instrument is present in any of the channels.

Another device used in gynecology is X-Cone that is a reusable single-site trocar with four integrated access ports was used (S-Portal X-Cone; Karl Storz, Tuttlingen, Germany). This new device consists of two symmetrical metal half shells that are connected and sealed by one large silicon cap containing the access ports [Figure 2]. Once in the peritoneal cavity the two-half shells fit together to form an X-shape and the final access portal, the silicon cap comprising three 5 mm and one 12 mm ports is connected on top of the X-Cone, which forms an airtight seal. A clamp integrated into the rubber sealing prevents the X-Cone from opening unintentionally. The external and internal diameters at the level of the X-waistline are 25 mm and 20 mm, respectively.

Cuschieri Endocone® (Karl Storz, Tuttlingen, Germany) is another trocar for single-port laparoscopic surgery, reusable, ergonomically placement of the valves for multiple telescope, and instrument access and has precise control of the telescopes and instruments because of the rigid seal cap [Figure 3].

The TriPort (Advanced Surgical Concepts, Wicklow, Ireland), also known as the R-port, is a device designed to be deployed through a single incision, typically at the umbilicus [Figure 4]. This device is Food and Drug Administration (FDA) approved and available in the United States. It requires a fascial incision approximately 1.5-2 cm long. A sheath is placed through the fascial opening, and the peritoneal surface of this sheath has a self-expanding ring, allowing the TriPort to remain inside the peritoneum.

The TriPort is introduced into the abdomen through the fascial defect via an introducer device. The outer component of the TriPort has three ports: two 5 mm ports and one 12 mm port. To maintain pneumoperitoneum, the ports contain the same gelatin material as the GelPort (Advanced Surgical Concepts) used for hand-assisted laparoscopic surgery.

Instruments require lubrication to pass through the ports without unnecessary drag.

Case reports on the TriPort are beginning to emerge in the gynecologic procedure; Langebrekke et al. published in 2009 a case report of a total laparoscopic hysterectomy with TriPort access. The TriPort has multiple advantages. First, multiple instruments can pass through different access points without loss of pneumoperitoneum. Moreover, the different ports allow instruments of variable sizes. Second, the TriPort is fairly simple to introduce into the abdomen and can even be replaced if it is removed, for example, for organ extirpation. Third, it can accommodate variable thickness of the abdominal wall. Fourth, each of the ports affords significant angles of distraction away from one another inside the abdomen. The disadvantages of the TriPort include the relative need for umbilical placement.

A second version of the TriPort, tentatively called QuadPort, will have four hubs for instrument: one 12 mm and two 10 mm ports and one 5 mm port.

The SILS port, made from an elastic polymer, is slightly hourglass shaped and can be deployed through a 2 cm fascial incision. It contains four openings: one for insufflation via a right-angled tube and three that can accommodate trocars 5-12 mm in size. The compressibility of the elastic polymer allows the access port to expand and fit the space in which it resides as well the ports passes through the working channels.

This device was used by Phongnarisorn et al. in 2010; they report a retrospective study to evaluate the feasibility, safety, and perioperative outcome of single-incision laparoscopic hysterectomy using conventional laparoscopic instruments for treatment of patients with symptomatic leiomyoma and/or adenomyosis.
An access port called AirSeal (SurgiQuest, Orange, CT, USA) involves a technology disruptive to the typical trocar concept [Figure 5]. All traditional laparoscopic ports use a mechanical barrier to maintain pneumoperitoneum while allowing instrument passage and limited specimen extraction through their lumen.
AirSeal ports do not use a mechanical barrier but rather a pressure barrier that well exceeds the pneumoperitoneum. This pressure barrier can be conceptualized as similar to the air curtain blowing down from the ceiling at the entrance of many operating suites. The barrier is created by gas pumped through openings within the housing of the port, creating turbulence that can be regulated and exceeding the pressure of the pneumoperitoneum, thus preventing gas loss, even when instruments and specimens are passed through its lumen. AirSeal allows the passage of multiple or odd-shaped instruments, extracorporeal knot tying without gas loss, and enhanced specimen extraction.

A 12 mm AirSeal port is FDA approved and currently available on a limited basis in the United States.\[16\]

The Uni-X single-port laparoscopic device, recently acquired from Pnavel Systems (Morganville, NJ, USA), is a system designed to allow the simultaneous use of three 5 mm laparoscopic instrument through a single-fascial incision [Figure 6]. The device is funnel shaped, which allows for a wide range of motion because the length of the tunnel through which an instrument can pass is shorter than a standard laparoscopic trocar.

The Uni-X system also has a port to allow abdominal insufflation. Fascial fixations are necessary to maintain the device in its position, and accompanying curved laparoscopic instruments are available that may be helpful when multiple instruments are operated through a single incision.\[16\]

**TECHNICAL CHALLENGES**

One early principle of laparoscopic surgery as it rapidly developed was the concept of triangulation. Triangulation, still a widely accepted concept, is included in the SAGES and American College of Surgeons (ACS) joint program called Fundamental of Laparoscopic Surgery (FLS).

As familiarity with angled telescopes took root in advanced laparoscopic surgical procedures, surgeons began to experiment with placement of the camera so that it no longer rested between the operating surgeon’s hands. Currently, it is commonplace for a camera to be positioned lateral to both of the surgeon’s working ports to maintain the best possible ergonomic positions for the surgeon and the assistant holding the scope.

It must be remembered that with in-line viewing, a move of the camera often results in an inadvertent move of an adjacent instrument. Although angled or flexible scopes can minimize this problem to some extent, there remains the issue of the limitations in external working space.

With single-port surgery, the external area within which the surgeons’ hands are located is much smaller than in standard laparoscopic surgery through multiple ports.

In single-port surgery 0° and 30° 5 mm laparoscope can be used for visualization to optimize the angle of the approach to the target tissue. The 0° laparoscope is used as a main scope, while the 30° one is used during the vescicovaginal approach, when this area is obscured by an anteriorly located myoma, and during colpotomy.

One such laparoscope, the Olympus EndoEye (Olympus America, Center Valley, PA, USA), differs from many commercially available scopes in that the image capture chip is at the distal tip of the scope. Also, the insufflation tubing needs to be placed in a position such that it does not interfere with the other instruments. This will require a connection different from the currently used stopcock and Luer-lock system.

Flexible-tip laparoscopes can be positioned favorably out of the field of view by deflection of the tip such that the external portion of the laparoscope is in a different plane than the working instruments. Texeira (personal communications) has used currently available flexible endoscopes to facilitate the working environment for single-port laparoscopic.

For the operative surgery single-port hysterectomy using instruments of differential overall lengths is also helpful. If one camera and two instruments occupy the multichannel port, varying lengths prevent the bulkiest portion of each instrument (the external handle) from overlapping extracorporeally; a rigid single-curved forceps or scissor and a standard straight bipolar dissector or device with grasping, coagulating, and transecting functions (EnSeal; Ethicon, USA; Ligasure sealing system-Valleylab, CO, USA; or Harmonic ultracision (Ethicon, USA) which has characteristics of both the unipolar and bipolar coagulator and could decrease time for inserting or removing the instruments. In addition, it can cut through thicker tissue, creates less smoke, causes less lateral thermal damage, and may offer greater precision. Other instruments used in single-port surgery including Endo-GIA, a single-use loading unit with titanium stapled developed by Covidien for dissecting of the ovarian ligaments, round ligament, and broad ligament.

The cuff of the vagina can be laparoscopically sutured with interrupted or barbed sutures; intracorporeally knotting
technique allowed the cuff to be sutured despite difficulties arising in relation to the reduced angle, the clashing of the instruments, and the considerable distance between the vagina and the umbilicus; bidirectional barbed sutures reduce the difficulty of technique intracorporealy knotting. Also the vaginal cuff can be repaired with interrupted sutures extracorporeally or transvaginally. Compared with traditional sutures, the benefits of the bidirectional self-retaining sutures with tissue retainers (barbs) include speed and economy of suture placement.

HYSTORICAL PERSPECTIVE

The single-incision approach to gynecological diseases is not a new idea. Laparoscopy was born as a single-access technique first for diagnostic procedures only and secondly for minor surgeries with the utilization of operative laparoscope through the umbilicus.

Wheeless and Thompson, in 1969, first published the technique and the results of a large series of laparoscopic tubal ligation with single-trocar laparoscopy. Wheeless later reported on 3600 cases, 2600 of which had a one-incision tubal ligation.[18,19]

The first laparoscopic total abdominal hysterectomy with bilateral salpingo-oophorectomy using only a single incision was reported by Pelosi and Pelosi in 1991.[20]

One year later four supracervical hysterectomy with BSO for benign uterine disease were reported by the same authors.[21]

These are the first reported cases of complex extirpative pelvic surgery using a single intraumbilical incision.

These procedures were performed using an operative laparoscope that, interestingly, never gained popularity in the general surgery arena.

Despite these efforts, single-incision laparoscopic surgery did not spread rapidly among gynecologic surgeons mostly due to technical difficulties in the absence of laparoscopic instrumentations appropriately adapted to the restricted operative field.

HYSTERECTOMY

Hysterectomy is one of the most common gynecologic procedures. In the USA, approximately 600,000 hysterectomy are performed annually.[8] It has been reported that laparoscopic hysterectomy offers several advantages, including faster return to normal activities, improved cosmetics, shorter length of hospital stay, lower cost, and reduced pain compared with laparotomy. Because of these advantages of laparoscopic surgery, hysterectomy has increasingly been performed using minimally invasive approaches.

The standard approach to laparoscopic hysterectomy consists of four incisions where four separated ports are placed, one for the laparoscope and three for surgical instruments.

Many studies report a new transumbilical (SPA: single-port access laparoscopic) approach for total (TLH), subtotal (SLH), and vaginal (LAVH) hysterectomy.

SPA-SLH

Recently, a first study[7] reported SPA-subtotal hysterectomy with transcervical morcellation using a wound retractor and a surgical glove.

After uterine vessels coagulation, the uterus is cut at the level of the cervical histhm; the cervix is dilated via the vaginal approach with a no.15 Hegar dilator and the morcellator was inserted through the dilated cervical os and the uterus was removed using the transcervical morcellator.

Several studies have compared perioperative outcome with LSH with that of various types of laparoscopic hysterectomy. In one study, blood loss, operative time, complication rate, and sexual function were substantially better with LSH compared with laparoscopy-assisted vaginal hysterectomy (LAVH). Compared with total laparoscopic hysterectomy (TLH), the complication rate is significantly lower, and mean operative time, blood loss, hospital stay, use of analgesia, and uterus weight were not significantly different.

Except for the number of ports, SPA subtotal hysterectomy is similar to LSH insofar as a surgical technique. Thus, SPA subtotal hysterectomy is expected to have similar advantages as LSH in perioperative outcomes over LAVH or TLH.

SPA-TLH

Phongnarisorn et al. (2010) showed that laparoscopic hysterectomy can be performed successfully with commercially available straight instruments through a single intraumbilical incision in patients with symptomatic benign uterine pathology and a uterine size of less than 16 week’s gestation or weight less than 560 g.
The uterine size is considered as one of the limiting factors for advanced laparoscopic procedures.\textsuperscript{117}

Recently, Jung \textit{et al.}\textsuperscript{8} carried out a pilot study of SPA-TLH in 30 patients with a modified port consisting of a wound retractor, surgical glove, and three trocar. One conversion occurred with a two-port approach (3.3%). The median operative time was 100 minutes (57-155), but the mean uterine weight was 157 g (45-482). A major factor affecting the mean operative time in the present study was the extra time required for uterine morcellation and extensive adhesiolsis.

Fader \textit{et al.}\textsuperscript{22} reported a series of 13 heterogeneous patients with various cancers who underwent SPAL using robotic and laparoscopic techniques with an average hospital stay of 0.7±0.5 days. Another study reported a median hospital stay of 3 days (2-6).

**SPA-LAVH**

The operative outcomes, including operative time, hospital stay, and estimated blood loss, in the SPA-LAVH group, were comparable to those of the conventional LAVH group (Tae-Joon Kim \textit{et al.}).

In SPA-LAVH a large uterus is more difficult to remove with a success rate of 94.6\%.\textsuperscript{9}

Ligation of the adnexal collateral vessels through a laparoscopic approach and bilateral uterine artery ligation to the vaginal approach are the mainstays of bleeding control in LAVH procedures.

SPA-LAVH for an extremely large uterus (>900 g) may be difficult, and associated with a longer operative time, more complications, and a higher conversion rate to conventional LAVH or laparotomy.\textsuperscript{9}

**CONCLUSION**

Single-port hysterectomy appears to be a technically feasible, safe, and effective procedure for the management of symptomatic patients diagnosed with leiomyoma or adenomyosis, with a uterine size < 16 weeks of gestation or weight < 560 g.

The concept of performing laparoscopic surgery via a single incision regardless of the technique is gaining traction rapidly among patients, surgeons, industry, and investors.

Conceptual development will occur as human experience grows, and techniques may be described to simplify maneuvers that currently seem complicated and more difficult than standard laparoscopic surgery.

The animal models represent a unique opportunity to acquire expertise in the technique, practice the herein-presented suggestions to improve the procedure, or even find other modifications with the same goal.

Future studies will be needed to elucidate the learning curve for this new technique and the contraindications in its use. A prospective trial comparing a standardized and successfully proven single-incision technique with conventional laparoscopic hysterectomy will be needed to show objective benefits, such as the impact on postoperative pain, recovery, wound complications, patient satisfaction, and cosmesis.

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