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Single-Port Access Laparoscopic Hysterectomy: A Literature Review

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Abstract

Background: Minimally invasive surgery has a central role in managing benign and malignant conditions in gynecology patients. While laparoscopy decreases morbidity directly related to the surgical approach, each working port used carries an inherent risk of bleeding, infection, concomitant iatrogenic visceral injury, hernia formation, and a less-satisfactory cosmetic outcome. Single-port access laparoscopy (SPAL) is either a single fascial-incision site with a single trocar with multiple ports or the use of either a single skin-incision site with multiple fascial incisions with individual trocars. Use of SPAL may be important for limiting some of the undesirable sequelae of the use of multiple ports. ***Objective:*** The purpose of this systematic review was to evaluate the feasibility, safety, and efficacy of SPAL hysterectomy. ***Materials and Methods:*** A literature search in PUBMED from 2008 to January 2014 was performed, using the key words single port hysterectomy, laparoendoscopic hysterectomy and single site hysterectomy. ***Results:*** Recently used port systems are discussed along with the advantages and disadvantages of the SPAL technique, and the indications and contraindications for use of the technique. ***Conclusions:*** SPAL hysterectomy appears to be a technically feasible, safe, and effective procedure for managing symptomatic patients who have been diagnosed with leiomyoma or adenomyosis, with a uterine size < 16 weeks of gestation or weight of < 560 g. (J GYNECOL SURG 30:329)

Introduction

MINIMALLY INVASIVE SURGERY has increasingly assumed a central role in managing benign and malignant conditions in gynecology patients. Although laparoscopy has decreased morbidity directly related to the surgical approach, it is well-known that each working port used carries an inherent risk of bleeding, infection, concomitant iatrogenic visceral injury, hernia formation, and a less-satisfactory cosmetic outcome.

Single-port laparoscopy refers to the technique of laparoscopy entry with the use of either a single fascial-incision site with a single trocar with multiple ports or the use of either a single skin-incision site with multiple fascial incisions with individual trocars.[1] Hence, the terms single-port laparoscopy can be a misnomer and may not portray accurately the technique being used. Several different acronyms exist in the literature to describe this technique including: LESS [laparoendoscopic single-site surgery], SPAL [single-port access laparoscopy], SILS [single-incision laparoscopic surgery], OPUS [one-port umbilical surgery], and NOTES (natural-orifice transluminal endoscopic surgery). Laboratory and early clinical series have shown the feasibility and safety of SPAL in general abdominal surgery, urology and, increasingly, in gynecology.[2,3]

The single-incision approach is not a new idea. In 1971, Wheeless and Thompson first published information about the technique and the results of a large series of laparoscopic tubal ligations using single-trocar laparoscopy.[4] In addition, 3600 cases, 2600 of whom had one-incision tubal ligation have been reported.[5] The first reported case of laparoscopic organ resection was not until 1981, when Tarasconi, a Brazilian obstetrician/gynecologist, performed an endoscopic salpingectomy using these techniques.[6]

Pelosi and Pelosi first performed single-port laparoscopically assisted vaginal hysterectomy and bilateral salpingo-oopherectomy (BSO) in 1991.[7] One year later, four supracervical hysterectomies with BSOs for benign uterine disease

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were reported by the same researchers. These are the first reported cases of complex extirpative pelvic surgery using a single intraumbilical incision. This surgery was not commonly performed because of its complexity.[8]

The objective of this article is to present the existing clinical evidence of the use of SPAL hysterectomy, compared to conventional hysterectomy, based on the currently available literature. A systematic search of PUBMED was performed from 2005 to January 10, 2014. The database used the term hysterectomy as the relevant medical subject heading; selected subheadings were: SPAL or single port or laparoendoscopic single site (LESS), and single port access.

Single-Port Trocars

Conventional laparoscopy, as practiced by most gynecologists, is the use of several laparoscopic port sites, which most often include an umbilical port, a right- and left-quadrant port, and possibly ports in more locations, depending on the procedure. SPAL is the technique of laparoscopic entry with the use of either a single fascial-incision site with a single trocar with multiple ports or the use of either a single skin-incision site with multiple fascial incisions with individual trocars.[9,10] However, the common factor with this technique, regardless of the type of SPAL is that the patient is left with a single skin incision at the umbilicus that is generally no larger than 1.5–2.5 cm. Single-port procedures can be performed with devices manufactured specifically for single-port surgery. Some of these devices include:

- The SILS™ port (Covidien, Mansfield, MA) system uses an hourglass elastic polymer that can accommodate three trocars varying in size from 5 to 12 mm (Fig. 1).
- The Gel Port (Applied Medical, Rancho Santa Margarita, CA) platform uses an Alexis® wound retractor and floats above incision, creating a pseudoabdomen above the umbilical ring (Fig. 2).[11]
- The Octo Port (DalimSurgNet, Seoul, Korea) 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 (Fig. 3).[12]

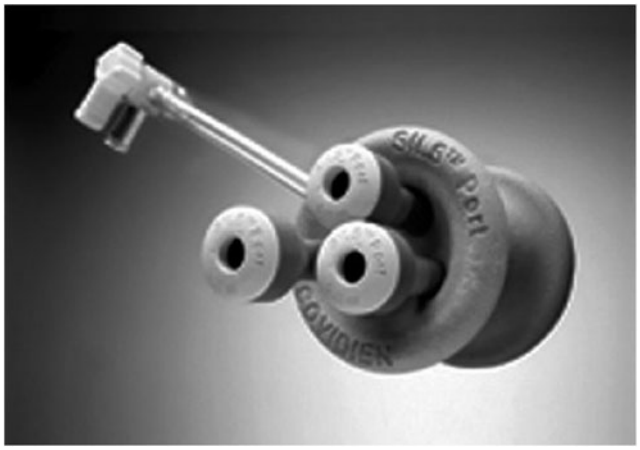

FIG. 1. SILS™ port (Covidien, Mansfield, MA). Used with permission.

FIG. 2. Gel Port (Applied Medical, Rancho Santa Margarita, CA). Used with permission.

- The X-Cone (S-Portal X-Cone; Karl Storz, Tuttlingen, Germany) is a reusable single site trocar with four integrated access ports. This new device consists of two symmetrical metal half shells that are connected and sealed by one large silicon cap containing the access ports. Current authors L. Mereu L and S. Angioni used this device, along with other researchers, in adnexal surgery for benign pathologies, including use of unilateral or BSO, adhesiolysis, excision of endometriosis, ovarian cystectomy, and myomectomy with use barbed sutures (Quill,™ Angiotech, Vancouver, Canada; V-Loc™, Covidien; Fig. 4).[1,2,13,14]
- The Cuschier Endocone® (Karl Storz, Tuttlingen, Germany) is an another trocar for SPAL; this trocar is reusable, allows ergonomic placement of the valves for multiple telescopes and instruments access; and has precise control of the telescopes and instruments because of the rigid seal cap (Fig. 5).[15]
- The TriPort (Olympus America, Center Valley, PA,), also known as the R-Port, is a device designed to be deployed through a single incision, typically at the umbilicus. This device requires a fascial incision ~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 has three ports: two 5-mm ports and one 12-mm port. To maintain pneumoperitoneum, the ports contain the same gelatin material as the Gel Port (Advanced Surgical Concepts) used for hand-assisted laparoscopic surgery (Fig. 6).[16]
- The Air Seal port (SurgiQuest, Orange, CT) involves a technology unlike to the typical trocar concept. All traditional laparoscopic ports use a mechanical barrier to maintain pneumoperitoneum while allowing instrument

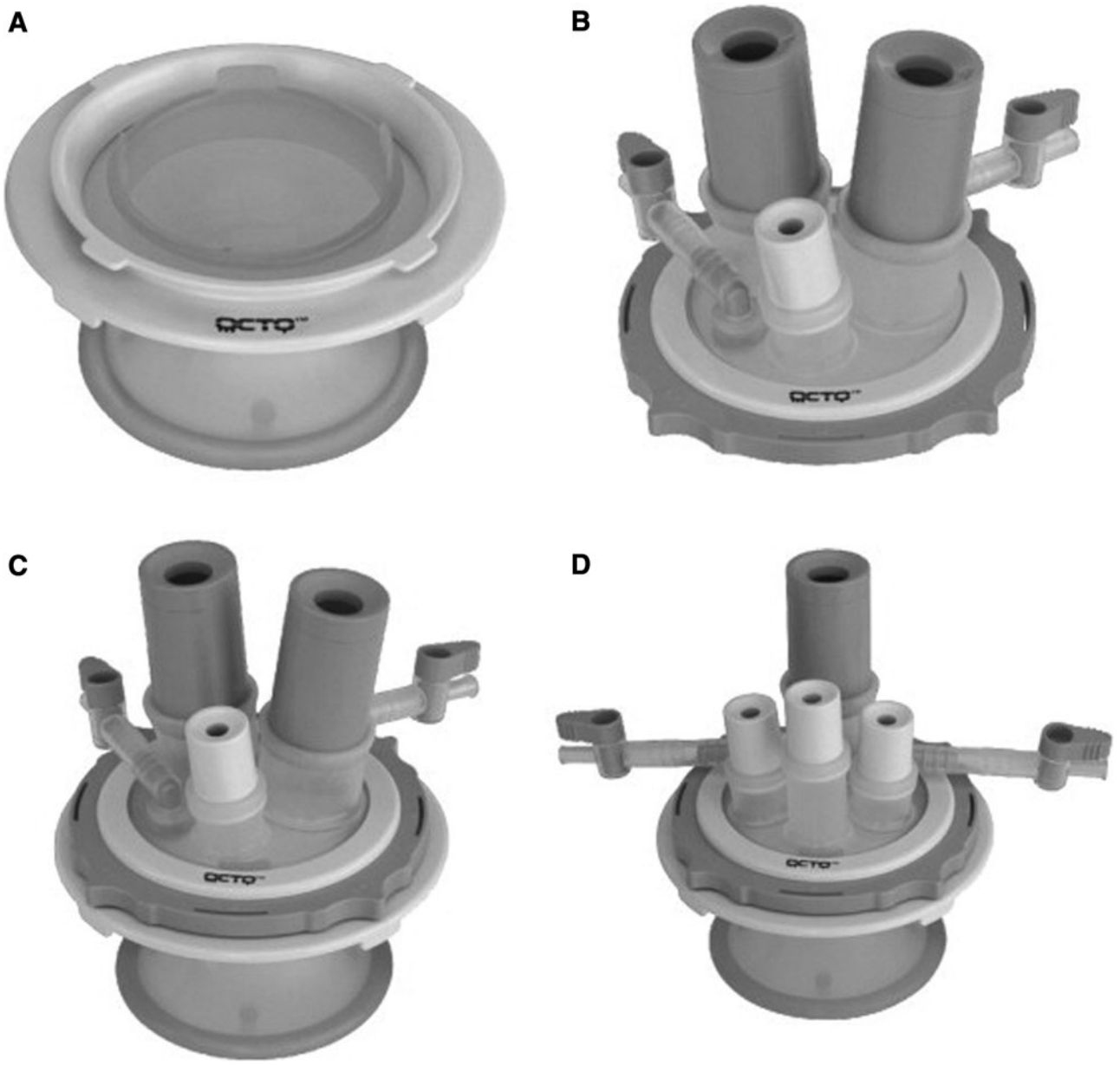

FIG. 3. (A–D). Views of Octo Port (DalimSurgNet, Seoul, Korea). Used with permission.

passage and limited specimen extraction though their lumen. Airseal port 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 (Fig. 7).[15]

- The Uni-X single port laparoscopic device, recently acquired from Pnavel Systems (Morganville, NJ,), is a system designed to allow the simultaneous use of three 5-mm laparoscopic instruments through a single fascial incision. 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 (Fig. 8).[15]

Dedicated Accessory Instruments

Two of the biggest caveats that limit use of the SPAL technique are instrument crowding and lack of triangulation. 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 maintains the best possible ergonomic positions for the surgeon and the assistant

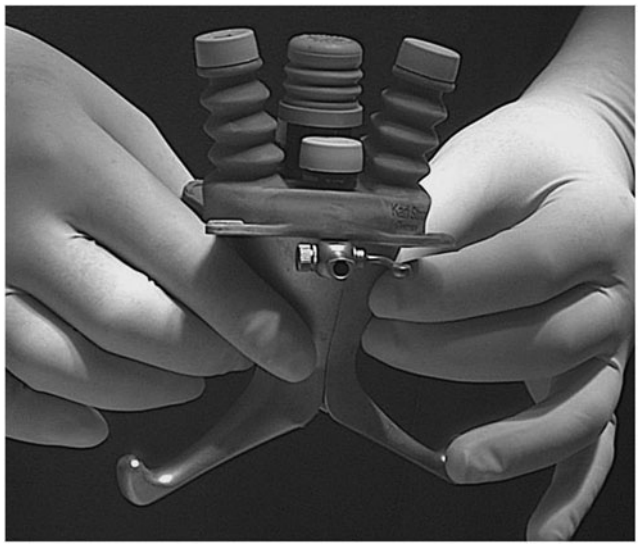

FIG. 4. X-Cone (S-Portal X-Cone; Karl Storz, Tuttlingen, Germany). Used with permission.

holding the scope (Fig. 9). 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 the external working space. In single-port surgery, 0° and 30° 5-mm laparoscopes for visualization to optimize the angle of approach to the target tissue can be used. The 30° one enables a better result in SPAL as the lateral movement of the scope can avoided and the operative field can be visualized by using a simple rotation of the instrument.

FIG. 5. Cuschier Endocone® (Karl Storz, Tuttlingen, Germany). Used with permission.

FIG. 6. TriPort (Olympus America, Center Valley, PA). Used with permission.

One system that is currently available is the rotatable 30° Visera EndoEYE (Olympus America, Center Valley, PA), which has the unique feature of a video laparoscope integrated with a coaxial light cable in line with the shaft of the telescope. The Olympus Endo Eye is currently the only laparoscope offering this unique feature, and it is available in 5-mm size in 0° and 30° configurations. This laparoscope is also available with a flexible actively deflectable tip Other special optics that may facilitate SPAL surgery included a 45° telescope (Stryker), which has a coaxial, right-angle light guide adapter to help minimize instruments' crowding.

Flexible-tip laparoscopes can be positioned favorably out of the field of view by deflection of the tip so that the external portion of the laparoscope is in a different plane than the working instruments. In addition, the insufflation tubing needs to be placed in a position so that the tubing

FIG. 7. Air Seal port (SurgiQuest, Orange, CT). Used with permission.

FIG. 8. Uni-X single port (Morganville, NJ). Used with permission.

FIG. 9. Ergonomic positions for the surgeon and the assistant holding the scope.

does not interfere with the other instruments. This will require a connection different from the currently used stopcock and Luer-lock system.

For SPAL hysterectomy, using instruments of different 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 devices with grasping, coagulating, and transecting functions (EnSeal, Ethicon, Somerville, NJ; a Ligasure sealing system (Valleylab, Boulder, CO; and an Ultracision Harmonic Scalpel Generator, Ethicon) could decrease time for inserting or removing the instruments (Fig. 10). The cuff of the vagina can be laparoscopically sutured with interrupted or barbed sutures. The knotting technique can be difficult 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. The vaginal cuff can be also repaired with interrupted sutures extracorporeally or transvaginally.

The Literature Search

A literature search in PUBMED from 2008 to January 2014 was performed, using the key words single port hysterectomy, laparoendoscopic hysterectomy and single site hysterectomy.

Reich et al. first performed laparoscopic assisted vaginal hysterectomy (LAVH) in 1989 in patients who were unable to undergo total vaginal hysterectomy, and performed total laparoscopic hysterectomy (TLH) successfully in 1994.[17] To date, many studies have proven the feasibility and efficacy of laparoscopic TLH and its technique development.[18,19]

More recently, the experiences of surgeons using a new transumbilical single-port access (SPA) approach for TLH, subtotal, and LAVH hysterectomy have been reported by several endoscopic centers.[20]

Single-port access total laparoscopic hysterectomy (SPA-TLH) was first performed in 2008, and, in many cases, has replaced conventional laparoscopic surgery. Langebrekke and Qvigstad described total laparoscopic hysterectomy through a single-port without vaginal surgery.[21] They

FIG. 10. Use of a multifunction instrument (EnSeal PTC•Trio, Ethicon, Somerville, NJ). to seal and cut the left round ligament and salpinx. Used with permission.

reported performing vaginal closure using bidirectional barbed sutures; compared with traditional sutures, the benefits of the bidirectional self-retaining sutures with tissue retainers (barbs) included speed and economy of suture placement.[21]

In 2010, Jung et al. reported initial clinical experience with using scarless, single-port, transumbilical laparoscopic hysterectomy.[22] Twenty-nine of 30 patients underwent single-port laparoscopic surgery without conversion to laparotomy or conventional laparoscopic hysterectomy. The median operative time was 100 minutes (range: 57–155 minutes), the median blood loss was 100 mL (range: 10–400 mL), the median postoperative hospital stay was 3 days (range: 26 days), and the median weight of resected uteri was 167 g (range: 45–482 g). Visual analogue scoring of pain at 6, 24, and 48 hours was 4,3, and 2, respectively. There were no operative complications.[22]

Also in 2010, Yim et al. retrospectively reviewed 157 patients who underwent SPA-TLH ($n=52$) or conventional TLH ($n=105$), comparing surgical outcomes and postoperative pain between the two groups of patients.[23] The SPA-TLH group had less intraoperative blood loss ($p<0.001$), shorter hospital stay ($p<0{,}001$), and earlier diet intake ($p<0.001$), compared with the conventional TLH group. There was no difference in perioperative complications. Immediate postoperative pain scores were lower in the SPA-TLH group ($p<0.001$). Postoperative pain after 6 and 24 hours was lower in the SPA-TLH group, with marginal statistical significance.[23]

Also in 2010, Kim et al. compared the perioperative outcomes, including the operative time, length of hospital stay, and postoperative pain for two groups of patients, SPA-LAVH and conventional LAVH, in a retrospective study.[24] The operative time, estimated blood loss (EBL), drop in hemoglobin preoperatively to postoperative day 1, and postoperative hospital stay were comparable between groups. SPA-LAVH was associated with significantly reduced postoperative pain 24 and 36 hours after surgery. There were no complications (such as reoperation, adjacent organ damage, and any postoperative morbidity) and no umbilical complications caused by using SPA. This case-control study was the first that compared the operative outcomes between SPA and conventional laparoscopy in gynecologic procedures.[24]

Subsequently, in 2011, Jung et al. had a randomized prospective study published.[25] This study compared single-port transumbilical total laparoscopic hysterectomy and four-port TLH in terms of postoperative pain, concluding that reduction of postoperative pain was not evident with single-port transumbilical TLH.[25]

Also in 2011, Lee et al. performed a prospective comparison of single-port LAVH using transumbilical GelPort access and multiport LAVH.[11] The researchers reported that there were no statistical differences between the groups with respect to patients' demographic characteristics, median operating times (92.5 versus 90 minutes; $p=0.479$), hospital stays (3 days for both groups; $p=0.554$), complication rates (3.8% versus 4.3%; $p=1.000$), and rates of using an additional trocar or conversion to laparotomy (1.3% versus 0.6%; $p=0.553$).[11] Also in 2011, Phongnarisorn and Chinthakanan evaluated, in a retrospective study, the feasibility, safety, and perioperative outcomes of single-incision laparoscopic hysterectomy, using conventional laparoscopic instruments for treatment of patients with symptomatic leiomyoma and/or adenomyosis.[9] Eleven consecutive patients, 10 whom were diagnosed with leiomyoma and 1 who was diagnosed with adenomyosis, underwent SPAL hysterectomy successfully during the study period, without conversion or requirement of any extra port. The average clinical uterine size and uterine weight were 13.2 ± 2.48 week's gestation and 281.6 ± 152.89 g, respectively. The mean operative time was 163.3 ± 20.46 minutes. The mean EBL and drop in hemoglobin level were 114.5 ± 48.65 mL and 0.33 ± 0.62g/dl, respectively. No intraoperative complications occurred. Postoperative febrile morbidity was found in two patients. The follow-up at 14 days and 6 weeks postoperatively was uneventful.[9]

In 2012, Li et al. compared transumbilical SPAL with traditional laparoscopic hysterectomy in a prospective randomized trial.[26,27] Although SPAL was associated with significantly longer duration of surgery, SPAL was also associated with shorter duration of immobilization, lower rate of port-site infection, and higher patient satisfaction than TLH.[26,27]

In 2013, Choi et al., in a retrospective study, evaluated the surgical outcome and complications of single-port versus conventional multiport-access (MPA) LAVH.[28] These researchers reported that use of SPA and MPA-LAVH produced similar results in terms of surgical outcomes and complications.[28]

SPAL reduces the morbidity of additional incisions and improves the final cosmetic outcome but initially needs longer operating time, and a surgeon who is already experienced in laparoscopic surgery needs learning time by performing SPAL in a certain number of cases. Laparoendoscopic single-site gynecologic surgery is associated with a low risk of major events. In a retrospective clinical study by Gunderson et al, in 2012, the overall umbilical hernia rate was 2.4% and was lower (0.5%) in subjects without significant comorbidities.[29]

In 2009, Lee et al. described their initial experiences with SPA-LAVH, using a wound retractor and a glove.[30] These researchers performed SPA-LAVH in 24 patients for benign conditions, including 16 uterine myomas and 8 cases of adenomyosis; all of the surgeries but three were performed exclusively through a single port. The median operative time, weight of the uterus, and EBL were 119 minutes (range: 90–255 minutes), 347 g (range: 225–732 g), and 400 mL (range: 100–1000 mL), respectively. The median hospital stay (postoperative days) was 3 days (range: 3–7 days). The researchers concluded that the SPA-LAVH approach was safe and effective, and that the procedure could be learned in a short period of time. In fact, the researchers compared an initial 10 cases (group A) and a latter 14 cases (group B) to consider the learning curve. There was a tendency toward decreased operative time in group B, although the difference was not significant.[30] Surgical time might be directly related to the size of the uterus.

In 2010, Song et al., described a prospective single-center study, that involved initial experience with SPA-LAVH in 15 patients with an extirpated uterine weight of >500 g.[31] The median operation time, weight of the uterus, and EBL were 125 minutes (range: 80–236 minutes), 690 g (range: 503–1260 g), and 500 mL (range: 150–1000 mL), respectively. There was a significant linear correlation between the operation time and the extirpated uterine weight ($p<0.002$). The SPA procedure failed in 2 cases: 1 (uterine weight, 732 g)

required 1 ancillary 5-mm port to manipulate with a myoma screw, and in the other, the researchers inserted one additional 15-mm port to use for a laparoscope morcellator. There were no umbilical complications, additional procedures, or surgical complications.[31]

Wang et al., in a 2012 prospective study, compared perioperative surgical outcomes and complication rates between single-port TLH and conventional four-port TLH.[32] There were no statistically differences in blood loss, hemoglobin changes, length of postoperative hospital stays, and complication rates. However, the mean operative time of the single-port group was significantly longer than that of the four-port group. The operative time for vaginal stump suture was profoundly decreased with experience in the single port-group. The operative time decreased in the single-port group with increasing experience on the part of the surgeons.[32] Even subtotal hysterectomy has been proposed using SPAL.

In 2010, Yoon et al. evaluated the feasibility, safety, and operative outcomes of managing myomas and adenomyosis using SPA subtotal hysterectomy with transcervical morcellation using a wound retractor and a surgical glove.[33] SPA subtotal hysterectomy was completed successfully in all 7 patients included in the study without any serious complications during surgery. The mean operative time was 157 minutes (range: 140–233 minutes), the mean morcellation time was 35 minutes (range: 28–100 minutes), the mean uterus weight was 300 g (range: 168–427), the mean EBL was 200 mL (range: 100–300 mL), and the mean hospital stay was 4 days (range: 3–4 days).[33]

In 2012, Wenger et al. described a case of supracervical hysterectomy via single-site laparoscopic surgery with transcervical morcellation after endocervical resection.[34]

Single-port hysterectomy was first performed for benign uterine pathology and later proposed even for use in oncology. In fact, in 2009, Fader and Escobar reported the first series of single port–site hysterectomy for treating various gynecologic oncologic conditions through single 2–3-cm umbilical incisions with a multichannel SILS port for laparoscopic cases.[35] In a 2011 article, Fader et al. reported that all of these procedures were performed successfully via a single incision and no postoperative complications occurred.[36] The majority of patients required no narcotics postoperatively.[35,36]

Subsequently, in 2011, Mohd and Siow described a case of a 40-year-old-woman with microinvasive squamous-cell carcinoma of the cervix. She was operated on successfully, using SPA-TLH with intracorporeal suturing of the vault.[36] Unique articulated and multifunction laparoscopic instruments were used to complete the surgery in 118 minutes, with no complications. The patient had minimal pain postoperatively.[37]

Fanfani et al. presented a pilot study in 2012, of the surgical treatment of endometrial cancer with single-port hysterectomy, concluding that this approach could represent a surgical option for extrafascial hysterectomy in patients with early stage endometrial cancer.[38] The technique, according to the researchers, has the potential to decrease invasiveness of the conventional laparoscopic approach further, and produces satisfactory results in terms of cosmetic outcome and postoperative pain.[38]

In 2014, Boruta et al. described a retrospective study of the feasibility, safety, and good outcomes of women with stage I cervical cancer treated with laparoendoscopic single-site radical hysterectomy with pelvic lymphadenectomy (LESS-RH/PLND), concluding that it could be used for select patients with stage I cervical cancer.[39] These researchers cautioned that the limitations of their study included the retrospective nature of the study and its susceptibility to all biases inherent in such a design, as well as lack of data on long-term surgical and oncologic outcomes.[39]

Recently, in 2014, Park et al compared the feasibility, safety, and efficacy of LESS surgical staging for early stage endometrial cancer with conventional laparoscopic surgical staging, concluding that LESS surgical staging was feasible and was associated with less postoperative pain and analgesic requirements and was comparable to conventional laparoscopic surgical staging in perioperative outcomes.[40]

Conclusions

Single-port laparoscopic surgery could represent the next step forward in minimally invasive surgery. The most apparent benefit of single-port surgery is improved cosmesis, with the surgical incision hidden in the umbilicus rather having a small (3–5-cm) abdominal incision that shows.

In 2013, Song T. et al, in a randomized controlled trial, compared cosmetic satisfaction with SPAL surgery with multiport surgery in patients who underwent LAVH via SPAL or multiport surgery.[41] The SPAL approach produced an advantageous cosmetic outcome; this assessment was performed with the Body Image Questionaire at baseline and at 1, 4, and 24 weeks after surgery.[41]

Nevertheless, many questions must be answered and research must be performed to support the general application of SPAL. While initial series in the urologic, general surgery, and gynecologic literature have demonstrated the safety, esthetic superiority, and potential improved pain profile of a single-port approach, compared with conventional laparoscopy, these early findings must be validated further. The published studies generally present small numbers of patients, and there is not yet complete agreement, particularly with respect to postoperative pain reduction, compared to to conventional laparoscopy.

Single-port hysterectomy appears to be a technically feasible, safe, and effective procedure for manging symptomatic patients diagnosed with leiomyoma or adenomyosis, with a uterine size < 16 weeks of gestation or weight < 560 g. Some studies have shown evidence of a longer operative time related to surgical experience or to uterine size.

The training of the surgeons on virtual or animal models represents a unique opportunity to acquire expertise in this technique, practice the suggestions presented herein to improve the procedure and improve surgical time. More prospective trials 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.

Disclosure Statement

The authors certify that they have no have actual or potential conflicts of interest in relation to this article.

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