Arch Gynecol Obstet (2014) 289:725–731
DOI 10.1007/s00404-013-3129-9

REVIEW

Single-site port robotic-assisted hysterectomy: a systematic review

Christos Iavazzo · Ioannis D. Gkegkes

Received: 29 March 2013 / Accepted: 12 December 2013 / Published online: 27 December 2013
© Springer-Verlag Berlin Heidelberg 2013

Abstract
Introduction Robotic single-port hysterectomy is a rather new technique.
Materials and Methods We performed a systematic literature review to evaluate the till-now evidence regarding the use of robotic single-port hysterectomy technique as a method of management in gynecological pathologies.
Results The till-now used port systems are discussed. The advantages and disadvantages of such a technique, as well as the indications and contraindications of it are also presented. Such a technically challenging operation seems to have similar results regarding blood loss and surgical time while the cosmetic outcome is better compared to the classic robotic hysterectomy. The technical difficulties include loss of instrumental triangulation, reduced operative working place, reduced visualization, instrumental crowding and clashing. The ways to overcome such difficulties are also described.
Conclusion The need of technique standardization is the future aim.

Keywords Single port · Laparo-endoscopic single site · Robotics · Hysterectomy

C. Iavazzo (✉)
IASO Maternity Hospital, 38, Seizani Str.,
Nea Ionia, 14231 Athens, Greece
e-mail: christosiavazzo@hotmail.com

I. D. Gkegkes
Department of Surgery, Korinthos General Hospital,
Corinth, Greece

Introduction

During the past decade, minimally invasive surgery including robotic-assisted surgery has been established as a new option in the standard of care in gynecological oncology [1]. Although some would argue that there is the disadvantage of longer operative time and higher cost, this new method is characterized by accuracy in surgical steps, less blood loss, shorter recovery time, shorter hospital stay, less wound complications and increased patient comfort [2]. In 2006, Sert and Abeler [3] have performed the first robotic-assisted radical hysterectomy with lymphadenectomy, having optimal clinical results. Laparoscopic single-port hysterectomy was first performed by Langebrekke in 2009 [4]. One of the latest advances in the field of minimally invasive surgery is the use of single port in the robotic-assisted surgery. Robotic single-port hysterectomy was first performed by Fader in the year 2009 [5]. The presence of single-site port requires only one entry point, normally situated at the umbilical region [1]. The decrease in the number of surgical ports represents an attempt to achieve further reduction in port-associated complications, improvement of the cosmetic results and faster recovery.

The objective of this article is to present the existing clinical evidence of the use of single-port robotic-assisted hysterectomy as a method of management in gynecological pathologies, based on the currently available literature.

Methods

Data sources

This review was performed by a systematic electronic search in PubMed (29 December 2012) and Scopus (29

December 2012). Both in PubMed and in Scopus databases, the search strategy which was applied included the combination of the key words: (LESS OR single port OR laparoendoscopic single site) AND (robot OR robotic OR telesurgery) AND hysterectomy. A hand search of the references of both potentially relevant articles and articles qualifying for inclusion was also performed.

Study selection criteria

Studies reporting data on the single-port robotic-assisted hysterectomy were considered includable for this review. Abstracts in scientific conferences, editorials, letters to the editor, animal studies as well as studies published in languages other than English, German, French, Italian, Greek and Spanish were not included in this review.

Results

The performed search in PubMed and Scopus retrieved a total of 63 and 150 search results, respectively, among which six studies (2 case series and 4 case reports) that were meeting the inclusion criteria of our review. No further studies were found to be included through hand-searching of references. The included studies were represented graphically in Fig. 1 (flow diagram).

The major characteristics of the studies included in our review (study design, the number of patients included in each study, the age, body mass index and diagnosis of the patients, the duration of the procedure, the blood loss due to the operation, the weight of the removed uterus, the conversion rate to three-port robotic or open procedures, the need for post operative transfusion, the postoperative complications, the post-operative hospital stay, the duration of follow up and the evaluation of scar cosmesis) are presented in Table 1.

In this study, 16 patients were included in total. Their age ranged from 34 to 70 years. The body mass index of the included patients ranged from 15.8 to 35.8 kg/m^2. In 10 out of 16 patients, hysterectomy was performed due to benign diagnosis (such as menorrhagia, endometriosis). The oncologic diagnosis of the rest of the patients was endometrial adenocarcinoma (4 out of 16), cervical cancer (1 out of 16) and in situ cervical carcinoma (1 out of 16). In two patients a prophylactic hysterectomy was performed. Regarding the duration of the procedure and the relative blood loss, they ranged from 105 to 311 min and 10 to 750 ml, respectively. The weight of the removed uteri ranged from 40 to 310 g. None of the included patients presented any post-operative complications such as urinary infection, wound infection, ileus or normal site hernia. In 1 out 16 patients there was the need of conversion to three-port robotic surgery due to severe pelvic adhesions, while there was no case where blood transfusion was needed. The post-operative hospital stay varied from 1 to 6 days. There was no information on the post-operative follow-up and scar cosmesis in any of the included tests.

Surgical technique

The patient is placed in the typical low lithotomy position and in Allen stirrups (Universal Medical Inc; Foxboro, MA). The arms are properly placed at the sides. A standard V-Care uterine manipulator (Conmed Endosurgery Utica, New York) and a Foley catheter are placed. ViKY can also be used as surgeon's third hand. A single, vertical incision (from 2.5 to 3 cm) is usually made at the base of the umbilicus via an open Hasson approach. A single-port device such as put names of devices (which permits the position of an 8.5 mm high-definition (HD) camera, two curve robotic cannulae and an insufflator port as assistant port) is placed through the incision with the use of a Mayo-Guyon clamp. The abdomen is insufflated to 15 mmHg with carbon dioxide.

The daVinci robot is docked between the legs. The body of the patient is then positioned in a Trendelenburg position (in 30–35°). The 30° robotic camera is best to be positioned upward to reduce collisions between the instruments and camera and provide increased space for instruments to move. The exposure of pelvis is succeeded by folding both the small bowel and the rectosigmoid colon out of the pelvis with the use of atraumatic graspers. Moreover, in hysterectomy and lymph node dissection, the HD camera, the curved scissors, the cadiere graspers (5 mm) as well as the electrocautery are placed in a 30° down scope. The surgical assistant can place an endoscopic suction device and a standard atraumatic laparoscopic grasper through the port.

Simple hysterectomy technique

The ovaries are examined. The round ligament is ligated and the retroperitoneal space is opened to identify the ureter. The infundibulopelvic ligament is coagulated and ligated. The bladder flap is developed and then similar steps are performed contralaterally. The uterine arteries are skeletonised and ligated. The bladder is dissected below the colpotomy cup and then a colpotomy is performed. The uterus and adnexae are removed through the vagina and then vaginal cuff is closed with interrupted sutures, barbed sutures or V-lock suture. In cases of younger patients with benign diagnosis or scuamous cell carcinomas, the ovaries could be preserved to avoid menopausal symptoms.

Pelvic lymphadenectomy technique

Peritoneum located between the external iliac artery and psoas muscle is elevated and incised along to the artery.

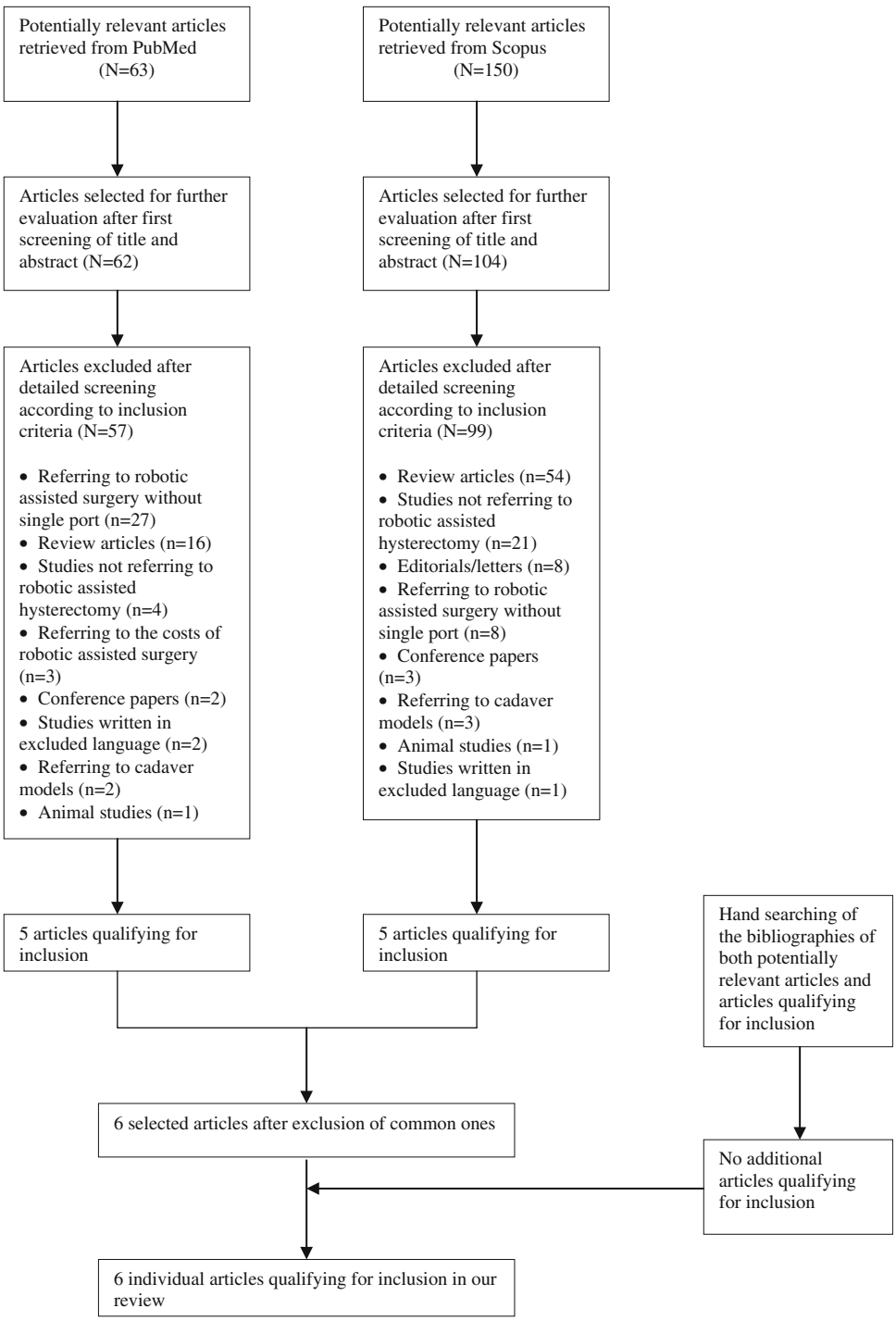

Fig. 1 Flow diagram of the detailed process of selection of articles for inclusion in the review

Furthermore, external iliac vessels are subsequently cauterized and located anterior and laterally, away from the muscle psoas, avoiding the possibility of injury to the genitofemoral nerve, collocated anteriorly along the muscle. Paravesical and pararectal spaces are then created by gentle dissection using the Cadiere grasper. All nodal tissue is removed from the mid portion of the common iliac artery superiorly, to the circumflex iliac vein inferiorly, as well as from the mid-portion of the psoas muscles laterally, to the ureters and the hypogastric artery and vein medially. Furthermore, the nodal tissue within the obturator fossa is also dissected and excised, anterior to the obturator nerve and vessels. The excised nodal tissue is placed in a sterile endoscopic bag placed through the assistant channel within the single-port device and the bag is left in the pelvis or right paracolic gutter until the end of the procedures. Dissection of the left pelvic lymph nodes is performed in a similar fashion and within the same anatomic boundaries as

Table 1 Studies referring to robotic single port hysterectomy

First author, year, country (Ref)	Publication type	No of patients	Age of patient (in yrs)	BMI (kg/m^2)	Diagnosis	Port system applied	Duration of the procedure (in min)	Blood loss (in ml)	Uterus weight (in gr)	Conversions (%)	Transfusion needed	Hospital stay (in days)	Compli-cations	Follow up	Cosmesis
Lue, USA [16]	Case report	1	46	NR	Menorrhagia, multiple leiomyomas	SILS Port	180	25	NR	No	No	NR	–	NR	NR
Mereu, Italy [17]	Case series	4	NR	Median (range): 25.65 (22–29.3)	Endometrial adenocarcinoma	Gelport	Median (range): 183 (160–250)	Median: 50	NR	No	No	2	–	NR	NR
Nam, Korea [10]	Retrospective study	7	Median (range): 48 (34–70)	Median (range): 21.9 (15.8–35.8)	5/7 (myomas), 1/7 (cervical cancer, stage IB1),1/7 (in situ cervical carcinoma)	Alexis Wound Retractor	Median (range): 109 (105–311)	Median (range): 100 (10–750)	Median (range): 200 (40–310)	1/7 (14.3)[a]	No	Median (range): 4 (3–6)	–	NR	NR
Kane, USA [18]	Case report	1	37	NR	Recurrent endometriosis	SILS Port	172	50	180	No	No	NR	–	NR	NR
Escobar, USA [19]	Case report	1	60	26	Prophylactic hysterectomy[b]	Gelport	168	80	NR	No	No	NR	–	NR	NR
Fader, USA [5]	Retrospective cohort study	2	59 49	27 20	Prophylactic hysterectomy[c]	NR NR	178 145	NR NR	NR NR	No	NR NR	1 1	– –	NR NR	NR NR

USA United States of America, *no* number, *NR* not referred, *BMI* body mass index, *yrs* years

[a] To 3-port robotic surgery due to severe pelvic adhesions

[b] Patient with BRCA(+) breast cancer

[c] Breast cancer, BRCA1(+), on tamoxifen: risk-reducing extrafascial hysterectomy combined with bilateral salpingo-oophorectomy

the right pelvic lymph nodes. At the end of pelvic lymphadenectomy, the nodal tissue is placed in an endoscopic bag. Moreover, the round ligaments are then dissected bilaterally with the Cadiere grasper. In addition, infundibulopelvic ligaments are cauterized and transected. The creation of the bladder flap is performed with the use of curved scissors and electrocautery (monopolar energy), while uterine vessels are skeletonized and dissected with the Maryland bipolar forceps. A colpotomy is then performed when the bladder is completely dissected below the cervico-vaginal junction. The created vaginal cuff is closed with interrupted 1–0 Vicryl suture, barbed sutures or V-lock suture. In the case of a radical hysterectomy, we further proceed with the removal of the paracervical tissue/parametria. The ureters are mobilized, the reflection of the bladder is more extended and upper vaginectomy is also performed.

Discussion

Minimal invasive surgical techniques are currently considered as a valuable alternative to laparotomy. Although laparotomy is a valued technique, minimal invasive techniques including laparoscopic and robotic management have already become the standard of care.

Laparo-endoscopic single-site surgery (LESS) and natural orifice transluminal endoscopic surgery (NOTES) are thought to be valuable surgical techniques [6, 7]. Regarding the application of single-site port in the field of gynecologic surgery, we should mention that it is not a novelty of the past decade. In 1973, Wheeless et al. [8] reported a rapid and effective surgical sterilization on 3,600 women with the use of single trocar laparoscopy. Consequently, Pelosi et al. [9] completed the first hysterectomy by a single-trocar technique in 1991. Regardless of these first efforts, the application of single-site port did not become a standard of care in gynecologic surgery. Technical issues, such as the lack of specifically designed port systems, the absence of special articulating/rotating instruments or nonexistence in specific optical systems, have prevented the wide use of single-port surgical technique.

From the analysis of the data retrieved, it can be shown that single-port-hysterectomy can be used even in patients with cervical cancer treated with radical hysterectomy. Of course, the duration of the procedure is longer and technically more challenging and it as shown that the blood loss is more and the hospital stay longer [10]. However, it should be mentioned that till now only Nam et al. have performed a single-port robotic radical hysterectomy and for this reason operative time, blood loss and hospital stay might decrease as the experience in the surgical field increases. Regarding the postoperative pain, Jung et al. [11] showed that it is similar to the four-port technique. Single-port robotic hysterectomy is a safe technique with excellent cosmetic results and patient satisfaction.

At present time, there are available several port systems. Some of these single use multichannel single-port systems include the GelPort (Applied Medical, Rancho Santa Margarita, CA), triport-quadport (Advanced Surgical Concepts, Wicklow, Ireland), the SILS port system (Covidien, Mansfield, MA), octoport (C-308, High Tech Center, Seoul, Korea) and the surgical glove made port. The Gelport system consists of a wound retractor with a flexible inner ring joined to an outer ring with a clear cover. The retractor can be used in incisions from 1.5 to 7 cm. The presence of multiple trocars of varying diameters through the gel interface can be easily modified, suitable for single-port laparoscopy. The advantages of the GelPort laparoscopic system consists of the fact that the existence of the 10-cm diameter of the outer ring can reduce the instrument crowding. Moreover, GelPort can also be used in obese patients with deep abdominal wall (>10 cm). On the contrary, the utilization of stiff materials through trocars can limit instrument movements [1]. TriPort as well as quadport are both multichannel access ports which permit the placement and the removal of multiple instruments without the loss of pneumoperitoneum. The triport has two 5-mm ports and one 12-mm port and can be used with fascial incisions ranging from 12 to 25 mm while quadport provides 4 ports, 5-mm port, 15-mm port and two of 10-mm ports, respectively, and is appropriate for fascial incisions with range from 25 to 65 mm. QuadPort has the advantage over the triport when organ retrieval would require a larger fascial incision. The variability of the angle at the different ports assists in the reduction of instrument crowding. The main disadvantages are the possibility of sleeve damage having as consequence the loss of pneumoperitoneum and the 10-cm maximum depth that can delimit the application of the device in obese patients. The SILS port is a flexible port which requires a fascial incision of 1.8–3 cm and can induce 1–3 instruments simultaneously through a single incision. The major advantages of the SILS device include the easy placement technique and the flexible material of the ports that make easier the instrument manipulation. In addition, SILS port uses a traditional laparoscopic seal which diminishes gas leak. In case organ retrieval, the limited dimensions of instruments impose the port removal to pass through the facial incision. OctoPort is also a multichannel port which has four ports of variable diameter from 5 to 12-mm and can be utilized with fascial incisions ranging from 15 to 50 mm. The 360^{o} rotation of the device, the possibility of easy removal of surgical specimens during the operation and the use of pliable materials (silicon) that permit greater manipulation of instruments are the major advantages of octoport. On the

other hand, the expensive setup of this port could be considered as the main disadvantage. The utilization of surgical gloves with conventional wound retractors has not any limitation as far as the diameter of the used ports and the length of the necessary facial incision. The main advantage of this economic method is that due to the fact that latex is a pliable material and permits greater manipulation of instruments. On the other hand, the bulky setup can potentially allow the loss of pneumoperitoneum due to the presence of gas leak, while the removal for organ retrieval could be time-consuming.

The evolution of robotic-assisted technique led to overcome the technical difficulties (loss of instrumental triangulation, reduced operative field, reduced visualization, instrumental crowding and clashing) in the use of single-site ports. As it is known, the robotic-assisted LESS offers several advantages over conventional laparoscopy; among them, greater dexterity, tremor filtration and three-dimensional vision [11]. Nam et al. [10] showed that the docking time can be reduced and the majority of the surgical time is correlated with the console and the vault suture time. Simultaneously, the development of multichannel port systems facilitates the realization of complex surgical procedures in gynecological oncology, such as radical hysterectomy. Paraaortic lymph node dissection has been already performed up to the level of inferior mesenteric artery [10]. However, many could argue that laparoscopic radical hysterectomy, trachelectomy or paraaortic lymphadenectomy could be thought to be the surgical frontiers while the oncologic outcome needs further investigation.

Although, the development of such new port systems and instrument designs is characteristic, there remain some technical issues in operating through a single port that should be taken into consideration. For example, the instrument crowding and the absence of triangulation are some of the most frequent technical challenges. For this reason, the variety of movements is limited due to the proximity of the instruments. This problem could be overcome in many ways. The change of the laterality of the arms in the current available robotic platform (da Vinci Surgical System, Intuitive Surgical, Inc, Sunnyvale, California, USA) can overwhelm the issue of instrument proximity, even though this may not be the most practical solution in simple cases for the reason that it can add both operating time and increase the total cost. Furthermore, another option is that surgeons can simply cross the instruments. Nevertheless, this may cause counterintuitive movements as the surgeon manipulates the instruments on the reverse side of the surgical field. Last but not least, the use of surgical ports with a larger outer cap, such as the Gel-POINT access device, can increase the instrument distance. In traditional laparoscopy, triangulation represents a necessary condition to provide the minimal flexibility for rigid instruments and ports that provide minimal flexibility. Nonetheless, the presence a single site port for both the camera and the instruments eliminate the effect of triangulation. The development of proximally curved coaxial instruments with double bending (S-Portal curved instruments, Karl Storz GmbH & Co. KG), permits the crossing over and allows the proper instrument triangulation. In addition, the presence of robotic system is in position to adjust the reversal movements of surgeon's hands. Finally, the possible future use of flexible endoscopes can also improve the practicality of robotic LESS and may increase the range of its applications [12].

On the other hand, it should also be mentioned that single site port robotic-assisted hysterectomy has some patient-related limitations. The selection of umbilicus as the entry point of the single surgical trocar limits the number of patients candidate for robotic-assisted LESS based on the patient's body mass index (BMI) [12]. This can be improved using 5 mm instead of 8 mm robotic ports as well as by using a robotic camera at 30° down or up to avoid instrument crowding. This type of adjustment can create the essential spacing of the camera arm as far as possible from the robotic arms. Further queries could be raised either regarding the possible increased possibility of port site metastasis in such patients or the gas leaking from some port systems caused by the various movements of the robotic arms. For this reason, longer follow-up period is necessary to clarify this possibility.

The learning curve of the technique is not clearly discussed in any of the studies. Single-port robotic hysterectomy seems to be a safe technique that can be learned by skillful surgeons in as less number of cases. Paek et al. [13] suggested that the learning curve and proficiency could be achieved after 40 cases; however, none of the included studies presents results from such a large number of patients. However, Escobar et al. [14] showed in an animal model that this technically challenging procedure could be performed in acceptable operating times without complications or transformation to three port or open techniques. The same author also showed in the cadaver models that single-port robotics can be performed in 87.5 % of the cases [15].

A number of limitations should be taken into consideration in the analysis of the findings of this study. The number of the included studies in addition to the total number of the patients included in these studies is small showing that the application of single port in robotic-assisted hysterectomy is a novel technique which is in evolution. Till now, although radical hysterectomy has been performed by the technique, the majority of the cases used for LESS are well selected, including for example prophylactic hysterectomies in BRCA carriers meaning

Table 2 Possible indications and contraindications in the utilization of single site port robotic assisted hysterectomy

Indications	Contraindications
Low body mass index	Metastatic disease/ carcinomatosis
Good physical status of the patient	Poor pulmonary function
Clear surgical history	Extensive prior umbilical surgery
Young age	Morbid obesity
	Central obesity
	Uterus of large dimension

that till now the technique needs standardization. Possible indications and contraindications of the technique should be further clarified (Table 2). In addition, case series or even better randomized control trials are essential with the intention of not only to standardize this technique but also to compare the complication rates between the multichannel and single site port surgical method. Last but not least, regarding our literature search, although it is extensive at its range, it could be considered selective by excluding abstracts, conference papers and editorials.

Conclusion

In conclusion, single-site port robotic surgery is currently in its infancy and the evolution of the existing technology will be capable to impose this kind of technique in everyday practice for various surgical fields. Specifically, in gynecologic surgical practice, the existing evidence on the use of single-site ports robotic surgery seems to be promising. Nevertheless, further studies are needed to be done in order to define better the ideal robotic-assisted operative procedures for single-site hysterectomy, which will continue to evolve with the development of new instrumentation; optics and robotic platforms are incorporated into the standard surgical treatment.

Conflict of interest None.

References

1. Uppal S, Frumovitz M, Escobar P, Ramirez PT (2011) Laparoendoscopic single-site surgery in gynecology: review of literature and available technology. J Minim Invasive Gynecol 18:12–23
2. Geetha P, Nair MK (2012) Laparoscopic, robotic and open method of radical hysterectomy for cervical cancer: a systematic review. J Minim Access Surg 8:67–73
3. Sert BM, Abeler VM (2006) Robotic-assisted laparoscopic radical hysterectomy (Piver type III) with pelvic node dissection—case report. Eur J Gynaecol Oncol 27:531–533
4. Langebrekke A, Qvigstad E (2009) Total laparoscopic hysterectomy with single-port access without vaginal surgery. J Minim Invasive Gynecol 16:609–611
5. Fader AN, Escobar PF (2009) Laparoendoscopic single-site surgery (LESS) in gynecologic oncology: technique and initial report. Gynecol Oncol 114:157–161
6. Gargiulo AR, Nezhat C (2011) Robot-assisted laparoscopy, natural orifice transluminal endoscopy, and single-site laparoscopy in reproductive surgery. Semin Reprod Med 29:155–168
7. Jernigan AM, Auer M, Fader AN, Escobar PF (2012) Minimally invasive surgery in gynecologic oncology: a review of modalities and the literature. Womens Heal (Lond Engl). 8(3):239–250
8. Wheeless CR Jr (1973) Thompson BH. Laparoscopic sterilization. Review of 3600 cases. Obstet Gynecol 42:751–758
9. Pelosi MA, Pelosi MA 3rd (1991) Laparoscopic hysterectomy with bilateral salpingo-oophorectomy using a single umbilical puncture. N J Med 88:721–726
10. Nam EJ, Kim SW, Lee M et al (2011) Robotic single-port transumbilical total hysterectomy: a pilot study. J Gynecol Oncol 22:120–126
11. Jung YW, Kim SW, Kim YT (2009) Recent advances of robotic surgery and single port laparoscopy in gynecologic oncology. J Gynecol Oncol 20:137–144
12. Escobar PF, Starks D, Fader AN, Catenacci M, Falcone T (2010) Laparoendoscopic single-site and natural orifice surgery in gynecology. Fertil Steril 94:2497–2502
13. Paek J, Kim SW, Lee SH et al (2011) Learning curve and surgical outcome for single-port access total laparoscopic hysterectomy in 100 consecutive cases. Gynecol Obstet Invest 72:227–233
14. Escobar PF, Haber GP, Kaouk J, Kroh M, Chalikonda S, Falcone T (2011) Single-port surgery: laboratory experience with the daVinci single-site platform. JSLS 15:136–141
15. Escobar PF, Knight J, Rao S, Weinberg L (2012) da Vinci(R) single-site platform: anthropometrical, docking and suturing considerations for hysterectomy in the cadaver model. Int J Med Robot 8:191–195
16. Lue JR, Murray B, Bush S (2012) Single port robotic hysterectomy technique improving on multiport procedure. J Minim Access Surg 8:156–157
17. Mereu L, Carri G, Khalifa H (2012) Robotic single port total laparoscopic hysterectomy for endometrial cancer patients. Gynecol Oncol 127:644
18. Kane S, S KJ (2010) Laparo-endoscopic single-site surgery hysterectomy using robotic lightweight endoscope assistants. J Robotic Surg 3:253–255
19. Escobar PF, Fader AN, Paraiso MF, Kaouk JH, Falcone T (2009) Robotic-assisted laparoendoscopic single-site surgery in gynecology: initial report and technique. J Minim Invasive Gynecol 16:589–591