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ORIGINAL ARTICLE

Single-port hysterectomy: robotic versus laparoscopic

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Abstract This study evaluated the feasibility and safety of robotic single port hysterectomy and laparoscopic single port hysterectomy, and to compare the perioperative parameters of the two systems. Twenty patients underwent robotic single port hysterectomy and 25 patients underwent laparoscopic single port hysterectomy. All hysterectomies were successfully performed via a single port and there were no conversions to conventional multi-port laparoscopy, multi-port robotic, open surgery, or vaginal surgery. The median operative time and hysterectomy time in robotic and laparoscopic groups were 90 vs. 90 min (*P* 0.74), 57.5 vs. 60 min (*P* 0.17), respectively. The median estimated blood loss was 40 ml in the robotic group and 50 ml in the laparoscopic group (*P* 0.77). No operative and post-operative complications were observed in the two groups. The median time to discharge from the hospital was one day for both techniques (*P* 0.17). Robotic and laparoscopic single port systems are feasible and safe for hysterectomy operation in terms of operative time, conversion to laparotomy or multiport laparoscopy/robotic rates, complication rates, and postoperative results in the hands of experienced surgeons. The possible benefits of robotic single port surgery compared with conventional laparoscopy should be evaluated in further randomized controlled studies.

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Introduction

Minimally invasive surgery is the standard treatment of many benign gynecologic procedures and also has gained popularity in the field of onco-gynecologic surgery. Currently, single port laparoscopic surgery and robotic assisted laparoscopy have been introduced as a further development of conventional multiport laparoscopy.

Since the first laparoscopic hysterectomy was described [1], improvements in the technology and instrumentation have made laparoscopic hysterectomy much more feasible, safer and probably easier to learn. Recently, the feasibility of the laparoscopic single port surgery for various gynecological procedures, including hysterectomy, adnexal surgery and myomectomy has been demonstrated [2–4]. The main expected advantages of the single port surgeries are minimizing some problems and complications related to multi-port surgery including vascular or visceral injury, hematoma, herniation, wound infection, and pain [5, 6]. Although this approach seems to be a less invasive technique compared to standard laparoscopy, it has some technical difficulties, such as instrument crowding, loss of triangulation and need for significant laparoscopic skills. Therefore, developing a better surgical instrument for laparoscopic single-incision surgery is essential. Considering technical challenges, introducing the robotic system into single port surgery has several potential advantages over laparoscopic single port surgery and may overcome some of the technical limitations of single port laparoscopy. Robotic surgery has greatly improved visualization, surgical precision, surgeon dexterity, and ergonomics.

The aim of this study was to describe our techniques and initial experiences and evaluate, and compare the feasibility and safety of robotic and laparoscopic single port hysterectomy techniques.

Materials and methods

This study was a cohort-study conducted at Acibadem Maslak Hospital, Istanbul, Turkey and Baskent University School of Medicine, Ankara, Turkey, between May 2014 and October 2016. The study was approved by the local ethical committee of both hospitals. Patient demographics, surgical and post-operative data were collected retrospectively.

A total of 45 patients who had undergone hysterectomy for various benign pathologies or early endometrial cancer apparently were enrolled in the study. Twenty patients were treated using robotic single port hysterectomy (R-SPH) in Acibadem Maslak Hospital and 25 patients were treated using laparoscopic single port hysterectomy (L-SPH) in Baskent University Hospital. All endometrial cancer patients (seven patients) were operated in Acibadem Hospital by robotic system only. Patients were informed about the surgical procedure and other alternative hysterectomy techniques, and they have signed informed consent forms for the surgery. Due to retrospective nature of the study, no strict criteria were applied for patient selection. But, standard inclusion or exclusion criteria for laparoscopic surgery were carried out in both centers. Briefly, exclusion criteria were as follows; large uteri ($\geq$16 gestational weeks), morbid obesity (BMI $\geq$35 mg/kg^2), active cardiopulmonary disease, or other risks for major surgery. For endometrial cancer patients, inclusion criteria were as follows; endometrioid type adeno cancer, grade 1 or grade 2 tumor, <50% myometrial invasion which was confirmed preoperatively and intraoperatively, no obvious evidence of extra-uterine spreading, lymph node and/or adnexal and/or cervical involvement at radiologic studies. All endometrial cancer patients underwent total hysterectomy and bilateral salpingo-oophorectomy without pelvic and para-aortic lymphadenectomy, based on preoperative data, intraoperative observation and frozen section analysis. Also, all hysterectomy specimens of patients with atypical endometrial hyperplasia were sent to frozen section analysis for evaluation of possible invasive adenocarcinoma component.

In the robotic group, operation time was calculated and recorded into three subgroups; (1) total operating time; the time from the beginning of skin incision to the closure, (2) docking time; the time from the moment of port placement until the last robotic arm is locked to the corresponding cannula, and (3) hysterectomy time; the time from the first contact of the surgical instruments to the uterus until the end of the amputation of the uterus. In the laparoscopic group operation time was calculated and recorded into two subgroups; (1) total operating time, and (2) hysterectomy time. The hysterectomy time was accepted as main parameter for comparing operation time due to heterogeneity of the set up procedures and techniques of the vaginal closure. Estimated blood loss was calculated by measuring the blood volume in the suction machine during surgery excluding liquid used for intraperitoneal washing.

Surgical techniques

All patients were placed in the modified lithotomy position, and general endotracheal-tube anesthesia was achieved. All patients received prophylactic antibiotic. A urinary Foley catheter and V-Care® Uterine Manipulator (Conmed Endosurgery, Utica, NY, USA) was used for all operations.

Robotic surgery

Surgical platform All operations were performed with the da Vinci single-site robotic surgery platform, instruments and accessories (da Vinci® Si Surgical System, Intuitive Surgical, Sunnyvale, CA, USA). The accessories include a multichannel access port with room for 4 cannulae and an insufflation valve. Two curved cannulae are for robotically controlled instruments. The other 2 cannulae are straight; one is 8.5 mm and accommodates the high-definition/3-dimensional, 30° endoscope and the other is a 5 mm bedside assistant surgeon port. The instruments currently available for this platform include needle-drivers, Cadiere grasper, Maryland dissector, hook with cautery, curved shears, clip applier and suction irrigation device. These are not articulated instruments, in contrast to standard robotic instrumentation. Same sided hand eye control of the instruments is maintained through assignment of software of the SI system that enables the surgeon's right hand to control the screen right instrument even though the instrument is in the left robotic arm and reciprocally the left hand controls the screen left instrument even though the instrument is in the right robotic arms. This coordination of screen images with the operating hand removes many of the current issues of single-port articulated instrumentation.

Surgical technique A 2 cm intraumbilical incision was made and then, the fascia was entered sharply and the incision is extended and stretched with retractors to 3 cm. The lubricated port is grasped using an atraumatic clamp and inserted. Pneumoperitoneum is established after insufflation of the abdomen up to approximately 12–15 mmHg. Under visual guidance by diagnostic

laparoscopy the table was placed in the Trendelenburg position (30°). Then, the robotic camera was placed first through the access port. Each of the curved cannulas was placed under direct vision so that the remote centers was located in the middle of the of the access port and then docked to the two robotic arms. The camera arm was docked and finally the 5 mm bedside assistant trocar was placed through the access port. At the console, the surgeon confirmed that the robotic arms were swapped such that the screen right instrument was being controlled by the right master and vice versa. There was no insertion of any accessory trocar, which was not part of the single site device. The assistant surgeon helped to retract bowel or the other tissues by using a standard 5 mm endograsper, or coagulated the vessels with a bipolar grasper, LigaSure® (5 mm Blunt Tip, Covidien, USA) or Thunderbeat® (5 mm Front Grip, Olympus, USA) through the assistant channel. Firstly, the round ligaments were ligated bilaterally, and the retroperitoneal spaces were developed. After visualization of the ureters, the infundibulopelvic ligaments were identified, coagulated, and transected by the Thunderbeat or LigaSure. A bladder flap was developed, and the uterine arteries and veins were coagulated and dissected. Once the bladder was dissected below the colpotomy cup, a circumferential colpotomy was performed using the monopolar Hook. The uterus, cervix and bilateral fallopian tubes/ovaries were removed through the vagina. In 14 patients, vaginal cuff was closed robotically with No: 0 or 2/0 V-Lock® absorbable wound-closure device (Covidien, Mansfield, MA, USA), whereas vaginal cuff was closed vaginally with No: 0 Vicyrl® (Ethicon, Piscataway, NJ, USA) in remaining 6 patients. After hemostasis, the fascia was repaired with a No: 0 Polysorb® 5/8 circle needle (Covidien, Mansfield, MA, USA).

Laparoscopic technique

Initially, the surgeon stood on the left side of each patient. The lateral sides of the umbilicus were everted using two clamps. Then, a 2 cm vertical intraumbilical skin incision was made. Sharp and blunt dissection was performed on the subcutaneous fatty tissue; the fascia was exposed and cut using number 11 scalpel blade, and the peritoneum was incised using Metzenbaum scissors. The incision was then extended by an additional 0.5 cm via stretching of the skin. No other extraumbilical skin incisions were used. A SILS® port (Covidien, Norwalk, CT, USA) with 3 access inlets was inserted into the abdominal cavity using a Heaney clamp, and a carbon dioxide pneumoperitoneum was created. A 10 mm rigid video laparoscope was used together with 2 classical non-roticulating straight laparoscopic instruments. A bipolar and monopolar cautery, a dissection forceps, and suction-irrigation devices were used sequentially as indicated during surgery. If collision of the instruments resulted in inadequate surgical movement for dissection, cutting, or coagulation, the surgeon changed the placement of the instruments, his position from the lateral side of the patient to the patient's head, or the placement of the endoscope in order to perform the necessary movements. All surgical procedures were performed using conventional non articulated rigid laparoscopic instruments and the LigaSure system.

We started the dissection from the right round ligament. The LigaSure is used to desiccate and cut the right round ligament. The uterovesical fold of the peritoneum was identified and sectioned from the round ligament to the uterovesical fold bilaterally. The bladder was dissected completely so that the uterine vessels on either side can be clearly seen and then coagulated using the LigaSure and bipolar electro cautery. Cardinal and uterosacral ligaments were resected by using LigaSure. Extirpation of uterus, and vaginal stump closure were performed with an intracorporeal continuous suture using No: 0 Vicryl vaginally in all patients. After hemostasis, the fascia was repaired with a No: 0 Polysorb 5/8 circle needle.

Statistics

SigmaStat for Windows, version 3.1 (Jandel Scientific Corporation, San Rafael, CA, USA) was used for statistical analysis. The Student's *t* test or Mann–Whitney *U* test was used to compare the values between the stimulation protocols. Differences in outcome rates were analyzed using a Chi-square test or Fisher's exact test. In all statistical analyses, P value < 0.05 was considered statistically significant.

Results

There were no demographic differences statistically between the groups (robotic vs. laparoscopic) in terms of mean age; 54.4 ± 7.8 (41–70) vs. 52.4 ± 7.0 (40–68); P 0.38, mean body mass index; 28.7 ± 3.6 (19.6–34.2) vs. 26.8 ± 3.6 (17.6–34.2); P 0.14, median number of parity; 2 (0–4) vs. 2 (0–5); P 0.72, and number of previous abdominal/pelvic surgery; 30 vs. 24%; P 0.91 (Table 1).

All hysterectomy operations were performed successfully via single port and there were no conversions to conventional multi-port laparoscopy, multi-port robotic, open surgery, or vaginal surgery. In the robotic group, the mean docking time was 8.2 ± 1.7 min. The median operative time was 90 (70–165) min in robotic group, and 90 (60–200) min in laparoscopic group (P 0.74). The median hysterectomy time in robotic and laparoscopic groups was

Table 1 Demographic data

	R-SPH ($n = 20$)	L-SPH ($n = 25$)	P value
Age (years)	54.4 ± 7.8	52.4 ± 7.0	0.38
BMI (kg/m^2)	28.7 ± 3.6	26.8 ± 3.6	0.14
Parity (n)	2 (0–4)	2 (0–5)	0.72
Previous abdomino-pelvic surgery history (n, %)	6 (30%)	6 (24%)	0.91

Data and values are mean ± SD or median with range in parentheses or percentage in parentheses

R-SPH robotic single port hysterectomy, *L-SPH* laparoscopic single port hysterectomy, *BMI* body mass index

57.5 (40–120) min vs. 60 (45–160) min (P 0.17). The median estimated blood loss was 40 (20–200) ml in the robotic group and 50 (20–250) ml in the laparoscopic group (P 0.77). No operative and post-operative complications occurred in the two groups. The median time to discharge from the hospital was one day for both techniques (P 0.17) (Table 2).

At a median of 12 months' follow-up (range 5–24 months), all endometrial cancer patients were free of disease.

Discussion

In the present study, all of the operations completed via single port successfully in the robotic and laparoscopic manner without conversion to standard laparoscopy, insertion of an additional port, intraoperative and postoperative complications. Seven patients in the robotic group had low-risk, early stage endometrial adenocarcinoma and we did not perform a lymphadenectomy or another staging procedures for these patients based on the literature data that there is very low lymphatic involvement rate and extra-uterine spreading risk in this group patient [7, 8].

In the last decade, many studies have demonstrated that laparoscopic hysterectomy is feasible and results in shorter hospital stay, provides improved quality of life and comparable surgical outcomes to open hysterectomy [9, 10]. Recently, a meta-analysis including randomized and quasi-randomized controlled trials of robotic assisted laparoscopy compared with conventional laparoscopy did not reveal an advantage for robotic assistance in hysterectomy for benign disease, and standard laparoscopic technique still remains the standard minimally invasive approach for hysterectomy [11].

Single port laparoscopic surgery has been introduced as a lesser invasive technique than multiport laparoscopy. The potential advantages of the single port system over multiport system are lesser operative complications related to trocar insertion, operative wound infection, hematoma, and hernia formation might be avoided by reducing the number of ancillary ports, lower postoperative pain, and better cosmetic results [5, 6]. On the other hand, the concept of multiple instruments and optics operating through a single incision give rise to specific challenges and unique ergonomic problems not previously encountered with conventional laparoscopy. Significant collisions between instruments, a limited degree of movement, inferior ergonomics and a longer learning curve are the main obstacles keeping this procedure from full integration into usual practice. So, when considering technical challenges, introducing the robotic system into single port surgery has several advantages over laparoscopic single port surgery such as 3-dimensional visualization, a stable camera platform, tremor control, scaling of movement and range of motion [12]. However, whether this platform is superior to

Table 2 Outcomes

	R-SPH ($n = 20$)	L-SPH ($n = 25$)	P value
Total operation time (min)	90 (70–165)	90 (60–200)	0.74
Hysterectomy time (min)	57.5 (40–120)	60 (45–160)	0.17
Docking time (min)	8.2 min ± 1.7	–	–
Estimated blood loss (ml)	40 (20–200)	50 (20–250)	0.77
Time to discharge (day)	1 (1–2)	1 (1–3)	0.17
Complication (n)	0	0	NA
Conversion to other techniques (n)	0	0	NA

Data and values are mean ± SD or median with range in parentheses or percentage in parentheses

R-SPH robotic single port hysterectomy, *L-SPH* laparoscopic single port hysterectomy, *min* minute, *NA* not applicable

conventional single port laparoscopy regarding performance and surgical outcomes remains to be enlightened by future clinical trials.

In the literature, there are few studies comparing the robotic and laparoscopic hysterectomy techniques in single site set. To the best of our knowledge there are four published studies compared robotic and laparoscopic single site hysterectomy techniques in the English literature and all of them had a retrospective design. Fagotti et al. in a double-centric, non-randomized study, reported the experience of the robotic single-site surgery in 19 early endometrial cancer patients and compared the perioperative outcomes with historical control groups [13]. The authors reported that all procedures were successfully performed through a single incision with no intraoperative complications in the selected early endometrial cancer patients. In that study, total operative time was slightly shorter in the robotic group but this is not statistically significant. Interestingly, the median estimated blood loss was statistically higher in the robotic group compared to "control" (laparoscopic) group. Recently, Paek et al. compared the findings of laparoscopic single port hysterectomy in 442 patients and robotic single port hysterectomy in 25 patients retrospectively. The authors reported longer hysterectomy and total operation time, lesser blood loss and better pain score at first hours after operation in the robotic group than laparoscopic group [14]. More recently, Lopez et al. in a retrospective cohort study, reported that the robotic-assisted, single-site group had a statistically significant decrease in length of hospital stay, but also experienced an increase in total operative time [15].

The present study and previous four similar studies clearly demonstrated that single site robotic and laparoscopic surgery both are feasible and safe techniques for total hysterectomy operation in terms of operative time, perioperative and early operative complication rate, conversion to another technique rate, postoperative pain scores, and recovery time.

One of the major drawbacks of the present study is its retrospective nature. The study was conducted in two different hospitals in two different cities and the robotic system was present in only one hospital (Acibadem Hospital). This was a difficulty for randomized control study in this setting. All surgical procedures were performed by the two same surgeons (MG, PD) experienced in the advanced minimal invasive surgery and single port surgery. While planning this study, we mainly aimed to demonstrate our initial experience and techniques and compare the preliminary findings yielded from the robotic and laparoscopic operations. Another drawback is heterogeneity in the techniques of vaginal closure. In the laparoscopic group, while vaginal vault was closed vaginally in all patients, more than half of the robotic patients were closed robotically. Therefore, we decided that the duration of hysterectomy was the main parameter for comparing operation time. Laparoscopic or robotic vaginal vault closure is still a technical difficulty in single-site hysterectomy and one of the major causes for prolonged operation time. The better wristed/articulated instruments will help to overcome this problem. Recently, a new improved needle-driver "wristed needle driver" was produced and marketed [16]. Da vinci® Xi system is newer robotic system and includes some advances over the Si model. The potential advantages of the Xi system are more user-friendly, easy installation, smaller and thinner arms that provide a greater range of motion, longer instrument shafts, and improved high definition optic system. Da vinci® Sp system is specifically designed for single port robotic surgery and expected to be available in the near future. This system delivers a flexible high definition camera and three fully articulating instruments through its 25 mm cannula. We believe that the new systems with more flexible instruments will lead to widespread use of single-port systems in the in the field of gynecologic surgery [17].

In conclusion, robotic and laparoscopic single port techniques are feasible and safe alternatives for hysterectomy operation in terms of operative time, conversion to laparotomy or multiport laparoscopy/robotic rates, complication rates, and postoperative results in the hands of experienced surgeons. Also robotic single port surgery seems to be safe and feasible in management of early stage and low-risk endometrial cancer. The robotic single port system clearly offers advantages over conventional single port laparoscopy in terms of 3-dimensional visualization, improved surgeon dexterity, surgical precision, and ergonomics. Robotic technology with these potential advantages may enhance surgical skills during single port hysterectomy. However, these possible benefits of robotic single-site surgery compared with laparoscopic single-site surgery should be evaluated in further randomized controlled studies.

Compliance with ethical standards

Conflict of interest Mete Gungor has no conflicts of interest or financial ties to disclose. Korhan Kahraman has no conflicts of interest or financial ties to disclose. Polat Dursun has no conflicts of interest or financial ties to disclose. Esra Ozbasli has no conflicts of interest or financial ties to disclose. Canan Genim has no conflicts of interest or financial ties to disclose.

Ethical standards All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964

Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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