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Fertility sparing surgery for treatment of early-stage cervical cancer: open vs. robotic radical trachelectomy

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Abstract

Background—To compare the open versus robotic surgical approaches and provide surgical outcome data on patients who have undergone radical trachelectomy (RT).

Methods—We identified patients who underwent open (ORT) or robotic radical trachelectomy (RRT) between September 2005–June 2011. Tumor characteristics, perioperative, operative and obstetrical outcomes were analyzed.

Results—Thirty-seven patients with early stage cervical cancer that desired future fertility underwent attempted radical trachelectomy, and 32 patients (20 with 1B1, 11 with 1A2, and 5 with 1A1 with LVSI/poorly differentiated histology) had successful completion of RT. Five (1 open/4 robotic) underwent conversion to radical hysterectomy secondary to close (<5mm) endocervical margin ($p=0.08$). The median age at diagnosis was 28.9 years (range; 21.4–37.2), 70% were nulliparous, and 9 had a visible lesion. Twenty-five patients (68%) underwent ORT and 12 (32%) underwent RRT. RRT was associated with less blood loss (62.5 mL vs. 300 mL, $p=0.0001$) and decreased length of postoperative stay (1 vs. 4 days, $p<0.001$), with no difference in operative time or histopathologic outcomes. Twenty-three patients (62%) had no residual cervical disease on final pathology. Common long-term morbidities were irregular menstrual bleeding or amenorrhea (25%), cerclage erosion (13%), or cervical stenosis (9%). Although there was a higher rate of conversion to hysterectomy in the robotic surgery cohort, rates of serious morbidities among the cohorts were comparable (robotic: 33% vs. open: 24%, $p=0.70$). Eleven (36%) patients are actively attempting pregnancy and three have achieved pregnancy. The median time of follow up is 17.0 months (range 0.30–64.9 months). There are no documented recurrences.

Conclusions—RRT results in less blood loss and decreased length of hospital stay with no compromise in histopathologic outcomes.

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Conflict of Interest Statement

The authors have no conflicts of interest to disclose.

Keywords

robotic surgery; radical trachelectomy

Background

Radical trachelectomy is an acceptable alternative to radical hysterectomy in a select population of early-stage cervical cancer patients who desire fertility conservation. Since Dargent introduced the clinical applicability of vaginal radical trachelectomy in 1994 [1], numerous reports have documented the successes and feasibility of the vaginal and abdominal approaches to trachelectomy [2–7]. Vaginal radical trachelectomy is a procedure that requires refined skills from an oncologic surgeon trained in advanced vaginal surgery making vaginal radical trachelectomy an option for patients at a few specialized centers. An alternative surgical approach has been the abdominal radical trachelectomy performed via laparotomy. Although making fertility sparing surgery for early-stage cervical cancer more feasible across gynecologic oncologists, the open approach has theoretical drawbacks, particularly formation of adhesions and scar tissue that may ultimately impact a woman's fertility, increased blood loss and prolonged hospital stay. Minimally invasive surgery has gained wide acceptance secondary to the implied advantages of faster return to normal activity and diet, decreased postoperative pain, reduced hospital stay and better cosmesis, as well as the potential advantage of decreased rate of adhesive disease [8, 9]. For advanced gynecologic procedures, the use of laparoscopy is still limited to those with experience in high complexity procedures. Although, laparoscopic radical trachelectomy has been described in the literature, limited numbers have been performed secondary to the degree of surgical skill and expertise required [10,11]. The introduction of the robotics surgical system offers a theoretical advantage to surgeons performing more complex procedures in that it offers 3-dimensional optics and wristed motion with finer instrumentation. Direct comparisons of abdominal and robotic trachelectomy are lacking. The focus of the current work is to report on the initial experience of a cohort of patients who underwent robotic radical trachelectomy and determine if there is a difference in perioperative outcomes between patients undergoing robotic radical trachelectomy compared to open radical approach.

Methods

After approval was granted by the University of Texas M. D. Anderson Cancer Center Investigational Review Board, data were collected retrospectively on all patients who had undergone open or robotic radical trachelectomy as previously described [7, 10] for early stage cervical cancer from September 2005 to June 2011.

The surgical dissection of robotic radical trachelectomy mimicked that of open radical trachelectomy. Briefly, an incision is first made over the round ligament, and the peritoneum lateral to the infundibulopelvic ligaments is opened bilaterally. The paravesical and pararectal spaces are then developed and the ureters are separated from the peritoneum down towards the parametrial tissue. The ureters are then dissected and mobilized completely to the bladder after division of the anterior and posterior vesicouterine ligaments. The

peritoneum over the bladder is incised and the bladder is mobilized inferiorly over the anterior vaginal wall. The uterine vessels are transected bilaterally at their origin and dissected over the ureters bilaterally. The peritoneum over the rectovaginal space is then incised and the uterosacral ligaments are divided bilaterally. A circumferential incision is made 2 cm below the vaginal stump to detach the specimen from the apical vagina. An electrosurgical device is then used to amputate the cervical stump. Regardless of the surgical modality, intraoperative evaluation of the surgical margin is carried out by perpendicular sectioning of the endocervical margin and adjacent 1.0 cm long portion of the endocervical canal with attached parametrial tissue being submitted in toto for frozen section. All frozen section evaluations are carried out by a pathologist who specializes in gynecologic pathology. If the surgical margin was grossly positive or close ($<10\text{mm}$) for dysplasia or invasive cancer, the patient underwent immediate additional resection or conversion to hysterectomy if the residual cervical length was felt to be inadequate to perform a reanastomosis to the apical vagina.

The surgical approach to trachelectomy was based on surgeon training and preoperative discussion concerning the risks, benefits and alternatives of each surgical approach with patients. Vaginal radical trachelectomy is not performed at our institution and consequently the robotics approach was compared only to the open approach. Patients who underwent conversion to radical hysterectomy were excluded from the portion of the analysis pertaining to early and late morbidities. Data extracted from the medical record included patient's age, marital status, pregnancy history, preoperative imaging, and findings on preoperative pelvic examination. Operative reports were reviewed and operative times, estimated blood loss, length of hospital stay, length of follow up, and incidence of intraoperative complications were recorded. Pathologic data included tumor histologic subtype and grade, size of residual tumor, surgical margin, presence or absence of lymph vascular space invasion, nodal status and number of lymph nodes removed, and parametrial length. All postoperative morbidities were recorded and dichotomized as early (occurring less than 30 days) or late (occurring greater than 30 days but within one year of surgery) morbidities. Serious morbidity was defined as need for readmission, reoperation or an additional procedure excluding patients taken to the back to the operating room for dilation of a stenotic cervix, anemia necessitating blood transfusion, venous thromboembolism, ICU admission, death, or loss of fertility. Postoperative fecundity rate was also determined. Specifically, attempts to achieve pregnancy and pregnancy outcome, and a postoperative diagnosis of infertility were ascertained from the electronic medical record. Lastly, patient and disease status at the time of last follow up was recorded.

Statistical analyses were performed using XLSTAT v. 2011. Associations between categorical variables and modality of radical trachelectomy (open vs. robotic) were determined using Fisher's exact or Chi-square test. Nonparametric continuous variables were summarized and compared using the Mann Whitney rank sum test. All tests were two-sided, and a p-value <0.05 was considered statistically significant.

Results

Thirty-seven patients with early-stage cervical cancer (20 [54%] with Ib1, 11 [30%] with Ia2, and 5 [14%] with Ia1 with LVSI or poorly differentiated tumor histology) underwent attempted radical trachelectomy. The median age at diagnosis was 28.9 (range 21.4–37.2). Twenty-three women (62%) were married and 70% were nulliparous. Thirty patients (81%) underwent cold knife conization for diagnostic purposes prior to trachelectomy. On preoperative pelvic examination 9/37 (24%) had a visible cervical lesion ranging from 1–3 cm, and there was no difference in mean tumor size based on surgical modality (robotic: 21.5 mm vs. open: 23 mm, $p=0.67$). Preoperative magnetic resonance imaging (MRI) was obtained in 24 patients and all but two had no evidence of extracervical disease. Ten patients (27%) had suspicion of tumor in the cervix on preoperative MRI. Two patients had an enlarged pelvic lymph node on preoperative MRI; both underwent a subsequent CT scan. One patient had no suspicious abnormality on CT scan, and one was noted to have an enlarged pelvic lymph node on CT and underwent nondiagnostic FNA. Intraoperatively, this lymph node was sent to frozen section and found to be negative prior to proceeding with trachelectomy. The majority of patients had adenocarcinoma (59%) followed by squamous (32%) and adenosquamous (8%).

Twenty-five patients (68%) underwent open radical trachelectomy and 12 (32%) underwent robotic radical trachelectomy. Twelve patients (8 in the open cohort and 4 in the robotics cohort) underwent intraoperative lymphatic mapping, and all had identification of sentinel lymph nodes. Patients undergoing robotic radical trachelectomy had significantly less blood loss than patients undergoing open radical trachelectomy (median EBL 62.5 mL [range 25–450] vs. 300cc [range 50–1100], respectively; $p=0.0001$) and spent fewer postoperative days in the hospital (median LOS 1 days [range 1–2] vs. 4 days [range 3–9], respectively, $p<0.001$) (Table 1). There was no difference in operative time (robotic: 328 minutes [range 207–379] vs. open: 294 minutes [range 203–392], $p=0.26$) and there were no intraoperative complications with either surgical modality.

Comparing histopathologic outcomes, there was no difference in median length of parametrial tissue removed based on surgical modality (robotic: right parametrial length 3.45 cm [range 2.5–4] and left parametrial length 3.55 cm [range 2.5–5] vs. open: right parametrial length 4.69 cm [range 2–8] and left parametrial length 4.58 cm [range 1.5–9.5]; $p=0.18$ and 0.16 , respectively) (Table 1). The median number of lymph nodes removed was 18.5 (range 7–50), and there was no difference in nodal counts based on surgical approach (robotic: 22 [range 9–50] vs. open: 18 [range 7–33]; $p=0.57$). On final pathology, three patients had positive lymph nodes. One patient with a positive parametrial lymph node received postoperative chemoradiation and two with positive pelvic lymph nodes had both been converted to radical hysterectomy secondary to a close surgical margin and recommended to undergo postoperative adjuvant therapy. The majority of patients (23/37 or 62%) had no residual disease at the time of trachelectomy. Among patients with residual disease 5/14 (1 open case (4%) vs. 4 robotic cases (33%), $p=0.03$) were converted to radical hysterectomy secondary to a close (<10 mm) or involved surgical margin (Table 2). All but one patient converted to radical hysterectomy had stage 1B1 disease. Two of the patients converted to a hysterectomy for a close surgical margin had residual adenocarcinoma-in-situ

in the hysterectomy specimen and one had residual moderately differentiated squamous cell carcinoma. Four (29%) patients had LVSI. Although a larger percentage of patients with squamous cell carcinoma had residual disease on final pathology (5/7 or 71%), there was no significant difference in the incidence of residual disease based on the different histologies ($p=0.94$).

Excluding patients that underwent conversion to radical hysterectomy, within 30 days of surgery, the most common morbidities included urinary tract infections or retention (7/32, 22%) and fever (5/32, 16%) (Table 3). The most common long-term (>30 day) morbidities were irregular menstrual bleeding or amenorrhea (8/32, 25%), cerclage erosion (4/32, 13%), and cervical stenosis (3/32, 9%). Cervical stenosis was defined as patients with sonographic evidence of hematometra and/or amenorrhea requiring cervical dilation. All but 3 patients had placement of a 0-Ethibond cerclage. There were 3 patients that had placement of a Mersaline suture. Among the patients that underwent Mersaline cerclage, only one experienced cerclage erosion. Differences in the rates of cervical stenosis between surgical modality, led us to examine how individual surgeons cannulated the cervical os postoperatively. Some surgeons chose to use pediatric foley catheters versus others who chose to use a Smit sleeve (Nucletron, Columbia, MD). Of all the patients who had a pediatric foley for cannulation of the cervical os, 14% developed cervical stenosis. Interestingly, among patients who had a Smit sleeve placed to maintain patency of the cervical os, none developed cervical stenosis ($p=0.50$). Although there was no significant difference in the rate of individual morbidities between surgical modalities, patients who underwent open radical trachelectomy had a cumulative greater rate of late morbidity compared to patients that underwent robotic radical trachelectomy (58% vs. 13%, respectively; $p=0.07$).

The rates of serious morbidity did not significantly differ between surgical modalities ($p=0.7$). Serious morbidity was defined as readmission, reoperation or need for 2nd procedure, anemia necessitating a blood transfusion, venous thromboembolism, ICU admission, death, or loss of fertility (including conversion to hysterectomy or need for postoperative radiotherapy). In the robotic surgery group, 4 patients underwent conversion to radical hysterectomy secondary to a close surgical margin. A total of 6 patients in the open surgery group experienced one or more serious morbidities. Three patients developed anemia, necessitating blood transfusion in the immediate postoperative period. One patient had a close surgical margin and underwent conversion to hysterectomy. Postoperatively, she was noted to have a positive parametrial lymph node and underwent postoperative adjuvant radiation therapy with concurrent chemotherapy. One patient had successful completion of an open trachelectomy; however, was noted to have a positive parametrial lymph node on final pathology and required postoperative concurrent chemoradiation. A total of three patients were readmitted. One patient developed a hemorrhagic cyst of the left ovary and was readmitted 2.5 months postoperatively for observation and pain control. Her pain subsided on hospital day 2 and she was discharged home without further incident. Another patient developed a cervicovaginal dehiscence following intercourse 3 months postoperatively. She was taken to the operating room and noted to have disruption of the posterior vaginal to uterine anastomosis, which was revised. Three weeks following secondary closure of the vaginal cuff, she developed a pelvic abscess and was again

readmitted, initiated on intravenous antibiotic therapy, and underwent CT-guided drainage of the abscess without further complication. The last patient developed what was thought to be disruption of the cervicovaginal anastomosis. She was taken to the operating room for revision of the cervicovaginal anastomosis, but was found to have necrosis of the residual lower uterine segment secondary to presumed vascular insufficiency of the residual uterine fundus and consequently underwent resection of the residual uterine fundus secondary to inadequate residual lower uterine segment tissue to create a new anastomosis.

In total, 7/37 (4 [50%] robotic vs. 3 [12.5%] open, $p=0.05$) patients were unable to maintain their fertility either secondary to a close surgical margin necessitating conversion to hysterectomy (5/7), need for postoperative adjuvant therapy (1/7), or a surgical complication (1/7). Among the patients that underwent trachelectomy without postoperative adjuvant treatment, 11/30 (36%) are actively attempting or have attempted pregnancy (Table 4). One woman delivered a healthy infant at 33.1 weeks estimated gestational age. Another patient became pregnant following in vitro fertilization; however, the fetus was affected with Down's syndrome and tetralogy of Fallot. This patient underwent cesarean section at 21 weeks. One patient had 2 spontaneous abortions. All patients who achieved a pregnancy underwent open radical trachelectomy. According to the electronic medical record, seven patients had documentation of an ongoing infertility evaluation and/or treatment postoperatively. The remaining 4 patients are currently attempting to achieve a spontaneous pregnancy. The median time to follow up is 17.0 months (range 0.30–64.9 months) across the entire cohort with a significantly shorter median time of follow up for robotic vs. open patients (10.8 months [range 0.43–24.6] vs. 26.4 months [range 0.30–64.9], $p=0.004$). There have been no documented recurrences in either cohort.

Discussion

The key findings of this study are that radical trachelectomy is feasible in appropriately selected patients with early-stage cervical cancer, and the robotics surgical approach is associated with less blood loss and decreased length of hospital stay. To the best of our knowledge this is the largest report of perioperative outcomes in a cohort of patients who underwent robotic radical trachelectomy and the first study to compare the open versus robotic surgical modalities in a series of patients undergoing radical trachelectomy.

Minimally invasive approaches to radical trachelectomy are now emerging in the gynecologic oncology literature. Reports documenting the surgical technique and outcomes of patients undergoing laparoscopic radical trachelectomy have been recently published [11, 12]. In the largest reported series of laparoscopic radical trachelectomy, perioperative outcomes were similar to those seen in the current work; however, no comparison to alternate modalities of radical trachelectomy was performed [11]. In addition, one could argue that laparoscopic radical trachelectomy requires refined skills as an advanced gynecologic minimally invasive surgeon limiting its use to a few specialized centers. The introduction of robotic-assisted surgery and its stated advantages overcomes some of these limitations. Robotic radical trachelectomy was first described by Geisler, et al in 2008, who reported on a single patient with Ib1 adenosarcoma of the cervix [13]. Since then two additional groups have reported on the feasibility of robotic radical trachelectomy, each with

slight modifications in surgical technique [14, 15]. Additionally, a case series from our own institution, documented both the safety and feasibility of robotic-assisted radical trachelectomy in a subset of patients with early-stage cervical cancer who desired fertility conservation [10]. Although outcomes comparing the abdominal versus vaginal approach to trachelectomy have been published [16], there has been no comparison of abdominal versus robotics surgery. Our findings support improved perioperative outcomes in patients undergoing robotic radical trachelectomy expanding on our earlier published work which suggested improved perioperative outcomes with robotic surgery when comparing the robotics approach to other modalities of trachelectomy [10].

In keeping with the current literature, our findings report on the feasibility of robotic radical trachelectomy. Despite a small cohort of patients, this data suggests safety of robotic trachelectomy from an oncologic perspective in that there was no difference in median parametrial length and median nodal counts. Acknowledging a shorter median time of follow up among patients in the robotics group, there was no difference in recurrence rates among patients undergoing robotic radical trachelectomy when compared to laparotomy. These findings differ from comparisons of the vaginal versus abdominal approach, which describe significantly increased parametrial length with abdominal radical trachelectomy compared to the vaginal radical trachelectomy (3.97cm vs. 1.45 cm, $p<0.001$) with no difference in lymph vascular space invasion or median number of regional lymph nodes excised, suggesting an abdominal approach provides similar histopathologic outcomes with a wider parametrial excision [16]. In keeping with findings in the literature, the robotics surgical approach also offered an advantage in surgical outcomes including less operative blood loss and decreased length of hospital stay findings that are commonly reported to be associated with robotic surgery [17–19]. Patients in the open cohort did not have increased risk factors for bleeding; thereby, highlighting one of the noted key advantages of robotic surgery.

Furthermore, patients undergoing robotic radical trachelectomy had a lower collective rate of postoperative early and late morbidity. Despite the limited numbers of patients in each surgical group, patients in the robotic surgery group experienced fewer postoperative urinary tract infections and cerclage erosions. Most of the cerclage erosions occurred in early on and one potential explanation for the difference in the rate of cerclage erosions placement of the cerclage too close to the cervicovaginal anastomosis. As a result of the noted erosions, attention was paid to undermining the uterine serosa and placement of the cerclage in a more proximal location to prevent erosions. Lastly, the patients in the robotic surgery group had placement of a Smit sleeve for cannulation of the cervical os, and as a result, no patients were diagnosed with cervical stenosis postoperatively.

In our study, significantly more patients undergoing robotic radical trachelectomy underwent conversion to radical hysterectomy, a finding that merits careful consideration when evaluating the integration of a new surgical technique. The overall small number of patients precludes more detailed evaluation of causative factors for conversion, but the predominance of conversions in the robotic surgery group warrants further discussion. The majority of the patients that underwent conversion to radical hysterectomy were stage 1B1, two underwent preoperative cold knife conization and only one had a visible cervical lesion

on preoperative physical examination. Each patient did undergo preoperative MRI examination and cervical abnormalities were noted in 3 patients, but none of the findings precluded attempt at radical trachelectomy. In each case conversion to hysterectomy was recommended secondary to a close (<10 mm) surgical margin and in actuality each patient that underwent conversion ultimately had an endocervical margin that was either involved or notable for tumor or dysplasia less than 5 mm from the endocervical margin. Some may argue this is a significant complication among patients who desire future fertility; however, it is standard in our practice for the endocervical margin to be clear of dysplasia or invasive carcinoma by 10 mm. If positive, patients underwent additional resection or hysterectomy if the remaining residual cervical stump was not sufficient for anastomosis to the vaginal apex. Furthermore, in reviewing the final pathology, the decision to proceed with completion hysterectomy was warranted in that 3 patients had high risk features (positive lymph nodes or deep cervical stromal invasion) on final pathology that resulted in a recommendation of postoperative adjuvant radiation therapy with concurrent chemotherapy and the remaining 2 patients had residual endocervical glandular atypia or adenocarcinoma-in-situ in the hysterectomy specimen pointing to tumor biology as the etiological factor necessitating conversion to hysterectomy rather than a deficiency in the surgical technique. Nonetheless, we acknowledge further study validating the adequacy of the robotic approach to radical trachelectomy is needed.

Unlike described reports of vaginal radical trachelectomy [20], patients undergoing open or robotic radical trachelectomy in this series underwent removal of the entire parametria and transection of the uterine arteries at their origin on the basis of the literature which lacks data confirming decreased perfusion of the uterus and impairment of conception and pregnancy if the uterine vessels are removed in their entirety [21]. This approach is further supported by data that confirms involvement of parametrial lymph nodes among patients with small cervical tumors, even in the absence positive pelvic lymph nodes highlighting the importance of a complete parametrial excision [22]. One patient in the current series experienced necrosis of the residual uterine fundus following open trachelectomy likely secondary to vascular insufficiency of the residual uterine blood supply demonstrating the first reported case of compromise of the uterine blood flow as a result of uterine artery transection at the time of trachelectomy.

This comprises the largest series of patients undergoing robotic trachelectomy to date; however, we do recognize that this is a small group of patients and the results pertaining to complication rates may not be reflective of those obtained in a larger cohort of patients. The goals of this study were to provide an initial comparison of the two surgical modalities, but equivalency of the two modalities should be independently validated and whether patients will benefit from the implied advantages of minimally invasive surgery such as faster recovery times and fewer adhesions remains to be seen.

In our series, 23% of women experienced postoperative infertility, a rate comparable to that published in the largest series of pregnancy outcomes following radical trachelectomy [2]. In the literature, cervical stenosis related to vaginal radical trachelectomy is the cause of infertility in 40% of the cases. Precise reasons for infertility in our study population were difficult to ascertain secondary to its retrospective nature and limited detail regarding

infertility evaluation in the electronic medical record. An analysis of the benefits of the robotic surgery approach with regards to postoperative fertility outcomes is limited by the small numbers of patients who underwent robotic radical trachelectomy. However, in an effort to better understand causes of infertility we are currently prospectively collecting outcome data from patients undergoing radical trachelectomy for early-stage cervical cancer.

In summary, the current work demonstrates the feasibility of robotic radical trachelectomy. The robotic surgery approach compared to laparotomy is associated with significantly less blood loss and decreased postoperative hospital length of stay. Despite these improved surgical endpoints, the decision to proceed with radical trachelectomy is not without risk. The finding of an increased conversion rate to hysterectomy in the robotic surgery cohort merits further investigation, and as a result we advocate for appropriate patient selection and counseling as to the best surgical approach. Long-term benefits of performing radical trachelectomy via a minimally invasive surgical approach remain to be delineated; however, we believe patients undergoing radical trachelectomy should be offered a minimally invasive surgical approach.

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Research Highlights

- We retrospectively compared robotic and open radical trachelectomy
- Robotic radical trachelectomy was associated with less blood loss and decreased postoperative stay with no compromise in histopathologic outcomes
- Patients undergoing robotic radical trachelectomy experienced comparable rates of serious morbidity

Table 1

Patient demographics, tumor, and perioperative characteristics based on surgical approach

	Robotic (n=12)	Open (n=25)	p-value
Age	29.8 (25.3–33.3)	28.8 (21.4–37.2)	0.79
Marital status			
Married	8 (67%)	15 (60%)	
Other *	4 (33%)	10 (40%)	0.70
History of previous pregnancy			
Yes	4 (33%)	7 (28%)	
No	8 (67%)	18 (72%)	0.74
Tumor stage			
IA1[‡]	3 (25%)	2 (8%)	
IA2	4 (33%)	7 (28%)	0.28
IB1	5 (42%)	16 (64%)	
Tumor histology			
Squamous	5 (42%)	7 (28%)	
Adenocarcinoma	7 (58%)	15 (60%)	0.39
Adenosquamous	0 (0%)	3 (12%)	
Estimated blood loss (mLs)	62.5 (25–450)	300 (50–1100)	0.0001
Rate of perioperative transfusion	0 (0%)	2 (9%)	0.54
Operative time (minutes)	294 (207–379)	328 (203–392)	0.09
Length of hospital stay (days)	1 (1–2)	4 (3–9)	<0.001
Parametrial length			
Right	3.45 (2.5–4)	4.69 (2–8)	0.18
Left	3.54 (2.5–5)	4.58 (1.5–9.5)	0.16
Nodal counts	22 (9–50)	18 (7–33)	0.57
Lymph vascular space invasion	2 (17%)	2 (8%)	0.82
Presence of residual disease	5 (42%)	9 (36%)	1.00
Rate of conversion to hysterectomy	4 (33%)	1 (4%)	0.03
Median follow up (months)	10.8 (0.43–24.6)	26.4 (0.30–64.9)	0.004

* Other = single or divorced;

[‡] with concurrent LVSI or poorly differentiated histology

Table 2

Characteristics of patients converted to radical hysterectomy.

Pt	Stage	Histology	Grade	Distance of Tumor/Dysplasia from Endocervical Margin	Final Pathology	Post-operative Adjuvant Treatment
1	1B1	Adenosquamous		AIS* within 2mm	Positive Parametrial and internal iliac lymph node	Chemoradiation
2	1B1	Adenocarcinoma	3	Adenocarcinoma within 3mm; AIS at the margin	Endocervical gland dysplasia	None
3	1B1	Squamous	3	Squamous cell carcinoma within 1.2 mm	Positive pelvic lymph node	Chemoradiation
4	1A2	Adenocarcinoma	2	Adenocarcinoma within 1 mm; AIS < 1mm	AIS	none
5	1B1	Squamous	2	Squamous cell carcinoma at the margin	Squamous cell carcinoma with full thickness stromal invasion and LVSI	Chemoradiation

* AIS = adenocarcinoma-in-situ

Table 3

Comparison of postoperative morbidities by surgical modality

	Robotic (n=8)	Open (n=24)	p-value
Morbidity < 30 days from surgery	3 (38%)	9 (38%)	0.67
Fever	2 (25%)	3 (13%)	0.78
UTI or retention	1 (13%)	6 (25%)	0.81
Morbidity > 30 days from surgery	1 (13%)	14 (58%)	0.07
Cerclage erosion	0 (0%)	4 (17%)	0.54
Cervical stenosis	0 (0%)	3 (13%)	0.73
Irregular menstrual bleeding or amenorrhea	1 (13%)	7 (29%)	0.64

Table 4

Obstetrical outcomes post-radical trachelectomy (n=30)

Women attempting pregnancy	11 (36%)
First trimester miscarriage	1 (9%)
Second trimester deliveries *	1 (9%)
Third trimester deliveries	1 (9%)
Pre-term	1 (100%)
Term	0 (0%)
Postoperative diagnosis of Infertility	7 (23%)

* Fetus with Down's syndrome and Tetralogy of Fallot delivered at 21 wks