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Feasibility and early oncologic outcomes of Total Intracorporeal Robotic Radical Hysterectomy with Vaginal Cerclage (TIRRHVC) for the treatment of clinical stage IB cervical cancer: A tumor containment technique

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ABSTRACT

Introduction: Minimally invasive radical hysterectomy (MIRH) has been reported to have a four-fold increase in recurrence compared to open radical hysterectomy (ORH) for the treatment of early-stage cervical cancer. The cause for the inferior outcomes with MIRH is unclear. However, the use of a uterine manipulator and the lack of tumor containment strategies may contribute to tumor seeding in previous MIRH approaches.
Objective: Determine the feasibility and early oncologic outcomes of a novel robotic-assisted surgical technique for the treatment of early-stage cervical cancer, Total Intracorporeal Robotic Radical Hysterectomy with Vaginal Cerclage (TIRRHVC).
Methods: Retrospective cohort study.
Results: Twenty-six patients between 2018 and 2022 underwent the TIRRHVC procedure after being counseled on the risks and benefits of ORH and TIRRHVC; these 26 patients' demographics, clinical, surgical, and oncologic outcomes were reviewed retrospectively. Seventeen patients (65.4 %) had clinical stage IB1 and 9 (34.6 %) were IB2 cervical cancer according to FIGO 2018 guidelines. Following hysterectomy and lymphadenectomy, 4 patients were upstaged. The average pathologic tumor size was 2.66 cm (0 cm – 5.6 cm); 65 % of tumors were > 2 cm. There were no intraoperative complications. There were 13 postoperative complications, including 10 urinary tract infections. Eleven patients (42.3 %) received adjuvant therapy. The average follow-up period was 2.8 years (IQR 2.3–3.6). Only one patient has recurred at 3.6 years. One patient expired from causes unrelated to gynecologic cancer. The 3-year disease free survival is 95.5 %.
Conclusion: These promising early oncologic outcomes are encouraging that TIRRHVC may be a treatment option that offers the benefits of minimally invasive surgery without compromising oncologic outcomes.

1. Introduction

The treatment for early-stage cervical cancer is surgery, specifically a radical hysterectomy and lymph node dissection (Cohen et al., 2019). Traditionally, the surgical procedure was a laparotomy. In 1987, Dargent introduced a new surgical technique: laparoscopic radical vaginal hysterectomy and pelvic lymph node dissection (Arispe et al., 2016). Then in 1989, Nezhat reported the first total laparoscopic radical hysterectomy with lymphadenectomy followed in 2006 by Sert and Abler performing the first robotic-assisted radical hysterectomy for early stage cervical cancer (Arispe et al., 2016; Geetha and Nair, 2012). More surgeons began to adopt minimally invasive surgery (MIS) for the treatment of early-stage cervical cancer because retrospective studies reported decreased blood loss and hospital stay with equivalent oncologic outcomes with MIS compared to laparotomy (Magrina et al., 2008; Lee et al., 2011; Malzoni et al., 2009; Nam et al., 2012; Frumovitz et al., 2007). However, the use of minimally invasive techniques for cervical cancer was largely abandoned after 2018 with the publication of the Laparoscopic Approach to Cervical Cancer (LACC) trial, the first prospective randomized study comparing the oncologic outcomes of open radical hysterectomy (ORH) to minimally invasive radical hysterectomy (MIRH) (Leitao, 2020; Brandt et al., 2022; Ramirez et al., 2006). The trial concluded early due to safety concerns. The MIS arm of the trial failed to meet the noninferiority endpoint with a 4-fold increase in

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recurrence with MIRH compared to ORH. These findings solidified ORH as the standard of care for early-stage cervical cancer. The LACC trial was not designed to understand cause of the inferior outcomes of the MIRH cohort. The difference in oncologic outcomes between MIRH and ORH in the trial remains unclear. Possible explanations for the inferior oncologic outcomes of MIRH may be pathologic factors such as tumor size, the surgeon's learning curve associated with MIRH, and the surgical technique used in the MIRH (Uppal et al., 2019; Zhang et al., 2021; Paek and Lim, 2021). The surgical technique in the MIRH cohort of the LACC trial commonly included the use of a uterine manipulator. Recent literature reports that the use of a uterine manipulator is associated with higher recurrence rates, potentially due to tumor seeding (Uppal et al., 2019). The SUCCOR study reported a minimally invasive group that used the uterine manipulator had a 2.76 higher chance of recurrence, but the minimally invasive cohort without the uterine manipulator had similar outcomes to the open cohort (Chiva et al., 2020). In this analysis, the large majority of the minimally invasive studies were performed laparoscopically, not robotically. There is a need for evaluation of the effect of the uterine manipulator in a robotically assisted MIRH approach. Additionally, better outcomes may be achieved with mechanisms that enhance tumor containment (Kong et al., 2016). We describe a minimally invasive tumor containment technique for early-stage cervical cancer to minimize tumor seeding and maximize tumor containment: Total Intracorporeal Robotic Radical Hysterectomy with Vaginal Cerclage (TIRRHVC). This technique does not utilize a uterine manipulator. This report analyzes intraoperative and post-operative outcomes, pathologic characteristics, and disease recurrence patterns of patients with IB1 cervical cancer to determine the feasibility and oncologic outcomes of this novel surgical technique.

2. Methods

2.1. Participants

This retrospective cohort study was determined exempt by the University of Nevada, Reno Institutional Review Board. All patients at the Center of Hope clinic in Reno, Nevada between 2018 and 2020 who were diagnosed with clinical stage IB based on the International Federation of Gynecology and Obstetrics (FIGO) 2018 and elected to have the TIRRHVC procedure instead of an open procedure were reviewed. All patients were seen initially for consultation and examined by the primary surgeon who then assigned a clinical tumor size based on a pelvic exam. A metastatic workup was performed that consisted of positron emission tomography (PET) scan to determine presence of metastatic disease. If the PET scan did not show any evidence of metastatic disease, the patients were then given the option of proceeding with primary radiation therapy or surgery. If the patient elected to proceed with surgery, they were informed of the LACC trial results of the inferior outcomes with minimally invasive procedure compared to open laparotomy. The patient decided whether to pursue the minimally invasive TIRRHVC or an open surgery. Only patients who underwent TIRRHVC were reviewed and reported in this retrospective analysis.

Demographics and *peri*-procedural characteristics were extracted from medical records. The data collected include age, BMI, operative time, estimated blood loss, intraoperative complications, post-operative complications, death, and adjuvant therapy. The pathologic characteristics recorded include clinical stage, clinical size, PET imaging size, total number of lymph nodes excised, pathologic size, surgical stage, upstaging, tumor cell type (squamous cell or adenocarcinoma), tumor grade, size of parametria, and size of vaginal cuff. Clinical stage is based on FIGO 2018 staging criteria and clinical size was determined by the clinician's physical exam. PET imaging size was determined by the radiologist. If there was no radiotracer uptake on the PET scan, the tumor size was immeasurable and therefore determined to be zero. Pathologic size is the measured length of the tumor following surgical removal, described on the pathology report. The number of lymph nodes, parametria, vaginal margins, and lymphovascular space with metastatic involvement was recorded. Lymphovascular space involvement was determined at the discretion of the pathologist reading the pathology slides; any presence of tumor cells in the lymphovascular space qualified as positive lymphovascular space involvement. The most recent follow-up exam including imaging was used to determine if the patient had any evidence of recurrence.

Surgical Technique: Total Intracorporeal Robotic Radical Hysterectomy with Vaginal Cerclage (TIRRHVC) is a complex surgical technique aimed at achieving radical hysterectomy while minimizing the risk of tumor spillage. This technique does not use a uterine manipulator. The procedure is divided into five phases. Double J ureteral stents were routinely placed prior to initiation of the procedure as a precaution due to extensive dissection and ureterolysis of the ureters and ureterovesical junction.

Phase 1: Pelvic lymphadenectomy.

- Standard pelvic lymphadenectomy is performed with removal of all the external and obturator pelvic lymph nodes

Phase 2: Development of parametrium and skeletonization and division of anterior division of uterine vessels, deep uterine vein. Hypogastric nerve plexus separation and division of the parametrium.

- The uterine vessels and deep uterine vein are skeletonized from the anterior hypogastric vessels and ligated at its origin lateral to the ureter
- The ureter along with the mesoureter are mobilized and dissected off the medial leaf of the peritoneum, developing the Okabayashi space (Kostov et al., 2020)
- Latzko's space is developed to separate the hypogastric cervical nerve fibers (HGCNF) from the hypogastric-vesicle nerve fibers (HGVNF) in preparation for the division of the posterior parametrium (Kostov et al., 2020)

Phase 3: Development of the rectovaginal space and division of the uterosacral ligaments, followed by development of the vesicouterine space. Skeletonization and division of the anterior uterovesical ligament.

- Utilize robotic "third arm" to provide cephalad traction while developing the vesicouterine and rectovaginal space
- Ethicon Endo-Surgery Circular Sizer (EEA) is placed in the vaginal canal to provide additional cephalad traction during the division of the anterior uterovesical ligament (CS23, (n.d.))

Phase 4: Paravaginal dissection and further development of vesicovaginal space to ensure adequate vaginal margin

- EEA is placed in the vaginal canal to provide additional cephalad traction to further mobilize the bladder and rectum away from the vagina
- After the anterior uterovesical ligament has been divided, the distal ureter is mobilized laterally, and the paravaginal tissue is divided.

Phase 5: Placement of vaginal cerclage suture followed by intracorporeal vaginal colpotomy.

- Throughout this step, optimal traction on the uterus is imperative. This is achieved using the EEA sizer in the vaginal canal pushing cephalad simultaneously with the robotic 3rd arm grasping the anterior lower uterine segment at the isthmus, pulling cephalad. Appropriate traction on the uterus is utilized throughout the following steps
- The bladder and rectum are dissected anteriorly and posteriorly, respectively, to obtain the desired vaginal margin

- Mersilene suture is delivered through 12 mm assistant port. Place vaginal cerclage suture circumferentially so the knot of the suture is anterior (RS22, (n.d.))
- After the vaginal suture cerclage is placed circumferentially, the cerclage suture is then tied down. Simultaneously the EEA is withdrawn from the vagina to achieve complete vaginal occlusion, thus achieving complete tumor containment.
- Intracorporeal vaginal colpotomy is performed distal to the cerclage suture to complete radical hysterectomy

Statistical Methods: Baseline demographic, disease and surgical characteristics are summarized using n and percentage for categorical variables and using the mean, standard deviation (SD), median, and 25th and 75th percentiles and ranges as appropriate for continuous variables. Follow-up was summarized using medians and interquartile ranges. Oncologic outcomes were summarized using the Kaplan-Meier estimator, with time zero being the procedure date and extending to the minimum of death, disease recurrence, last follow-up visit or October 31, 2023 as appropriate.

3. Results

3.1. Demographics and clinical findings (Table 1)

Between October 2018 and August 2022, 26 patients with early-stage cervical cancer underwent a robotic assisted nerve sparing radical hysterectomy with vaginal cerclage (TIRRHVC) after appropriate informed consent was obtained. The ages of patients range from 26 to 84 (mean = 47.5). The average body mass index was 29.6 kg/m^2 (range 19–49.4). All patients had clinical stage IB according to FIGO 2018 guidelines; 17 (65.4 %) were IB1 (less than or equal to 2 cm), and 9 (34.6 %) were IB2 (2–4 cm). The mean clinical tumor size was 2.12 cm (range 0.7–4 cm). None of the patients had any positive lymph nodes or evidence of metastasis on the preoperative PET scan. Nine of the 26 patients (34.6 %) did not have any radiotracer uptake on the PET scan. Considering that the PET tumor size for the patients with no uptake was determined to be zero, the mean PET tumor size was 1.95 cm (range 0–3.9 cm). Of the 17 tumors that showed positive metabolic activity on the PET scan, the mean tumor size was 2.98 cm (range 1.2–3.9). Comparing clinical size with PET size, 50 % of the tumors were measured as smaller on the PET scan (13/26), 46 % were larger on PET scan (12/26), and 4 % measured the same as the clinical size on PET scan (1/26).

3.2. Pathological characteristics (Table 2)

One surgeon at the Center of Hope performed 96.1 % (25/26) of the surgeries. Fourteen patients (53.8 %) had squamous cell carcinoma, 11 (42.4 %) patients had adenocarcinoma, and 1 (3.8 %) patient had adenosquamous carcinoma of the cervix. The mean pathology size was 2.66 cm (range 0 cm (no residual tumor) − 5.6 cm). Seventeen patients had a tumor size greater than 2 cm (65.4 %). The pathologic tumor size was greater than the estimated clinical size in 50 % (13/26) of patients, less than estimated in 27 % (7/26) of patients, and equivalent to the clinical size in 23 % (6/26) of patients. The pathologic tumor size was greater than the PET imaging tumor size in 54 % (14/26) of patients, smaller than PET size in 42 % (11/26) of patients, and the same in 4 % (1/26) of patients. Nine patients were surgical stage IB1 (34.6 %), 10 were IB2 (38.5 %), 3 were IB3 (11.5 %). Four (15.4 %) patients were upstaged to stage IIIC due to metastasis to the pelvic lymph nodes. Of these four patients, one patient additionally had positive vaginal margins. Nine patients (34.6 %) had positive lymphovascular space involvement. The average number of lymph nodes excised was 22.5 (range 6–39). The average left parametrial margin was 4.70 cm (range, 2.8–7.9 cm), right parametrial margin was 4.23 cm (range 2.6–6.0 cm), and vaginal cuff margin was 2.38 cm (range 1.0–3.6 cm).

Table 1
Patient Characteristics.

		Total (N = 26)
Age	Mean ± SD	47.5 ± 14.6
	Med. [25 %, 75 %]	43.5 [38.0, 54.0]
	Range	26—84
Body Mass Index (BMI)	Mean ± SD	29.6 ± 7.85
	Med. [25 %, 75 %]	27.6 [23.8, 37.0]
	Range	20.8—49.4
Clinical Size (cm)	Mean ± SD	2.12 ± 1.10
	Med. [25 %, 75 %]	2.00 [1.00, 3.00]
	Range	0.7 – 4 cm
Clinical Stage	1B1	17 (65.4 %)
	1B2	9 (34.6 %)
PET imaging size	Mean ± SD	1.95 ± 1.61
	Med. [25 %, 75 %]	2.65 [0, 3.6]
	Range	0–3.9

Clinical staging is based on FIGO 2018 guidelines.
BMI, body mass index kg/m^2; PET, positron emission tomography.

3.3. Intraoperative outcomes (Table 3)

All patients successfully underwent a robotic radical hysterectomy, as described in the methods, and no patients required a conversion to open surgery. The average operative time was 211.3 min (range 157–330), and the average estimated blood loss was 117 mL. There were no intraoperative complications reported.

3.4. Postoperative course (Table 3)

Patients were hospitalized post-operatively for an average of 1.5 days (range 1–4 days). Twenty patients (77 %) returned home with a foley catheter in place. The catheter was removed after a median of 6 days (range 3–77). Thirteen (50 %) patients had postoperative complications following the surgery. Ten patients had a urinary tract infection (UTI) and were treated with oral antibiotics. Two patients developed pyelonephritis which required rehospitalization for intravenous antibiotics, and one of these patients developed bacteremia. One patient, in addition to a UTI, developed a seroma, treated by CT guided drainage. One patient developed cuff cellulitis, treated with oral antibiotics.

3.5. Oncologic outcomes

The 3-year disease free-survival rate estimate (DFS) was 95.5 %. The median follow-up period was 2.8 years (IQR 2.3 to 3.6). Through 3 years, there were no recurrences. One patient, who had clinical stage IB2 (tumor size 3.5 cm), had a recurrence at 3.6 years despite undergoing adjuvant concurrent chemoradiation for 2 pelvic lymph node metastases post TIRRHVC. The site of metastasis was to the lung. Only one patient died; she expired at 2.45 years post-treatment, from a disease unrelated to gynecologic cancer. Forty-two percent of patients (11/26) required adjuvant therapy based on Sedlis criteria or for advanced regional disease, and were treated with concurrent chemotherapy and whole pelvic radiotherapy (Sedlis et al., 1999). Of these 11 patients who underwent adjuvant treatment, 5 patients were clinical stage IBI and 6 patients were clinical stage IB2. Four of these patients had positive lymph nodes, the other seven patients met Sedlis criteria, with a pathologic tumor size greater than 4 cm and positive LVSI (Sedlis et al., 1999).

Table 2
Pathologic Characteristics.

		Total (N = 26)
Pathology Size (cm)	Mean ± SD Med. [25 %, 75 %] Range	2.66 ± 1.45 2.55 [1.50, 3.60] No residual tumor – 5.6
Surgical Stage	1B1 1B2 1B3 3C	9 (34.6 %) 8 (30.8 %) 5 (19.2 %) 4 (15.4 %)
Histology	Squamous cell carcinoma Adenocarcinoma Adenosquamous carcinoma	14 (53.8 %) 11 (42.3 %) 1 (3.8 %)
Grade	1 2 3	10 (38.5 %) 12 (46.2 %) 4 (15.4 %)
Lymph Nodes	Mean ± SD Med. [25 %, 75 %] Range	22.50 ± 8.344 22.00 [18.00, 28.00] 6–39
Left parametria (cm)	Mean ± SD Med. [25 %, 75 %] Range	4.70 ± 1.22 4.35 [4.00, 5.00] 2.8–7.9
Right parametria (cm)	Mean ± SD Med. [25 %, 75 %] Range	4.23 ± 0.881 4.05 [3.50, 4.90] 2.6–6
Vaginal cuff (cm)	Mean ± SD Med. [25 %, 75 %] Range	2.38 ± 0.912 2.45 [1.50, 2.90] 1–3.6
Lymph node metastasis	No Yes	22 (84.6 %) 4 (15.4 %)
Parametria metastasis	No	26 (100.0 %)
Vaginal metastasis	Yes No	1 (3.8 %) 25 (96.2 %)
Lymphovascular space involvement	Yes No	9 (34.6 %) 17 (65.4 %)

Pathology report; Med, median.

Table 3
Operative Outcomes.

		Total (N = 26)
Operative Time (min)	Mean ± SD Med. [25 %, 75 %] Range	211.3 ± 47.16 207.0 [175.0, 224.0] 135–330
Estimated blood loss (mL)	Mean ± SD Med. [25 %, 75 %] Range	117.0 ± 66.50 100.0 [50.00, 200.0] 25–250
Days of Hospitalization	Mean ± SD Med. [25 %, 75 %] Range	1.50 ± 0.707 1.00 [1.00, 2.00] 1–2
Upstage	Yes No	4 (15.4 %) 22 (84.6 %)
Adjuvant Treatment	Yes No	11 (42.3 %) 15 (57.7 %)
Catheter Removed Post-operative Day	Mean ± SD Med. [25 %, 75 %] Range	13.19 ± 17.62 6.000 [3.000, 15.00] 0–77

Adjuvant Treatment included systemic chemotherapy and radiation therapy. Med, Median.

4. Discussion

Tumor containment and optimal surgical resection have been long-standing principles of surgical oncology. In 1715, Dutch physician Hermann Boerhaave wrote "If we cannot entirely eradicate the cancer with its roots and its seeds, it becomes irritated, enters within, produces other cancers and increases those which have formed" (Drouin et al., 2023). TIRRHVC is a promising novel technique that integrates tumor containment strategies without compromising the radicality of the procedure for high-risk clinical stage IB cervical cancer. To the authors' knowledge, our review is the first to evaluate the feasibility of TIRRHVC and to report early oncologic outcomes of patients with high-risk stage IB cervical cancer who underwent this procedure. Though the LACC trial demonstrated inferior oncologic outcomes with MIRH compared to ORH for the treatment of cervical cancer, the cause of those inferior outcomes remains unclear. Possible explanations include poor tumor containment, tumor seeding, surgical learning curve, and pathological factors. One study demonstrated that poor oncologic outcomes are associated with tumor size > 2 cm (Doo et al., 2019). In our series, 61.5 % of lesions were greater than 2 cm while 39.5 % were less than or equal to 2 cm. With an average pathologic tumor size of 2.6 cm, adequate parametrial and vaginal margins were removed with sufficient lymph nodes excised. The surgical and oncologic outcomes using this technique are promising for the role of MIS for high-risk early-stage cervical cancer.

The TIRRHVC technique affords the many advantages of MIS, such as decreased blood loss and hospital stay, and decreasing morbidity that is often associated with this procedure. A 2022 *meta*-analysis compared operative outcomes of open and laparoscopic radical hysterectomies for early-stage cervical cancer, and reported a shorter hospitalization and decreased blood loss in the laparoscopic group compared to the open group (Kampers et al., 2022). Similarly, in the 2022 MEMORY study, a multi-institutional retrospective cohort study, there was significantly decreased hospitalization length and decreased blood loss in the minimally invasive robotic-assisted radical hysterectomy group compared to the open hysterectomy group. Using the TIRRHVC technique, the mean EBL was 117 mL, mean operative time was 211.3 min, and mean hospital stay was 1.50 days. In addition, there were no intraoperative complications, and no conversions to an open laparotomy.

Oncologic outcomes are another imperative component in evaluating the feasibility of TIRRHVC. A multi-institutional retrospective analysis compared ORH with MIRH for patients with IA1, IA2 and IB1 cervical cancer and reported inferior disease-free survival in the MIRH group, however no statistical difference in the overall survival in the MIRH group compared to the ORH group for tumors < 2 cm (Uppal et al., 2019). The MIRH cohort in this study's technique did not specify the use of a uterine manipulator and did not have a uniform tumor containment technique. In a retrospective analysis at Memorial Sloan-Kettering Cancer Center, the 5-year disease free survival rates were 87.0 % in the MIS group and 86.6 % in the ORH group (p = 0.92) (Brandt et al., 2020). The patients in this review were mostly IB1 in both the MIS and open groups (88 % and 94.9 %, respectively) with an average tumor size of 1.6 cm in the MIS group and 1.9 cm in the open group. Especially recognizing the large tumor size and advanced stage of the patients who

underwent TIRRHVC, the oncologic outcomes are encouraging. The rate of recurrence is 3.8 % (1/26), and only one patient died, though notably, this was a death unrelated to cancer. The three-year disease-free survival estimate is 95.5 %, with a mean follow-up period of 2.83 years. Notably, 11 patients underwent adjuvant chemoradiation therapy following surgery due to positive lymph nodes or large pathologic tumor size and positive LVSI, based on Sedlis criteria (Sedlis et al., 1999). These promising oncologic outcomes further suggest the feasibility of this new technique and the need for further investigation to compare oncologic outcomes of ORH, MIRH without a uterine manipulator and without a cerclage, and TIRRHVC.

The favorable outcomes observed in our series may be attributed to the tumor containment technique. Others have similarly postulated that better tumor containment strategies may contribute to lower recurrence rates with minimally invasive approaches. In a two patient case series, Martino et al describes a robotic assisted radical hysterectomy with a vaginal cerclage technique (Martino et al., 2020). The No-Look No-Touch (NLNT) procedure, described by Fusegi et al, closes off the vagina with circumferential sutures followed by a vaginal colpotomy prior to the laparoscopic tumor resection (Fusegi et al., 2021). The 4-year survival for the NLNT procedure was 95.0 %. A multicenter retrospective study by Kohler et al reported 3-, 4.5-, and 10-year disease-free survival rates of 96.8 %, 95.8 %, and 93.1 %, respectively using a transvaginal-laparoscopic radical hysterectomy without use of a uterine manipulator (Kohler et al., 2019). Park et al is beginning a prospective multicenter study, the SOLUTION trial, on the safety and efficacy of a laparoscopic or robotic-assisted technique in which an endoscopic stapler separates the cervix from distal structures (Park et al., 2022).

The TIRRHVC technique provides some unique advantages. The intracorporeal approach may be advantageous during the complete circumferential dissection of the vaginal apex because it allows for the desired vaginal margin and minimizes the risk of any potential injury to the bladder, rectum, and surrounding structures. In contrast, when placing the cerclage suture using a vaginal approach, clear delineation of the bladder and vagina may be more challenging. In addition, as described in phase 4 and 5 of the technique, the EEA sizer and robotic 3rd arm is essential in providing cephalad traction enhancing visualization during the colpotomy. The Mersilene suture knot technique is utilized to ensure complete vaginal occlusion prior to colpotomy, and in contrast to a slip-knot technique, the suture knot minimizes the risk of knot slipping. An endoscopic stapler has been proposed as another method for occlusion at the time of colpotomy however the ability to successfully occlude the vagina may depend on the thickness of vaginal mucosa (Limbachiya and Kumari, 2021). The other contributing factor that might explain our low rate of recurrence is 42 % of patients underwent adjuvant therapy with chemoradiation for high-risk features. One patient experienced recurrence in the lung at 2.8 years after surgery despite receiving adjuvant concurrent chemoradiation therapy for positive pelvic nodes after undergoing TIRRHVC.

While zero patients encountered intraoperative complications, it is noted that ten patients acquired a urinary tract infection and two patients developed pyelonephritis following surgery. This may be a consequence of the routine placement of stents at the time of surgery and removal typically 6 weeks post-operatively. Robotic assisted radical hysterectomy involves extensive ureterolysis to the ureterovesical junction, including the use of an energy device to ligate the vasculature. This may result in devascularization and a potential ureterovaginal fistula. Therefore, stents are placed for all patients to prevent the aforementioned complication. Unfortunately, the patients reviewed did experience a significant rate of urinary tract infections. Though fortunately, there were zero ureteral injuries or ureterovaginal fistulas. Considering the high rates of urinary tract infections though low rate of potentially more harmful complication, this may be an area of review and improvement for future patients. Interestingly, the SHAPE trial evaluated the oncologic outcomes of a simple versus radical hysterectomy in patients with FIGO 2009 Stage IA2 and IB1 cervical cancer with lesions no greater than 2 cm and found noninferior oncologic outcomes at 3 years between the two procedures (Plante et al., 2024). However, a simple hysterectomy was associated with fewer urologic complications. Particularly, there were significantly fewer reports of urinary retention and incontinence following a simple hysterectomy compared to a radical hysterectomy. Indeed, some patients in this review had a catheter in place for a greater than expected period of time due to urinary retention. Further investigation may be warranted on the necessity of a radical hysterectomy with a greater risk of ureteric injuries and therefore the preventative use of stents in our cohort of patients. Seventeen patients who underwent TIRRHVC were clinical stage IB1 and may have qualified for the SHAPE trial.

Limitations of this retrospective analysis include the lack of a control arm in the study design, single surgeon experience, small cohort of patients, and short follow-up period. The TIRRHVC was not compared to other surgical approaches such as ORH or TLH with the use of uterine manipulator and without a vaginal cerclage because of the limited number of cases and short follow-up period. This analysis was not designed as a randomized control trial; the purpose was not to compare the results of TIRRHVC to other techniques, but simply to report the feasibility and early outcomes of this novel surgical strategy. The investigators aim to compare robotic-assisted hysterectomy without tumor containment techniques and TIRRHVC as more patients reach 4.5 years of follow-up in 2026 for more meaningful survival data.

It is known that surgical volume and learning curve contribute to surgical outcomes (Paek and Lim, 2021; Baeten et al., 2021; Fusegi et al., 2023; Mikami et al., 2019). A single surgeon who performs a high volume of robotic cases performed all but one of the surgeries in this cohort of patients. Though there is limited external validity, a single surgeon experience nearly eliminates the confounding variable of surgeon experience, favors better outcomes considering the high volume, and ensures uniform technique amongst nearly all the cases.

The feasibility of the TIRRHVC and favorable early oncologic outcomes in the treatment of early-stage cervical cancer is quite encouraging for the possible future of offering patients the advantages of MIS without compromising oncologic outcomes. The positive outcomes are thought to be due to the vaginal cerclage as a tumor containment technique and the lack of a uterine manipulator, lowering the risk of tumor seeding. As the data from this patient group matures, the investigators will report additional survival outcomes. Additionally, two prospective trials, the Robotic-assisted Approach to Cervical Cancer (RACC) trial and the Robotic versus Open radical hysterectomy for Cervical Cancer (ROCC) trial will be imperative in addressing the oncologic outcomes of MIRH in comparison with ORH (Bixel et al., 2022; Falconer et al., 2019). The TIRRHVC should be further evaluated as one possible strategy to overcome the inferior outcomes previously reported with MIS for early-stage cervical cancer.

CRediT authorship contribution statement

Lauren Lim: Writing – review & editing, Writing – original draft, Investigation, Data curation. **April Slee:** Writing – review & editing, Methodology. **Peter C. Lim:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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