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Case Report

A modified technique of laparoscopic radical trachelectomy combined with extracorporeal cervical amputation through a mini-laparotomy

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Radical trachelectomy is an optional fertility-sparing treatment for early-stage cervical cancer, and recently, the minimally invasive approach (MIA) has become a major trend in radical trachelectomy. MIA radical trachelectomy requires a more careful surgical technique to avoid tumor spillage and exposure of the cancerous tissue under carbon dioxide pneumoperitoneum to reduce the risk of recurrence. We present a case of a 33-year-old nulliparous woman with stage IB1 cervical cancer who underwent MIA radical trachelectomy through a combination of laparoscopic surgery and mini-laparotomy, mainly to prevent postoperative complications and tumor spread during cervical amputation. A Papanicolaou test suggested the diagnosis of squamous cell carcinoma of the cervix without any symptoms such as atypical bleeding. The subsequent biopsy revealed squamous cell carcinoma with stromal invasion of the cervix. Cervical amputation was performed extracorporeally through a small incision in the lower abdomen. There were no perioperative complications. The patient was discharged on postoperative day 13. The final pathological evaluation revealed residual microinvasive cancer of the endocervical canal with clear margins, no lymphovascular space involvement, and 27 negative lymphatic nodes. The joint of the neo-cervix and vagina had healed completely without erosion or stenosis of the cervical canal, and no problems occurred during sexual intercourse. No cancer recurrence or menstrual disorders have been reported in the short postoperative period of 6 months. The surgical technique of laparoscopic radical trachelectomy combined with extracorporeal cervical amputation may be an acceptable alternative to reduce the risk of recurrence by preventing intraperitoneal tumor spillage.

Keywords

Cervical cancer; Radical trachelectomy; Minimally invasive approach; Fertility preservation; Mini-laparotomy; Cervical amputation; Extracorporeal

1. Introduction

It is estimated that 13.1 women worldwide and 14.7 women in Japan suffer from cervical cancer per 100,000 annually [1]. The incidence of cervical cancer has recently decreased in many developed countries [1, 2]. However, for women in their twenties and thirties, cervical cancer remains the second most common malignancy after breast cancer in Japan and overseas [2–4]. The lack of early screening facilities in developing countries coupled with the high incidence of cervical cancer in women of childbearing age is a major problem in early diagnosis and treatment of cervical cancer [1]. As fertility preservation is important for young women with early-stage cervical cancer, radical trachelectomy is recognized as the first choice among established fertility-sparing treatments for early-stage cervical cancer [5].

Since Dargent *et al.* first reported vaginal radical trachelectomy (VRT) with laparoscopic pelvic lymphadenectomy in 1986 [6, 7], various surgical approaches to and devices for VRT have been developed. Recently, the usefulness of the minimally invasive approach (MIA) in early cervical cancer treatment, including radical trachelectomy, has been reported [8–10]. In 2018, a randomized controlled trial [the Laparoscopic Approach to Cervical Cancer (LACC) trial] conducted to evaluate the usefulness of MIA radical hysterectomy versus open radical hysterectomy in treating early-stage cervical cancer revealed that MIA radical hysterectomy was associated with higher recurrence and worse 4-year overall survival (OS) rates than open radical hysterectomy [11, 12]. The results of the LACC trial prompted gynecologic oncologists to reassess if MIA radical hysterectomy was a suitable surgical procedure to maintain optimal oncologic outcomes for patients with early-stage cervical cancer.

Additionally, distinctive procedures in trachelectomy including the determination of the accurate resection range of the cervix and effective cervical cerclage are considerably significant in preventing postoperative complications such as cervical stenosis, cerclage erosion, and premature rupture of membranes. The purpose of this report was to present a case of early-stage cervical cancer managed by radical trachelectomy performed through a combination of laparoscopic surgery and mini-laparotomy, mainly to prevent postoperative complications and tumor spread during cervical amputation. We had introduced abdominal radical trachelectomy (ART) in 2002, and have carried out about 2 cases each year. Since 2018, laparoscopic radical surgery for the invasive cervical cancer in Japan has been covered by insurance,

and this case has become the first at our facility. Taking this opportunity, we would like to maximize the benefits of MIA such as the reduction of complications, ileus and pelvic adhesions, and preservation of fertility, while ensuring oncological safety such as local control. The complications of ART among multi-institutions including our hospital were described in our previous report [13]. MIA radical trachelectomy was planned with the aim of minimizing invasion. We decided to adopt a small incision during amputation of the cervix, making neo-cervix and cerclage, because it was thought that switching from laparotomy to laparoscope for all procedures could lead to technical difficulty, a prolonged time surgery, and increased risk of tumor dissemination if having complications with intra-abdominal operative procedure.

2. Case report

The patient was a 33-year-old Japanese woman, nulligravida, with a height of 169.2 cm and weight of 71.1 kg. A diagnosis of squamous cell carcinoma (SCC) of the uterine cervix was revealed in routine cancer screening [Papanicolaou (Pap)] test during a regular check-up without any symptoms such as atypical bleeding. A colposcopy-guided punch biopsy revealed SCC with stromal invasion of the cervix. No obvious tumor mass or enlargement of the pelvic and paraaortic lymph nodes was seen on magnetic resonance imaging or computed tomography. Cervical conization was performed to assess the depth of invasion and spread of the tumor. The surgical lesion of the SCC was pathologically characterized as having a maximum depth of invasion of 7 mm, maximum horizontal spread of 11 mm, no lymphovascular space involvement (LVSI), and a negative margin. Thus, the patient was diagnosed with SCC of the uterine cervix, clinical stage IB1 [International Federation of Gynecology and Obstetrics (FIGO) 2018 staging] [14]. A cervical cytology test performed after conization was negative for intraepithelial lesions or malignancy (NILM). The patient desired future fertility and requested a fertility-sparing minimally invasive surgery (MIS) after being briefed about the therapeutic options for early-stage invasive cervical cancer, such as re-conization with laparoscopic pelvic lymphadenectomy and sentinel lymph node mapping.

One month after conization, the patient underwent a laparoscopically assisted radical trachelectomy with pelvic lymphadenectomy. Four trocars were placed in the diamond position (a 12-mm trocar at the umbilical site and three 5-mm trocars in the central and bilateral quadrants of the lower abdomen), and a uterine manipulator (ClearView®, Clinical Innovations, UT, USA) was used. The pneumoperitoneum pressure was set to 10 mm Hg. No dissemination was observed in the peritoneal cavity. First, a laparoscopic pelvic lymphadenectomy was performed. The anterior broad ligament was cut, and the paravesical and Latzko's pararectal spaces were developed down to the level of the elevator muscle fascia, and a systematic pelvic lymphadenectomy up to the level of the common iliac lymph node was performed. There were no swollen lymph nodes in the pelvis. Intraoperative pathological consultation for lymph node metastasis was not done. After the Okabayashi pararectal space was developed and the course of the hypogastric nerve confirmed, the cervicovesical vessels (anterior leaf of the vesicouterine ligament) were dissected, and the ureter was completely released from the paracervix. The bilateral uterine arteries were isolated at the ureteral intersection, and the descending branches of both sides were clipped and separated, while their ascending branches were preserved. The vesical veins (posterior leaf of the vesicouterine ligament) were clipped and dissected, sparing the pelvic plexus. The rectovaginal space was developed, and the sacrouterine and rectovaginal ligaments were dissected, sparing the hypogastric nerve. Subsequently, the paracolpos were dissected. In this way, we transected the paracervix and paracolpos preserving the autonomic nerves according to type C1 radical hysterectomy of the Querleu–Morrow (QM) classification [15] (Fig. 1A).

Before the colpotomy, a 5-cm Maylard low transverse abdominal incision was made to enable the cervix to be dissected extracorporeally. Immediately after the vagina was circularly cut out with a 3-cm margin of the vaginal cuff intracorporeally, the cervix with the vaginal cuff was immediately drawn out of the peritoneal cavity through a minilaparotomy (Fig. 1B). The cervix was separated off 5-mm from the internal os under direct vision. After clean margins were confirmed by a frozen section diagnosis, the cervix was ligated at the level of the internal os using a 2-0 nylon suture as the permanent cerclage, and the cervical serosa was exfoliated to create the neo-cervix. The seromuscular edge of the remaining uterus was laparoscopically joined to the dorsal and ventral sides of the vagina with barbed sutures (Fig. 1C). Finally, an intrauterine device (FD-1®, Fuji Latex Co., Tokyo, Japan) was inserted into the uterine cavity for menstrual drainage.

Since the intraoperative rapid diagnosis took approximately 1 hour, the surgery lasted 496 minutes. The blood loss was 384 mL. There were no perioperative complications such as transfusion, infection, suture failure, or other organ injuries. The urinary catheter was removed on postoperative day 7, and the patient was discharged on day 13 to enable clean intermittent self-catheterization for measuring the residual urine at home for a month. One month after the operation, a self-check sheet for residual urine revealed that the patient did not have any problems related to urination, and self-catheterization was discontinued.

The final pathological evaluation revealed residual microinvasive cancer of the endocervical canal with a size of 2 cm or less, clear margins of 30 mm from the vaginal stump and 10 mm from the cervical stump, no LVSI, negative parametria and 27 negative lymphatic nodes (Fig. 1D,E). As this case had a low risk of recurrence based on the results of final pathological evaluation, no adjuvant therapy was applied. At the 6-month follow-up, no recurrence of the cancer was noted. The joint of the neo-cervix and vagina had healed

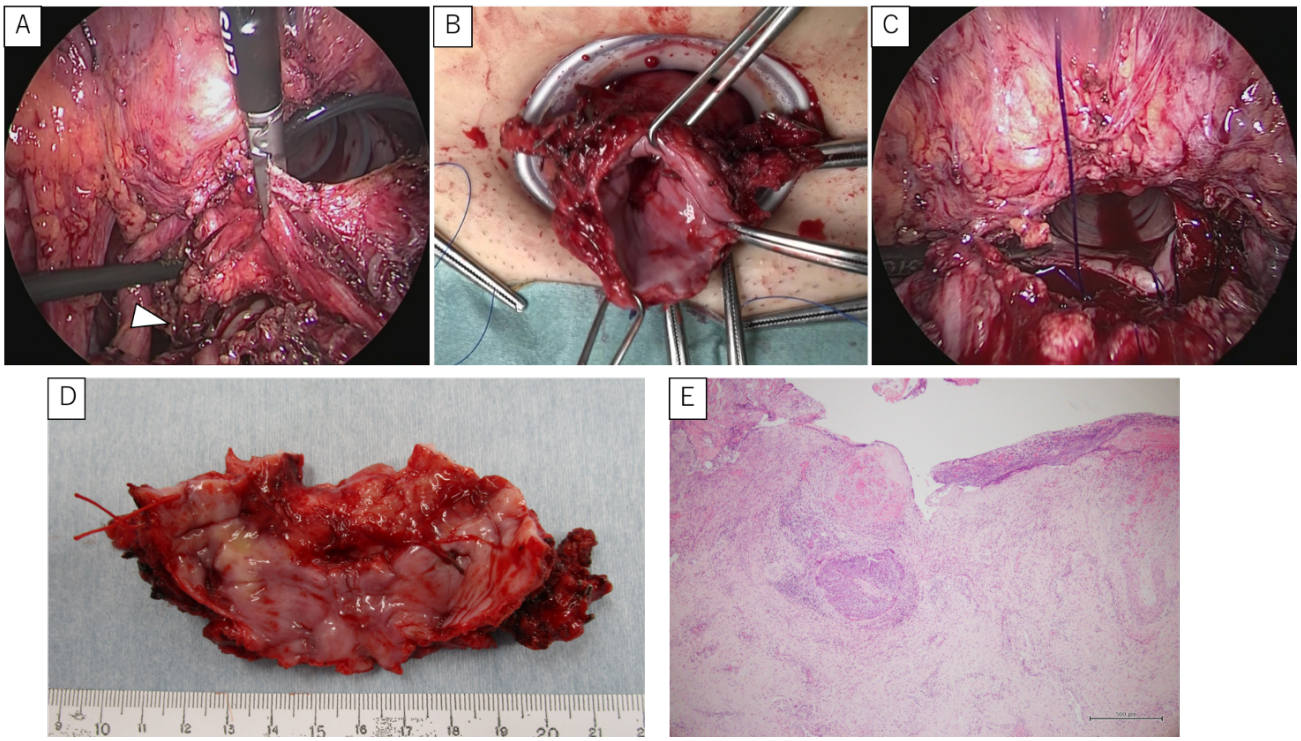

Fig. 1. Surgical procedure findings and specimen findings. (A) Laparoscopic view of intracorporeal colpotomy. The paracolpos was dissected while sparing the pelvic nerve plexus (arrow); (B) Mini-laparotomy findings. The cervix could be pulled out of the abdominal cavity without tension. It was easy to set an accurate incision line; (C) Laparoscopic view of connecting the residual uterine corpus and vagina using barbed sutures. Reliable suturing was possible without applying extra traction; (D) Macroscopic findings of the excised specimen. The vaginal wall was removed by 2 cm or more and the paracervix and paracolpos were sufficiently removed; (E) Histopathological findings of the endocervical canal (×40, Hematoxylin-Eosin). Residual microinvasive lesion of the SCC is observed in only one place.

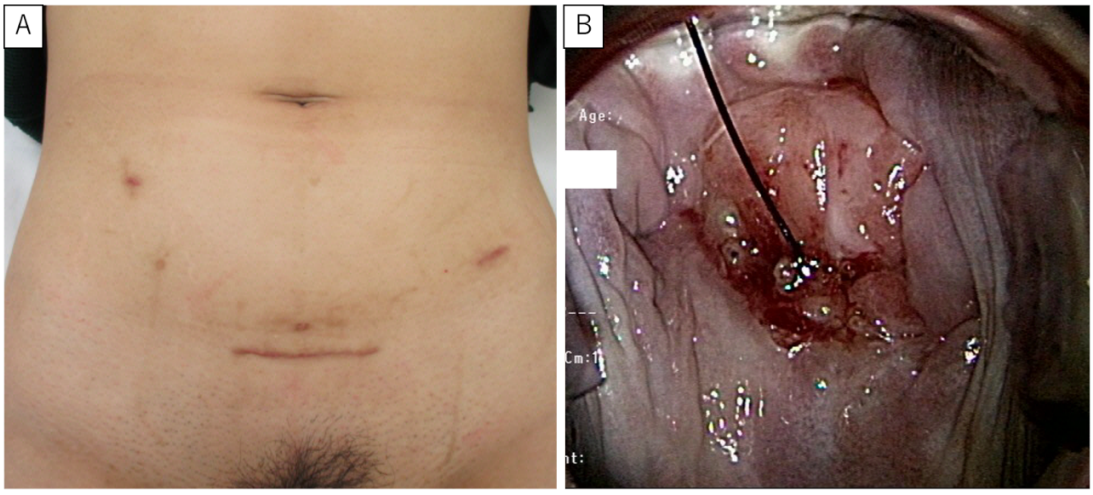

Fig. 2. Postoperative findings at 3 months after the surgery (A) Abdominal wound findings. Laparoscopic wounds (umbilical and lateral lower abdomen) and the small incision wound (central lower abdomen, horizontal) were recognized; (B) Colposcopy findings. The epithelialization of the stump and the junction was good, and no stenosis was observed. An intrauterine device inserted into the uterine cavity for menstrual drainage was visible.

completely without erosion or stenosis of the cervical canal, and there were no problems during sexual intercourse (Fig. 2). The patient did not report any menstrual disorders such as irregular cycles or scanty menstruation and was permitted to plan a pregnancy 1 year after the operation if the cancer did not recur.

3. Discussion

This case demonstrated that a complete transection of the paracervix and resection of the vagina of an appreciable

length according to type C1 radical hysterectomy of the QM classification can be performed laparoscopically, and the accurate resection area of the uterus can easily be determined through a mini-laparotomy. No recurrence or menstrual disorders have been reported by the patient to date, even 6 months after the surgery. The surgical technique of MIA radical trachelectomy described herein may be an acceptable alternative to reduce the risk of recurrence by preventing intraperitoneal tumor spillage. VRT with laparoscopic pelvic lymphadenectomy that had been performed in 1986 was originally described by Dargent *et al.* [6, 7] and has proven to be a feasible technique [7, 16]. However, VRT requires surgeons having a high level of expertise in performing vaginal surgeries [17] and is burdened with procedural issues such as insufficient resection of the paracervix and vaginal cuff [16], especially in young nulliparous women and those who have undergone preoperative conization. Smith *et al.* developed a new approach in 1997 called ART that is similar to the traditional radical hysterectomy and addresses the drawbacks of VRT [17]. The oncological safety of ART is guaranteed in early-stage cervical cancer, especially in cases with tumors smaller than 2 cm [18, 19]. The first total laparoscopic radical trachelectomy was reported in 2002 by Pomel *et al.* [20] and the first robot-assisted laparoscopic procedure in 2008 by Persson *et al.* [21]. Moreover, the noninferiority of MIA radical trachelectomy, including the pure laparoscopic and robotic approaches, in maintaining optimal oncological and obstetric outcomes has been proven in several previous reports [8, 22, 23]. In a retrospective study conducted in the United States using data from the National Cancer Database between 2010 and 2015, Matsuo *et al.* reported that the 4-year OS rates for MIA trachelectomy (n = 144) and open trachelectomy (n = 102) in reproductive-aged women with early-stage cervical cancer were similar (MIA, 95.7%; open approach, 92.3%) [8]. In the international radical trachelectomy assessment (IRTA) study which compared the disease-free survival (DFS) after radical trachelectomy between the MIA (n = 310) and open approach (n = 388) in women with early-stage cervical cancer, Salvo *et al.* recently noted that there was no significant difference in the recurrence rate during the follow-up time (median 40.9 months); (MIA, 6.4%; open approach, 5.7%), (P = 0.7492) [22]. Moreover, several reports have shown a higher pregnancy rate in women who underwent MIA radical trachelectomy than in those who underwent ART or VRT, although the issue of higher prematurity rate compared to VRT remains [13, 23]. Thus, MIA radical trachelectomy has the potential to achieve a more favorable obstetric outcome than conventional techniques. Against this backdrop, MIA trachelectomy is expected to become the most promising technique among fertility-sparing treatments for early-stage invasive cervical cancer.

The LACC trial, the first randomized controlled trial that investigated the efficacy of surgical treatment for cervical cancer, showed that MIA radical hysterectomy was associated with higher recurrence and worse OS rates than laparotomy [11, 12]. The results of the LACC trial have changed the surgical treatment policies for cervical cancer. Surgical techniques specific to the laparoscopic approach such as the use of uterine manipulators, intracorporeal colpotomy, and carbon dioxide (CO_2) pneumoperitoneum are being increasingly recognized as leading causes of tumor spillage and a subsequent inferior oncologic outcome in MIA radical hysterectomy [12]. Recently, surgical procedures such as the creation of a vaginal cuff and avoiding the use of uterine manipulators have been proposed to prevent tumor spillage [24, 25], and these ideas may be applied to MIA radical trachelectomy. Additionally, radical trachelectomy has a unique surgical procedure in that the cervix is amputated, while the uterine body and the blood vessels connected to it are preserved. There is a narrow space between cancer margin and internal os of the uterus; therefore, it is not easy to resect the cervix along with the expected excision line thought to be appropriate. Thus, MIA radical trachelectomy has a greater potential to spread the cancerous cells into the abdominal cavity than MIA radical hysterectomy.

In several previous studies on MIA radical trachelectomy [22, 23], the cervix was transvaginally or intraperitoneally separated after the transection of the paracervix and paracolpos and incision of the vaginal canal. In the transvaginal approach, it can sometimes be difficult to amputate the cervix, especially in young or nulliparous women as in the present case, and any additional resections are even more difficult to perform in the narrow and secluded space. Conversely, using the intraperitoneal approach, the initial as well as any additional dissections of the cervix are relatively easy. However, several authors have suggested that a CO_2 pneumoperitoneum milieu induces intraperitoneal implantation and proliferation of the cancerous cells in animal and *in vitro* experimental models [26, 27]. Kong *et al.* reported that the recurrence rate was higher in MIA radical hysterectomy through intracorporeal colpotomy than through vaginal colpotomy (16.3% vs. 5.1%, P = 0.057), and more cases of intraperitoneal dissemination were found in the intracorporeal colpotomy group than in the vaginal colpotomy group [28]. The authors pointed out that intracorporeal colpotomy under CO_2 pneumoperitoneum caused tumor spillage and spread. Intracorporeal dissection of the cervix under CO_2 pneumoperitoneum may also be associated with a potential recurrence risk. In the present case, we performed an extracorporeal incision of the cervix to avoid tumor spillage, even when additional excisions were required. The use of a uterine manipulator in MIA radical trachelectomy has not been fully investigated. As far as radical hysterectomy is concerned, Rakowski *et al.* showed that the use of a uterine manipulator during robotic-assisted radical hysterectomy was not associated with any clinicopathological parameters including the depth of invasion, LVSI, or parametrial involvement unlike that in open surgery [29]. In contrast, McFarland *et al.* reported a case of artefactual displacement of grade III cervical intraepithelial neoplasia (CIN) to both fallopian tubes during a laparo-

scopic hysterectomy due to the use of an intrauterine balloon manipulator. The authors of this case discussed an intriguing possibility that the CIN epithelium in the cervix was displaced during insertion and due to the use of the balloon manipulator [30]. We used a uterine manipulator to apply upward traction on the uterus because it was judged that there was no residual tumor post cervical conization. Although the observation period was short, no recurrence was observed. Since this was the first surgical procedure performed at our facility, we selected this case, which is extremely unlikely to have lesions on the surface or vaginal and cervical stump after conization, and used a uterine manipulator in consideration of surgical operability. We do not use uterine manipulator in laparoscopic radical hysterectomy for any invasive cervical cancer. In the following minimal invasive radical trachelectomy cases, uterine manipulators will not be used with or without residual tumor.

The transection of the uterine arteries did not affect the reproductive outcomes in previous studies [23]. A case of uterine necrosis caused by the vastly reduced blood flow to the residual uterus due to the transection of the uterine artery has been reported [31]. Prolonged uterine ischemia should be avoided during fertility-sparing surgeries. In one case, postoperative cervical stenosis was reportedly associated with ART and cerclage [32]. In this case, the extreme tension on the bilateral infundibulopelvic ligaments and the uterine arteries was relieved, and an adequate blood flow to the uterus was maintained throughout the procedure. Moreover, the cervical cerclage was applied using appropriate force to avoid overtightening of the cervical canal. Finally, intraoperative conversion to hysterectomy due to necrosis of the residual uterus could be avoided, and there were no menstrual disorders or thinning of the endometrium postoperatively. Although preserving the uterine artery made it difficult to secure the operative field, and more time was required to process the cardinal ligament and paracervix, this procedure was feasible with adequate laparoscopic skill.

The procedural technique described herein provides an easy and accessible route to transect the cervix, taking advantage of the convenience of open surgery and laparoscopic surgery, while considering both oncological safety and fertility preservation. Therefore, this technique is useful for institutions that have been considering MIA radical trachelectomy as the first step of the surgical procedure. Conversely, if the abdominal wall is thick due to severe obesity or if the uterine mobility is restricted due to adhesions, it may be difficult to extract the uterus from the abdominal cavity; therefore, MIA radical trachelectomy using this technique may not be indicated in some cases.

All previous reports describing the surgical approaches to radical trachelectomy were based on retrospective studies, and there has been insufficient research focusing on the approach to cervical amputation in MIA radical trachelectomy. Using this technique intraabdominal tumor cell spillage can be reduced, but not ruled out since performing an intracorporeal colpotomy laparoscopically. Therefore, further research in this area is necessary.

4. Conclusions

This case report showed that a complete transection of the paracervix and resection of the vagina of an appreciable length according to type C1 radical hysterectomy of the QM classification can be performed laparoscopically and the accurate resection area of the uterus can easily be determined through a mini-laparotomy. The procedure described herein may reduce the risk of recurrence and help to preserve fertility by preventing intraoperative spillage and exposure of the cervical amputation stump to the cancerous tissue without excessive resection in a more reliable manner. When introducing MIA radical trachelectomy, high skill and abundant experience are required to obtain better results, and this technique may be advantageous due to the ease and accuracy of the procedure. However, the follow-up period was too short, and it was difficult to fully evaluate the effect of this surgical technique. It is necessary to evaluate cases with a longer follow-up period to verify the surgical procedure. Large-scale prospective studies are needed to elucidate the ideal patient profile for each surgical procedure of MIA radical trachelectomy, including this technique.

Abbreviations

ART, abdominal radical trachelectomy; DFS, disease-free survival; FIGO, International Federation of Gynecology and Obstetrics; IRTA, international radical trachelectomy assessment; LACC, laparoscopic approach to cervical cancer; LVSI, lymphovascular space involvement; MIA/MIS, minimally invasive approach/surgery; NILM, negative for intraepithelial lesions or malignancy; QM, Querleu-Morrow; OS, overall survival; SCC, squamous cell carcinoma; VRT, vaginal radical trachelectomy.

Author contributions

ZW, HT, and MS designed the case study. ZW wrote the manuscript. MI, SS, KT, TN, MT, and NY supervised this study. All authors contributed to the editorial changes as well as read and approved the final version of the manuscript.

Ethics approval and consent to participate

This case report was approved by the ethics committee of our institution. The study was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from the patient for the publication of this case report.

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Conflict of interest

The authors declare no competing interests.

References

[1] Arbyn M, Weiderpass E, Bruni L, de Sanjosé S, Saraiya M, Ferlay J, *et al.* Estimates of incidence and mortality of cervical cancer in 2018: a worldwide analysis. The Lancet Global Health. 2020; 8: e191-e203.

[2] Utada M, Chernyavskiy P, Lee WJ, Franceschi S, Sauvaget C, de Gonzalez AB, *et al.* Increasing risk of uterine cervical cancer among young Japanese women: comparison of incidence trends in Japan, South Korea and Japanese-Americans between 1985 and 2012. International Journal of Cancer. 2019; 144: 2144-2152.

[3] Ushijima K. Current status of gynecologic cancer in Japan. Journal of Gynecologic Oncology. 2009; 20: 67-71.

[4] Siegel RL, Miller KD, Jemal A. Cancer statistics, 2018. CA: A Cancer Journal for Clinicians. 2018; 68: 7-30.

[5] Cui RR, Chen L, Tergas AI, Hou JY, St Clair CM, Neugut AI, *et al.* Trends in use and survival associated with fertility-sparing trachelectomy for young women with early-stage cervical cancer. Obstetrics and Gynecology. 2019; 131: 1085-1094.

[6] Dargent D. Pregnancies following radical trachelectomy for invasive cervical cancer. Gynecologic Oncology. 1994; 52: 105.

[7] Marchiole P, Benchaib M, Buenerd A, Lazlo E, Dargent D, Mathevet P. Oncological safety of laparoscopic-assisted vaginal radical trachelectomy (LARVT or Dargent's operation): a comparative study with laparoscopic-assisted vaginal radical hysterectomy (LARVH). Gynecologic Oncology. 2007; 106: 132-141.

[8] Matsuo K, Chen L, Mandelbaum RS, Melamed A, Roman LD, Wright JD. Trachelectomy for reproductive-aged women with early-stage cervical cancer: minimally invasive surgery versus laparotomy. American Journal of Obstetrics and Gynecology. 2019; 220: 469.e1-469.e13.

[9] Park DA, Yun JE, Kim SW, Lee SH. Surgical and clinical safety and effectiveness of robot-assisted laparoscopic hysterectomy compared to conventional laparoscopy and laparotomy for cervical cancer: a systematic review and meta-analysis. European Journal of Surgical Oncology. 2017; 43: 994-1002.

[10] Zhao Y, Hang B, Xiong G, Zhang X. Laparoscopic radical hysterectomy in early stage cervical cancer: a systematic review and meta-analysis. Journal of Laparoendoscopic & Advanced Surgical Techniques. 2017; 27: 1132-1144.

[11] Melamed A, Margul DJ, Chen L, Keating NL, del Carmen MG, Yang J, *et al.* Survival after minimally invasive radical hysterectomy for early-stage cervical cancer. New England Journal of Medicine. 2018; 379: 1905-1914.

[12] Ramirez PT, Frumovitz M, Pareja R, Lopez A, Vieira M, Ribeiro R, *et al.* Minimally invasive versus abdominal radical hysterectomy for cervical cancer. New England Journal of Medicine. 2018; 379: 1895-1904.

[13] Tokunaga H, Watanabe Y, Niikura H, Nagase S, Toyoshima M, Shiro R, *et al.* Outcomes of abdominal radical trachelectomy: results of a multicenter prospective cohort study in a Tohoku Gynecologic Cancer Unit. International Journal of Clinical Oncology. 2015; 20: 776-780.

[14] Bhatla N, Aoki D, Sharma DN, Sankaranarayanan R. Cancer of the cervix uteri. International Journal of Gynecology & Obstetrics. 2018; 143: 22-36.

[15] Querleu D, Cibula D, Abu-Rustum NR. 2017 update on the querleu-morrow classification of radical hysterectomy. Annals of Surgical Oncology. 2017; 24: 3406-3412.

[16] Plante M. Vaginal radical trachelectomy: an update. Gynecologic Oncology. 2008; 111: S105-S110.

[17] Smith JR, Boyle DCM, Corless DJ, Ungar L, Lawson AD, Priore GD, *et al.* Abdominal radical trachelectomy: a new surgical technique for the conservative management of cervical carcinoma. BJOG: An International Journal of Obstetrics and Gynaecology. 1997; 104: 1196-1200.

[18] Pareja R, Rendón GJ, Sanz-Lomana CM, Monzón O, Ramirez PT. Surgical, oncological, and obstetrical outcomes after abdominal radical trachelectomy-a systematic literature review. Gynecologic Oncology. 2013; 131: 77-82.

[19] Machida H, Iwata T, Okugawa K, Matsuo K, Saito T, Tanaka K, *et al.* Fertility-sparing trachelectomy for early-stage cervical cancer: a proposal of an ideal candidate. Gynecologic Oncology. 2020; 156: 341-348.

[20] Pomel C, Castaigne D, Atallah D, Lauratet B, Camatte S, Morice P. Laparoscopic (type III Piver like) radical trachelectomy. European Journal of Surgical Oncology. 2002;28:302.

[21] Persson J, Kannisto P, Bossmar T. Robot-assisted abdominal laparoscopic radical trachelectomy. Gynecologic Oncology. 2008; 111: 564-567.

[22] Salvo G, Ramirez P, Wu X, Leitao M, Mosgaard B, Falconer H, *et al.* 22 open vs. minimally invasive radical trachelectomy in early stage cervical cancer: international multicenter irta study results. BMJ Publishing Group Ltd. 2019.

[23] Bentivegna E, Maulard A, Pautier P, Chargari C, Gouy S, Morice P. Fertility results and pregnancy outcomes after conservative treatment of cervical cancer: a systematic review of the literature. Fertility and Sterility. 2016; 106: 1195-1211.

[24] Köhler C, Hertel H, Herrmann J, Marnitz S, Mallmann P, Favero G, *et al.* Laparoscopic radical hysterectomy with transvaginal closure of vaginal cuff-a multicenter analysis. International Journal of Gynecologic Cancer. 2019; 29: 845-850.

[25] Kanao H, Matsuo K, Aoki Y, Tanigawa T, Nomura H, Okamoto S, *et al.* Feasibility and outcome of total laparoscopic radical hysterectomy with no-look no-touch technique for FIGO IB1 cervical cancer. Journal of Gynecologic Oncology. 2019; 30: e71.

[26] Volz J, Köster S, Spacek Z, Paweletz N. The influence of pneumoperitoneum used in laparoscopic surgery on an intraabdominal tumor growth. Cancer. 1999; 86: 770-774.

[27] Lin F, Pan L, Li L, Li D, Mo L. Effects of a simulated CO2 pneumoperitoneum environment on the proliferation, apoptosis, and metastasis of cervical cancer cells *in vitro*. Medical Science Monitor. 2015; 20: 2497-2503.

[28] Kong T, Chang S, Piao X, Paek J, Lee Y, Lee EJ, *et al.* Patterns of recurrence and survival after abdominal versus laparoscopic/robotic radical hysterectomy in patients with early cervical cancer. Journal of Obstetrics and Gynaecology Research. 2016; 42: 77-86.

[29] Rakowski JA, Tran TAN, Ahmad S, James JA, Brudie LA, Pernicone PJ, *et al.* Does a uterine manipulator affect cervical cancer pathology or identification of lymphovascular space involvement? Gynecologic Oncology. 2013; 127: 98-101.

[30] McFarland M, Craig E, Lioe TF, Dobbs SP, McCluggage WG. Artefactual displacement of cervical epithelium showing CIN III to fallopian tubes during laparoscopic hysterectomy with intrauterine balloon manipulator. Histopathology. 2015; 65: 139-141.

[31] Nick AM, Frumovitz MM, Soliman PT, Schmeler KM, Ramirez PT. Fertility sparing surgery for treatment of early-stage cervical cancer: open vs. robotic radical trachelectomy. Gynecologic Oncology. 2012; 124: 276-280.

[32] Li X, Li J, Wu X. Incidence, risk factors and treatment of cervical stenosis after radical trachelectomy: a systematic review. European Journal of Cancer. 2015; 51: 1751-1759.