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Research Report

Feasibility of the “cuff-sleeve” suture method in improving the uterine blood supply after radical trachelectomy: A retrospective analysis

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ABSTRACT

Objective: To explore the feasibility of the “cuff-sleeve” suture method in improving the uterine blood supply after radical trachelectomy (RT).

Study design: Patients in the “cuff-sleeve” (n = 25) and traditional group (n = 10) underwent computed tomography angiography (CTA) to evaluate the residual uterine blood supply pattern after the surgery, and the preoperative group patients (n = 20) underwent CTA before the procedure.

Results: The uteri of the 20 patients in the preoperative group were all supplied by bilateral uterine arteries of average diameter, 2.25 ± 0.35 mm. The uterine artery-supplying, hybrid supplying, and ovarian artery-supplying patterns accounted for 40 %, 36 %, and 24 % in the “cuff-sleeve” group and 20 %, 50 %, and 30 %, respectively, in the traditional group. The average diameter of the uterine arteries among the uterine artery-supplying pattern in the “cuff-sleeve” group (1.98 ± 0.36 mm) was more extensive than that in the traditional group (1.73 ± 0.15 mm) ($p = 0.049$). As also, the ovarian artery diameter of the hybrid supplying pattern in the “cuff-sleeve” group (1.65 ± 0.25 mm) was significantly larger than that in the traditional group (1.50 ± 0.35 mm) ($p = 0.010$). Additionally, while the pregnancy rate in the “cuff-sleeve” group (50.0 %) was higher than that in the traditional group (25.0 %), this difference was not statistically significant.

Conclusions: The “cuff-sleeve” suture method was associated with increased diameter of the uterine and ovarian vessels and may be a feasible method to improve the uterine blood supply and pregnancy rate after radical trachelectomy. It still warrants further evaluation for both fertility and oncologic outcomes.

1. Introduction

Cervical cancer is one of the most commonly observed malignant tumors in women and the fourth leading cause of cancer-related deaths worldwide, estimated at 604,000 new cases and 342,000 deaths globally in 2020 (Sung et al., 2020). In recent years, cervical cancer has developed at a younger age. Approximately 40 % of the patients diagnosed with early-stage cervical cancer are under 40 years of age and strongly desire to preserve their fertility (Salvo et al., xxxx). Therefore, fertility-preserving surgery in these patients has become an urgent social concern.

More than 20 years have passed since Dargent introduced the fertility-sparing radical trachelectomy (RT) technique (Costales et al., xxxx). A series of studies have confirmed its safety and effectiveness in patients with early-stage cervical cancer, and it shows a recurrence rate of 3.3 %, similar to that of radical hysterectomy. Since type C resection in RT requires ligation of the uterine arteries at their origin from the internal iliac artery, some surgeons believe that the blood supply to the residual uterus after RT is poor and insufficient to support normal gestation (Costales et al., xxxx; Smith et al., xxxx; Gabriele et al., xxxx; Li et al., xxxx). Therefore, RT with the preservation of the ascending branch of the uterine artery has been proposed and widely performed to

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ensure improved blood supply to the residual uterus for successful pregnancy and delivery later (Al-Niaimi et al., xxxx; Hong et al., xxxx; Wan et al., xxxx).

Nevertheless, the clinical value of preserving the ascending branch of the uterine artery in improving the uterine blood supply after RT remains controversial. Tang et al. believe that the advantages of preserving the uterine artery during RT may be minimal (Tang et al., xxxx). They found that the primary blood supply of the residual uterus was obtained from the ovarian artery and that 87.5 % of the preserved ascending uterine artery branches were occluded after RT. Another study using indocyanine green (ICG) intraoperative angiography to determine the uterine vascular perfusion during RT found no statistically significant difference in the mean ICG fundal fluorescence intensity between the uterine artery-sparing group and uterine artery non-sparing group (Escobar et al., xxxx). It may be the unavoidable impact on the remaining uterine arteries during the ligation of the descending branch of the uterine artery and the continuous or intermittent suturing of the vaginal stump with the lower uterine segment, resulting in postoperative blockage of the ascending branch of the uterine artery (Tang et al., xxxx; Wang et al., xxxx).

Consequently, we introduced the “cuff-sleeve” suture method to suture the vaginal stump with the lower uterine segment during RT in 2017, attempting to reduce the damage to the ascending branch of the uterine artery. The feasibility and safety of this technique have been proved previously (Xu et al., xxxx). This study explored the differences in uterine blood supply patterns and obstetric outcomes between patients under this new and traditional suture method.

2. Methods

This retrospective study included 48 patients with early-stage cervical cancer who underwent RT to preserve the ascending branch of the uterine artery at Sun Yat-sen Memorial Hospital, Sun Yat-sen University, between March 2012 and October 2022. The follow-up period was 7.8–136.9 months. This study was approved by the Ethics Committee of Sun Yat-sen Memorial Hospital, Sun Yat-sen University (SYSKY-2022-038-01). All patients provided preoperative informed consent and signed the operating agreement.

2.1. Study groups

The patients were categorized into 3 groups.

The preoperative group included 20 patients who had undergone surgery between February 2021 and April 2022. They underwent CTA before RT to determine baseline evaluation prior to surgery.

The “cuff-sleeve” group involved 25 patients who accepted the uterine artery ascending branch preserved RT from November 2017 to October 2022. Out of these, 10 patients were also part of the preoperative group. The “cuff-sleeve” suture method was carried out as described before (Xu et al., xxxx). In brief, we carefully skeletonized the 3 branches of the uterine artery, ligated the vaginal and cervical branches, and preserved the ascending branch of the uterine artery under direct vision (Fig. 1). Furthermore, a new skill called the “cuff-sleeve” suture method was introduced to wrap the vagina around the stump cervix, wherein they were sutured using a 2–0 absorbable suture by placing 2 cross-stitches in the anterior and posterior wall, respectively, without piercing the cervical mucosa layer or damaging the uterine arteries (Xu et al., xxxx).

The traditional group consisted of 10 patients who underwent RT using a laparoscopic approach between March 2012 and March 2022, with preservation of the ascending branch of the uterine artery. Of these, 3 patients were also part of the preoperative CTA group. Their vaginas were then sutured to the lower uterine segments with a 1–0 catgut suture in an interrupted fashion at the front, back, left, and right (Yao et al., xxxx).

All patients in the “cuff-sleeve” and the traditional groups underwent computed tomography angiography (CTA) to evaluate the status of the preserved ascending branch and the residual uterine blood supply pattern 6–44 months after surgery.

2.2. Data collection

Data regarding individual patient characteristics, International Federation of Gynecology and Obstetrics (FIGO) stage, histologic subtype, lymphovascular space involvement (LVSI) status, recurrence, CTA data, fertility results, and obstetric outcomes were collected for the patients in the “cuff-sleeve” group and the traditional group. The CTA findings of the preoperative group were also obtained.

The CTA data was mainly analyzed to determine the arteries supplying the uterus. The reconstruction focused on three key aspects. Firstly, we aimed to identify the source of the supplying arteries for the remaining uterus. We sought to determine whether these arteries were uterine arteries, ovarian arteries, or newly formed collateral circulation originating from other arteries. Secondly, we assessed the number of supplying arteries to the remaining uterus. And thirdly, we measured the diameter of the visualized supplying vessels. Evaluation of the

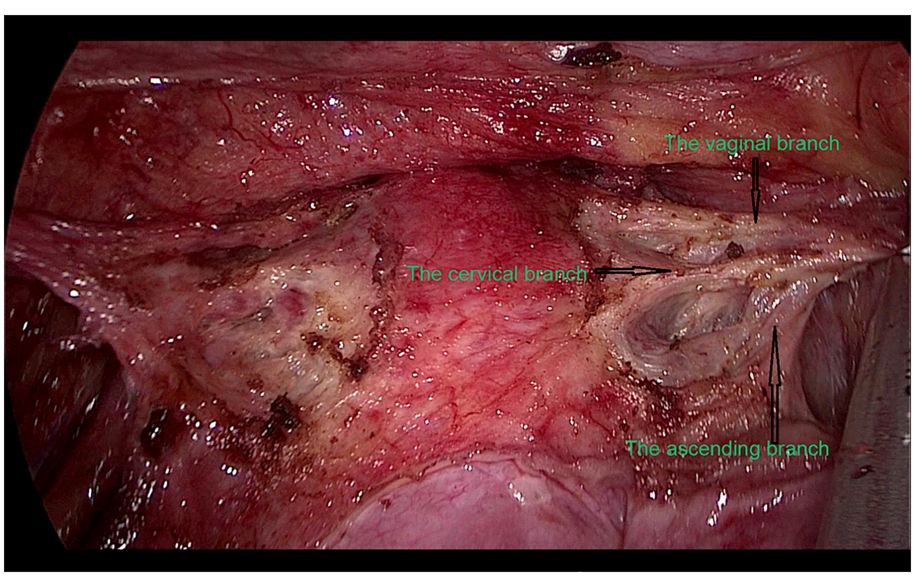

Fig. 1. The 3 branches of the uterine artery were skeletonized. The vaginal, cervical, and ascending branches were shown.

reconstructed results was conducted by both the gynecologic surgeon and radiologist.

We established criteria for identifying a supplying vessel: it must be identifiable continuously from its origin to the uterus and must enter the corpus uteri before giving off branches. Based on the distinct origins of the supplying vessels, we categorized the patients into three groups according to their blood supply patterns. The first was the uterine artery-supplying pattern, wherein the residual uterus was supplied only by bilateral uterine arteries. The second was the hybrid-supplying pattern, in which an ovarian artery and the contralateral uterine artery supplied the residual uterus. The third was the ovarian artery-supplying pattern, wherein only the ovarian arteries supplied the residual uterus.

Furthermore, the diameter of the vessel was considered indicative of its importance in the supplying function. So we also recorded the diameter of the visualized supplying vessels. The diameter of the uterine artery was measured 2 cm before they entered the corpus uteri. For the ovarian arteries, which are curved, measurements were taken at three fixed points: the ovarian arterial bud at the aorta ventralis, beside the external iliac artery, and 2 cm before entering the corpus uteri (Tang et al., xxxx).

2.3. Statistical methods

Statistical analyses were performed using IBM SPSS Statistics, version 26. The *t*-test was used for analyzing the continuous variables, and the chi-squared test was used for categorical variables. The difference was considered statistically significant at $p < 0.05$.

3. Results

3.1. Baseline characteristics

In this study, the “cuff-sleeve” and traditional groups included 25 (71 %) and 10 (29 %) patients, respectively (Table 1). All the patients expressed a strong desire to preserve their fertility. The FIGO stages ranged from IA1 to IB2 in both groups. The median age of the patients at diagnosis was 30 years in the “cuff-sleeve” group (range: 22–39 years) and 31.5 years in the traditional group (range: 26–40 years). Squamous carcinoma was detected in 23 patients (92 %) of the “cuff-sleeve” group, and 13 of them (54 %) were LVSI positive. In the traditional group, 9 patients (90 %) were diagnosed with squamous carcinoma, and 2 patients (20 %) had positive LVSI. All these clinical characteristics had no statistical differences between the 2 groups.

Table 1
Patient baseline characteristics.

Variable	Cases		The “cuff-sleeve” group		The traditional group		p value*
	N	(%)	N	(%)	N	(%)	
Age (years)							
≤30	18	0.75	14	0.56	4	0.40	0.392
> 30	17	0.71	11	0.44	6	0.60	
FIGO Stage							
IA	9	0.38	6	0.24	3	0.30	0.714
IB	26	1.08	19	0.76	7	0.70	
Histologic subtype							
Squamous	32	1.33	23	0.92	9	0.90	1.000
Non-squamous	3	0.13	2	0.08	1	0.10	
LVIS							
positive	13	0.54	11	0.44	2	0.20	0.184
Negative	22	0.92	14	0.56	8	0.80	
Recurrence							
Yes	35	1.46	25	1.00	10	1.00	–
No	0	0.00	0	0.00	0	0.00	
Death							
Yes	35	1.46	25	1.00	10	1.00	–
No	0	0.00	0	0.00	0	0.00	

* χ^2 test.

The preoperative group included 20 patients, with a median age of 30 years, ranging from stage IA1 to IB2 (Table S1). Squamous carcinoma was found in 10 of them (85 %). The LVSI states were positive in 9 patients (45 %).

3.2. Blood supply of the residual uterus

The uteri of the 20 patients in the preoperative group were all supplied by bilateral uterine arteries of average diameter, 2.25 ± 0.35 mm (Table S2). We identified 2 arteries supplying each residual uterus, which were always on the contralateral sides. They comprised uterine or ovarian arteries (Fig. 2). The uterine artery-supplying, hybrid supplying, and ovarian artery-supplying patterns accounted for 40 %, 36 %, and 24 %, respectively, in the “cuff-sleeve” group and 20 %, 50 %, and 30 % in the traditional group (Table 2). However, no significant difference was identified in the distribution of the blood-supplied pattern between these two groups (p = 0.507). The rate of the uterine artery-supplying pattern in the “cuff-sleeve” group (40 %) was double that of the traditional group (20 %), but this difference was not statistically significant. Table 3.

We divided both the “cuff-sleeve” group and the traditional group into two subgroups based on the median time interval between CTA and surgery (range: 6–44 months, median: 19 months). Unfortunately, we did not find any statistically significant differences between these subgroups in uterine blood supply patterns (Table S3). Additionally, we subdivided the “cuff-sleeve” and traditional groups according to the median age at which they received CTA (range: 23–41 years, median: 31 years). The distribution of uterine blood supply patterns did not show any statistically significant differences between these subgroups either (Table S4).

All the diameters of the uterine arteries and ovarian arteries in both the “cuff-sleeve” and traditional groups were smaller than that of the uterine arteries in the preoperative group ($p < 0.05$). However, the average diameter of the uterine arteries among the uterine artery-supplying pattern in the “cuff-sleeve” group (1.98 ± 0.36 mm) was more extensive than that in the traditional group (1.73 ± 0.15 mm) ($p = 0.049$). As also, the ovarian artery diameter of the hybrid supplying pattern in the “cuff-sleeve” group (1.65 ± 0.25 mm) was significantly larger than that in the traditional group (1.50 ± 0.35 mm) ($p = 0.010$). Although no statistical differences in the diameter of an ovarian artery in the ovarian artery-supplying patterns were found between the 2 groups ($p = 0.431$), the ovarian artery of the “cuff-sleeve” group was 1.88 ± 0.24 mm in diameter, which was more significant than the traditional group (1.57 ± 0.16 mm). A similar result was found in the uterine artery diameter of the hybrid supplying pattern.

The results above suggested that the remaining uterine blood supply after RT in the “cuff-sleeve” group was more abundant than in the traditional group.

3.3. Fertility results and obstetric outcomes

The median follow-up period in the “cuff-sleeve” group was 36.2 months (7.8–68.0 months). Among the 10 patients who actively attempted to conceive, 5 (50.0 %) succeeded. One patient was still at 6 weeks of pregnancy by follow-up, and one had a spontaneous abortion at 23 weeks. Two were born prematurely at 31 weeks and 35 weeks, respectively, and the other underwent an induced abortion at 8 weeks due to social factors. The bilateral uterine arteries supplied the residual uteruses in 2 (40 %), another 2 (40 %) were given by the hybrid-supplying pattern, and bilateral ovarian arteries provided the other (20 %).

The median follow-up period in the traditional group was 113.7 months (15.3–136.9 months). Four patients had a strong desire to become pregnant, and one had achieved (25.0 %). But unfortunately, it

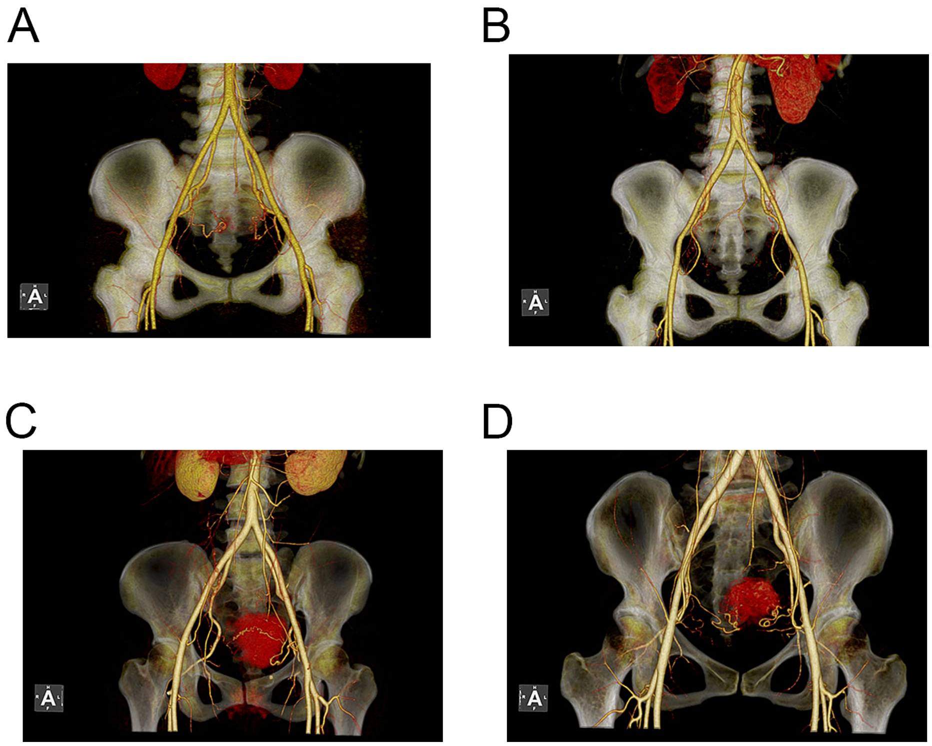

Fig. 2. The uterus blood supply patterns. (A) The uterus was supplied by bilateral uterine arteries. (B) Ovarian artery-supplying pattern. (C) Ovarian artery-uterine artery supplying pattern. One ovarian artery (right) and one uterine artery (left) supplied the residual uterus. (D) Uterine artery-supplying pattern.

Table 2
The distribution of the three blood supplying patterns in the postoperative period.

Supplying pattern	Cases		The "cuff-sleeve" group		The traditional group		p value*
	N	(%)	N	(%)	N	(%)	
Uterine artery-supplying	12	0.33	10	0.40	2	0.20	0.507
Hybrid supplying	14	0.39	9	0.36	5	0.50	
Ovarian artery-supplying	9	0.25	6	0.24	3	0.30	

* χ^2 test.

Table 3
The diameter of supplying artery in the postoperative group.

Supplying pattern	Groups	Utreine artery diameter (mm)			Ovarian artery diameter (mm)		
		N	mean ± SD	*p* value	N	mean ± SD	*p* value
Uterine artery-supplying	The "cuff-sleeve" group	20	1.98 ± 0.39	0.049	/	/	/
	The traditional group	4	1.73 ± 0.15		/	/	
Hybrid supplying	The "cuff-sleeve" group	10	1.91 ± 0.26	0.940	10	1.65 ± 0.25	0.010
	The traditional group	5	1.90 ± 0.25		5	1.50 ± 0.35	
Ovarian artery-supplying	The "cuff-sleeve" group	/	/	/	12	1.88 ± 0.24	0.431
	The traditional group	/	/		6	1.57 ± 0.16	

was an ectopic pregnancy. Her residual uterus was supplied by the one uterine artery and contralateral ovarian artery.

The results above showed that the pregnancy rate in the "cuff-sleeve" group was higher than that in the traditional group.

3.4. Oncologic outcomes

In our study, none of the 35 patients in both groups experienced recurrence or death, possibly due to the short follow-up period and the small sample size (Table 1). In future studies, we plan to incorporate oncologic outcomes data to provide a more holistic view of the technique's effectiveness and long-term implications.

4. Discussion

Although cervical cancer screening has significantly reduced its incidence, it still ranks fourth among all significant malignant tumors as the cause of cancer-related mortality (Segarra-Vidal et al., xxxx). Traditional early invasive cervical cancer treatments include radical hysterectomy, lymphatic dissection, and radiation therapy for the cancer foci and metastatic lymph nodes, leading to permanent infertility (Salvo et al., xxxx). With the increase in younger patients with cervical cancer and the postponement of the childbearing age, RT, which preserves the reproductive function of patients, has become the ideal treatment choice in patients with early-stage cervical cancer (Li et al., xxxx; Kasuga et al., xxxx; Ungar et al., xxxx).

Physiologically, the blood supply of the uterus mainly comes from the bilateral ovarian and uterine arteries. The diameter of normal ovarian arteries should be <1 mm in the natural state and invisible on the reconstructed image (Umemura et al., xxxx; Pelage et al., xxxx; Mori et al., xxxx). When we examined the preoperative CTA of the 20 patients in our study, the ovarian arteries were challenging to identify, suggesting that the uterine artery predominates the uterine blood supply in the physiological state. In conventional RT, both uterine arteries were removed, leaving only 2 ovarian arteries to supply the uterus. Although there were no cases of uterine atrophy or ischemic necrosis after RT in this study, some scholars still believe that the preserved bilateral ovarian arteries cannot provide sufficient blood supply to the uterus during pregnancy, leading to the frequent occurrences of premature delivery or premature rupture of membranes (Smith et al., xxxx; Cibula et al., xxxx; Li et al., xxxx). Therefore, recently, RT with the preservation of the ascending branch of the uterine artery has been widely performed.

Nevertheless, only a few studies have investigated the function of the ascending branch of the uterine artery after RT. Some researchers used sonography to explore whether RT affected the uterine blood supply and discovered that the absolute refractive index values after RT did not differ from those in the control group (Klemm et al., xxxx). Tang et al. used CTA to evaluate uterine perfusion after RT with preserved ascending uterine artery branches, as sonography did not provide a complete view of the pelvic anatomical structures (Tang et al., xxxx). They found that the ovarian artery was the main blood supply vessel after surgery. The occlusion rate of the preserved uterine artery was as high as 87.5 %. Another study using ICG intraoperative angiography to determine uterine vascular perfusion during RT found no statistically significant difference between the uterine artery-sparing and artery non-sparing group (Escobar et al., xxxx). Therefore, it was believed that preserving the ascending branch of the uterine artery had no obvious functional advantage. However, in recent years, objections have been raised (Wang et al., xxxx). A literature review also demonstrated that oncologic and obstetric outcomes were promising when the ascending branch of the uterine artery was preserved (Kim et al., xxxx).

We assumed that ligating the descending branch of the uterine artery without direct vision and suturing the vagina and stump cervix continuously or intermittently might inevitably damage the preserved uterine arteries (Gabriele et al., xxxx; Yao et al., xxxx; Li et al., xxxx; Klemm et al., xxxx; Chang et al., xxxx). The most likely reason for uterine artery occlusion was unavoidable injury. To the best of our knowledge, this is the first study to consider the skeletonization of the 3 branches of the uterine artery before ligating its descending branch and to introduce the novel "cuff-sleeve" suture method to avoid damage (Xu et al., xxxx). In the "cuff-sleeve" group, we carefully skeletonized the 3 branches of the uterine artery, ligated the vaginal and cervical branches, and preserved the ascending branch of the uterine artery under direct vision. The novel "cuff-sleeve" suture method was also introduced to avoid unnecessary damage to the uterine arteries. We sutured the vagina around the stump cervix using a 2–0 absorbable suture by placing two cross-stitches in the anterior and posterior walls without piercing the cervical mucosa layer (Xu et al., xxxx).

Two arteries on the contralateral sides were identified to supply each residual uterus. More patients were provided by the uterine artery-supplying pattern in the "cuff-sleeve" group than in the traditional group. However, no significant difference was identified in the distribution of the blood-supplied pattern between these 2 groups. All the diameters of the uterine and ovarian arteries in both the "cuff-sleeve" and traditional groups were smaller than that of the uterine arteries in the preoperative group. But the average diameter of the uterine arteries among the uterine artery-supplying pattern and the ovarian artery diameter of the hybrid supplying pattern in the "cuff-sleeve" group was significantly larger than that in the traditional group. The ovarian artery of the "cuff-sleeve" group was more significant than the traditional group, although no statistical differences in the diameter of the ovarian artery in the ovarian artery-supplying patterns were found between the 2 groups. A similar result was found in the uterine artery diameter of the hybrid supplying pattern. We cannot determine the difference between these 2 arteries because of the limited sample size in this study. Extensive sample-size studies are warranted for reliable results. The pregnancy rate in the "cuff-sleeve" group was higher than in the traditional group. However, their fertility outcomes were not as good as expected. Premature delivery and spontaneous abortion occurred. The timing of the CTA, ranging from 6 to 44 months post-surgery, and the age of patients, ranging from 23 to 41 years, introduce variability that could affect the robustness of the blood supply observations. The lack of significant changes in blood supply patterns over time may be due to the relatively small sample size and variability in timing. Future studies with standardized CTA intervals are recommended to better understand the potential impact of time on blood supply dynamics.

Additionally, we utilized CTA data to identify the arteries supplying the uterus, establishing a criterion where a vessel would be considered a supplying artery only if it exhibited continuity from its origin to its entry into the uterus and branching (Tang et al., xxxx). While this criterion helped distinguish perfusion from uterine or ovarian vessels, it also posed limitations. Despite the CTA's resolution of 0.1 mm, measurable vessels needed to be at least 0.8 mm in diameter. As a result, newly formed collateral vessels with diameters less than 0.8 mm remained undetectable. This constraint likely hindered our ability to identify such formations in our analysis.

Adapting this technique to a vaginal or open approach may present unique challenges and considerations. For the vaginal approach, surgeons would need to focus on maintaining clear visualization and access to the surgical field, possibly requiring specialized instruments or techniques to ensure the preservation of critical structures. For the open approach, careful attention to minimizing tissue trauma and ensuring precise hemostasis would be crucial. Further studies are necessary to refine these adaptations and determine their efficacy and safety compared to the laparoscopic approach. We recommend that surgeons consider these factors and adjust their techniques accordingly when adapting to different surgical routes.

Summarizing the above results, we observed an increased diameter of the uterine artery using the cuff sleeve approach. The clinical significance of this finding remains to be determined and would require a larger sample size for confirmation. Given the small cohort size, the findings may not be generalizable to a broader population. Additionally, other sources of bias, such as selection bias and the retrospective nature of the study, could affect the results. We recommend that future research include larger, multicenter cohorts and prospective study designs to mitigate these limitations and provide more robust data on the outcomes and efficacy of the technique.

5. Conclusion

Based on the findings of this study, we conclude that the "cuff-sleeve" suture method was associated with increased diameter of the uterine and ovarian vessels and may be a feasible method to improve the uterine blood supply and pregnancy rate after radical trachelectomy. Extensive sample size and self-controlled prospective studies are warranted for both fertility and oncologic outcomes.

6. Consent statement

All the participants has given informed consent to participate in the research.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author, Huaiwu Lu. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

CRediT authorship contribution statement

Chunxian Huang: Writing – original draft, Data curation, Conceptualization. **Shaodan Lin:** Writing – original draft, Data curation. **Miaochun Xu:** Investigation, Funding acquisition, Formal analysis. **Aoshuang Cheng:** Project administration, Methodology, Investigation. **Yunyun Liu:** Resources, Project administration. **Zhongqiu Lin:** Software, Resources. **Ming Gao:** Writing – review & editing, Visualization, Validation. **Huaiwu Lu:** Writing – review & editing, 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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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gore.2024.101432.

References

Al-Niaimi, A.N., Einstein, M.H., Perry, L., Hartenbach, E.M., Kushner, D.M., xxxx. Uterine artery sparing robotic radical trachelectomy (AS-RRT) for early cancer of the cervix. Int. J. Gynaecol. Obstet. doi: 10.1016/j.ijgo.2010.07.028.

Chang, S.J., Ryu, H.S., Nam, J.H., xxxx. Uterine artery-preserving laparoscopic radical trachelectomy for early cervical cancer: technical aspects. Gynecol Oncol, doi: 10.1016/j.ygyno.2012.04.039.

Cibula, D., Abu-Rustum, N.R., Benedetti-Panici, P., et al., xxxx. New classification system of radical hysterectomy: emphasis on a three-dimensional anatomic template for parametrial resection. Gynecol Oncol, doi: 10.1016/j.ygyno.2011.04.029.

Costales, A., Michener, C., Escobar-Rodriguez, P.F., xxxx. Radical trachelectomy for early stage cervical cancer. Curr. Treat Options Oncol., doi: 10.1007/s11864-018-0591-4.

Escobar, P.F., Ramirez, P.T., Garcia, O.R., et al., xxxx. Utility of indocyanine green (ICG) intra-operative angiography to determine uterine vascular perfusion at the time of radical trachelectomy. Gynecol. Oncol. doi: 10.1016/j.ygyno.2016.08.239.

Gabriele, V., Lecointre, L., Faller, E., Akladios, C., xxxx. Type B laparoscopic radical trachelectomy with uterine artery preservation for stage IB1 cervical cancer. J. Minim. Invasive Gynecol., doi: 10.1016/j.jmig.2018.05.006.

Hong, D.G., Lee, Y.S., Park, N.Y., Chong, G.O., Park, I.S., Cho, Y.L., xxxx. Robotic uterine artery preservation and nerve-sparing radical trachelectomy with bilateral pelvic lymphadenectomy in early-stage cervical cancer. Int. J. Gynecol. Cancer, doi: 10.1097/IGC.0b013e31820b3003.

Kasuga, Y., Ikenoue, S., Tanaka, M., Ochiai, D., xxxx. Management of pregnancy after radical trachelectomy. Gynecol. Oncol. doi: 10.1016/j.ygyno.2021.04.023.

Kim, S., Chung, S., Azodi, M., Menderes, G., xxxx. Uterine artery-sparing minimally invasive radical trachelectomy: a case report and review of the literature. J. Minim. Invas. Gynecol., doi: 10.1016/j.jmig.2019.05.017.

Klemm, P., Tozzi, R., Kohler, C., Hertel, H., Schneider, A., xxxx. Does radical trachelectomy influence uterine blood supply? Gynecol. Oncol. doi: 10.1016/j.ygyno.2004.09.059.

Li, J., Li, Z., Wang, H., et al., xxxx. Radical abdominal trachelectomy for cervical malignancies: surgical, oncological and fertility outcomes in 62 patients. Gynecol. Oncol. doi: 10.1016/j.ygyno.2011.01.032.

Li, X., Li, J., Jiang, Z., et al., xxxx. Oncological results and recurrent risk factors following abdominal radical trachelectomy: an updated series of 333 patients. BJOG, doi: 10.1111/1471-0528.15621.

Mori, K., Saida, T., Shibuya, Y., et al., xxxx. Unenhanced MR angiography of uterine and ovarian arteries after uterine artery embolization: differences between patients with incomplete and complete fibroid infarction. Cardiovasc. Intervent. Radio, doi: 10.1007/s00270-011-0182-2.

Pelage, J.P., Walker. W.J., Le Dref, O., Rymer, R., xxxx. Ovarian artery: angiographic appearance, embolization and relevance to uterine fibroid embolization. Cardiovasc. Intervent. Radio doi: 10.1007/s00270-002-1875-3.

Salvo, G., Ramirez, P.T., Leitao, M.M., et al., xxxx. Open vs minimally invasive radical trachelectomy in early-stage cervical cancer: international radical trachelectomy assessment study. Am. J. Obstet. Gynecol., doi: 10.1016/j.ajog.2021.08.029.

Salvo, G., Pareja, R., Ramirez, P.T., xxxx. Minimally invasive radical trachelectomy: considerations on surgical approach. Best Pract. Res. Clin. Obstet. Gynaecol. doi: 10.1016/j.bpobgyn.2021.01.009.

Segarra-Vidal, B., Persson, J., Falconer, H., xxxx. Radical trachelectomy. Int. J. Gynecol. Cancer, doi: 10.1136/ijgc-2020-001782.

Smith, E.S., Moon, A.S., O'Hanlon, R., et al., xxxx. Radical Trachelectomy for the treatment of early-stage cervical cancer: a systematic review. Obstet Gynecol. doi: 10.1097/AOG.0000000000003952.

Sung, H., Ferlay, J., Siegel, R.L., et al., xxxx. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J Clin, doi: 10.3322/caac.21660.

Tang, J., Li, J., Wang, S., Zhang, D., Wu, X., xxxx. On what scale does it benefit the patients if uterine arteries were preserved during ART? Gynecol. Oncol. doi: 10.1016/j.ygyno.2014.04.043.

Umemura, K., Ishioka, S., Endo, T., et al., xxxx. Changes of uterine blood flow after vaginal radical trachelectomy (VRT) in patients with early-stage uterine invasive cervical cancer. Int. J. Med. Sci. doi: 10.7150/ijms.7.260.

Ungar, L., Palfalvi, L., Hogg, R., et al., xxxx. Abdominal radical trachelectomy: a fertility-preserving option for women with early cervical cancer. BJOG doi: 10.1111/j.1471-0528.2004.00421.x.

Wan, X.P., Yan, Q., Xi, X.W., Cai, B., xxxx. Abdominal radical trachelectomy: two new surgical techniques for the conservation of uterine arteries. Int. J. Gynecol. Cancer, doi: 10.1111/j.1525-1438.2006.00648.x.

Wang, Y., Peng, Y., Lin, Z., Yao, T., xxxx. The safety and effectiveness of preserving the ascending uterine artery in a modified fertility-sparing abdominal radical trachelectomy. Eur. J. Obstet. Gynecol. Reprod. Biol., doi: 10.1016/j.ejogrb.2020.06.053.

Xu, M., Huo, C., Huang, C., et al., xxxx. Feasibility of the "Cuff-Sleeve" suture method for functional neocervix reconstruction in laparoscopic radical trachelectomy: a retrospective analysis. J. Minim. Invasive Gynecol. doi: 10.1016/j.jmig.2022.01.002.

Yao, T., Mo, S., Lin, Z., xxxx. The functional reconstruction of fertility-sparing radical abdominal trachelectomy for early stage cervical carcinoma. Eur. J. Obstet. Gynecol. Reprod. Biol. doi: 10.1016/j.ejogrb.2010.02.035.