Research Square

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Precision management of the ureteral tunnel via the Dual-Bridge technique during laparoscopic radical hysterectomy

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Abstract

Background

Cervical cancer remains the most common gynecological malignancy. Radical hysterectomy is the standard treatment for early-stage cervical cancer, the complex neurovascular anatomy of the ureteral tunnel often leads to intraoperative bleeding or ureteral injury. This study evaluates the "Dual-Bridge" technique, a novel ureter-centric approach designed to simplify ureteral tunnel dissection through two interconnected anatomical windows.

Methods

In this retrospective cohort study, we analyzed 197 patients with FIGO stage IB or IIA cervical cancer who underwent laparoscopic radical hysterectomy between May 2023 and May 2025. Patients were divided into the Dual-bridge group (n = 104) and the conventional group (n = 93). Primary outcomes included operative time, intraoperative blood loss, and surgical complications.

Results

The Dual-bridge group showed a significantly shorter total operative time (189.35 ± 33.27 vs. 221.22 ± 37.80 min, $p < 0.01$) and a reduced duration for uterine artery and vesicouterine ligament dissection (41.73 ± 7.60 vs. 50.90 ± 8.79 min, $p < 0.01$). Furthermore, intraoperative blood loss was significantly lower in the Dual-bridge group compared to the conventional group (107.12 ± 66.75 vs. 129.35 ± 66.39 mL, $p < 0.01$). There were no significant differences in urological or other surgical complications between the two groups.

Conclusion

The Dual-bridge technique offers a safe and efficient approach for managing the ureteral tunnel during laparoscopic radical hysterectomy. By utilizing natural anatomical planes, this method minimizes blood loss and enhances surgical efficiency without compromising oncological safety or increasing the risk of ureteral injury.

Background

Cervical cancer is the fourth most common cancer in women, constituting 6.8% of all cancers in the female population in 2022[1]. It is also a fatal malignancy, causing 8.1% of all cancer-related deaths in women globally [1]. The incidence and mortality rates of cervical cancer vary significantly, primarily due to disparities in human papillomavirus vaccination and cervical cancer screening. A threefold difference

in the incidence of cervical cancer is observed between high and low-human-development-index countries [2].

Surgery is the primary treatment for early-stage cervical cancer. According to the tumor stage, the surgical classification system was first proposed by Piver in 1974 and was later formalized as the Piver-Rutledge-Smith classification (encompassing Types I-V), which has since been widely adopted and recognized [3]. However, with the evolution of medical practice, it has become apparent that the Piver-Rutledge-Smith classification does not fully address critical anatomical considerations, such as the extent of resection of the vesicouterine ligament and the protocols for pelvic nerve preservation. It was not until 2008 that the Querleu-Morrow (QM) classification, including types A-D, was introduced [4]. It explicitly defined the boundaries for each type of hysterectomy, including the length of vaginal resection, the extent of vesicouterine ligament resection, and the level of uterine artery transection. For patients with International Federation of Gynecology and Obstetrics (FIGO) stages IB1, IB2, and IIA1 cervical cancer, Q-M Type C radical hysterectomy is recommended as the preferred treatment by the National Comprehensive Cancer Network (NCCN) and European Society for Medical Oncology (ESMO) guidelines. This recommendation also extends to patients with stage IB3 and IIA2 disease who decline or are unsuitable for concurrent chemoradiotherapy.

The first laparoscopic radical hysterectomy (LRH) was conducted by Nezhat et al in 1989 and has gained popularity in the 21st century [5]. The complex anatomy of the plexus encompassing the parametrial and periureteral regions renders the performance of a standard Type C radical hysterectomy technically challenging [6]. The anatomical junction where the uterine artery crosses the ureter is characterized by dense tissue and anastomotic branches, rendering ureteral mobilization prone to vascular injury. Moreover, the vesicouterine ligament (VUL), which anchors the ureter to the vaginal wall and cervical surface, consists of anterior and posterior leaves and contains a rich vascular network [7]. The conventional method needs lateral traction on the ureter to transect the uterine artery and VUL, which poses a risk of ureteral overstretching or injury. Furthermore, the surgeon may tend to transect the anterior leaf of the VUL overly close to the vaginal wall to prevent thermal injury to the ureter, which can lead to massive bleeding or compromise the oncological integrity. Once bleeding occurs, blind electrocautery in this narrow space around the ureter can potentially cause a ureteral fistula. Therefore, precise dissection of the tissue plane between the ureter and the uterine artery/ VUL is critical for ureteral protection.

To address this challenge, we propose a feasible dissection method termed the dual-bridge LRH, emphasizing a ureter-centric approach through two interconnected anatomical windows. This study aimed to investigate the practicality and safety of the dual-bridge LRH by comparing the outcomes with those of the conventional LRH.

Materials and methods

Statement

This study was approved by the ethics committee of Chongqing Health Center for Women and Children, which waived the requirement to obtain informed consent (approval number: (2026)-076). The requirement for informed consent was waived due to the retrospective study design.

Study population

This retrospective study screened all eligible cervical cancer patients from the electronic medical records of Chongqing Health Center for Women and Children from May 2023 to May 2025. Inclusion criteria were as follows: (1) patients preoperatively diagnosed with stage IB or IIA cervical cancer undergo LRH; (2) patients who received standard Q-M type C LRH with pelvic and/or para-aortic lymphadenectomy;(3) no preoperative suspected lymph nodes metastasis, ureteral invasion, parametrial involvement, or lower 1/3 vagina involvement. (4) Previous diagnosis of another malignancy. Exclusion criteria were as follows: (1) previous diagnosis of another malignancy; (2) radical hysterectomy with inadequate surgical scope; (3) pregnancy; (4) insufficient clinical data; (5) Robotic or open surgery. The pathological type for all patients was confirmed by cervical biopsy or conization, and the clinical staging was based on gynecological examination and magnetic resonance imaging.

Data collection

The clinical data of the patient, including age, body mass index (BMI), postoperative FIGO stage, tumor size, surgical profiles, and postoperative histologic type, lymphovascular space invasion, lymph node metastasis, and parametrial infiltration) were collected. Surgical safety, including intraoperative blood loss, ureteral, bladder, and intestinal injury, and delayed ureteral and bladder fistula. Surgical efficiency included total operative time and duration of uterine artery and VUL dissection. All surgeries, including conventional and dual-bridge LRH, were performed by a senior gynecologic oncologist with extensive experience. After LRH, postoperative chemoradiotherapy was recommended if the pathological examination exhibited a high-risk factor or two intermediate risk factors.

Procedure of dual-bridge LRH

The "dual-bridge" method for ureteral tunnel dissection in laparoscopic radical hysterectomy emphasizes a ureter-centric approach through two interconnected anatomical windows. The first bridge exploits the natural plane between the uterine artery, its ureteral nutrient branch, and the lateral peritoneum, enabling safe ureteral mobilization. The second bridge targets the vesicocervical ligament complex after uterine artery transection, leveraging the bladder lateral space (between the uterine and superior vesical arteries) and the Yabuki space for systematic parametrial resection. This method minimizes iatrogenic injury while ensuring oncological completeness.

1. First bridge: dissection of the ureteral-uterine arterial plane (key anatomical landmarks: uterine artery, ureteral nutrient branch, and lateral peritoneum). Step 1: Incise the lateral peritoneum and trace the

uterine artery along the internal iliac artery. Step 2: Identify the "ureteral nutrient branch" of the uterine artery. Bluntly dissect the avascular plane between the uterine artery, its nutrient branch, and the lateral peritoneum (Fig. 1A). Step 3: Ligate the uterine artery at its origin, preserving the ureteral blood supply. Mobilize the ureter laterally and superiorly, creating continuity with the second bridge's plane (Fig. 1B).

2. Second bridge: dissection of the vesicocervical ligament and bladder lateral space (key anatomical landmarks: bladder lateral space, Yabuki space, and superficial/deep vesicocervical ligaments). Step 1: After transecting the uterine artery and its bladder branch, retract the bladder downward to expose the bladder lateral space (bounded by the uterine artery stump and superior vesical artery) (Fig. 2A). Step 2: Enter the Yabuki space to further mobilize the bladder and delineate the vesicocervical ligament complex. Step 3: Bluntly dissect the superficial vesicocervical ligament (anterior leaf) from the ureter in an outward and upward direction, followed by division of the deep vesicocervical ligament (posterior leaf) (Fig. 2B). Step 4: En bloc resection of parametrial tissue is achieved while avoiding ureteral traction.

Key point: anatomical innovations and rationale ureter-centric principle. Both bridges revolve around the ureter, utilizing its natural fascial planes to minimize manipulation. Interconnected Windows: The first bridge's plane (ureter-uterine artery) transitions seamlessly into the second bridge's space (vesicocervical ligament), ensuring continuity and exposure.

Statistical analysis

Continuous data were shown as the mean with a corresponding standard deviation. The Student's t-test or the Mann-Whitney U test was used to analyze the continuous variables. Chi-squared or Fisher's exact tests were used to compare categorical variables, including basic clinical characteristics and surgical complications. All statistical analyses were performed using SPSS version 26.0. Two-sided $p < 0.05$ was considered to be statistically significant.

Results

Clinical and pathological characteristics

A total of 197 patients were finally enrolled in this study, as shown in Table 1. 104 patients underwent LRH by the Dual-bridge method, and 93 patients underwent LRH by the conventional method. The tumor sizes of the Dual-bridge group were larger than the conventional group (2.16 ± 1.09 vs. 2.60 ± 1.33 cm, $p < 0.01$). No other differences in the characteristics of patients were observed between the two groups.

Table 1
The clinical characteristics of patients

Indicators	**Conventional LRH (n = 93)**	**Dual-bridge LRH(n = 104)**	***P* value**
Age (year)	52.37 ± 9.28	50.58 ± 10.38	0.21
BMI	24.27 ± 3.16	23.98 ± 3.33	0.53
Tumor size (cm)	2.16 ± 1.09	2.60 ± 1.33	0.01
Postoperative FIGO stage (2018)			0.87
IB1	30	30	
IB2	31	34	
IB3	4	6	
IIA1	13	12	
IIA2	1	4	
IIB	1	2	
IIIC1	11	13	
IIIC2	2	3	
Histological type			0.55
squamous carcinoma	71	81	
adenocarcinoma	17	14	
Other types	5	9	
Metastasis in the lymph nodes			
Yes	13	17	0.67
No	80	87	
Lymphovascular space involvement			
Yes	56	71	0.25
No	37	33	
Parametrial involvement			
Yes	1	2	1.00
No	92	102	
BMI: Body Mass Index; LRH: laparoscopic radical hysterectomy.			

Indicators	Conventional LRH (n = 93)	Dual-bridge LRH(n = 104)	*P* value
Adjuvant chemotherapy\radiotherapy			
Yes	64	68	0.64
No	29	36	
BMI: Body Mass Index; LRH: laparoscopic radical hysterectomy.			

Comparison of the surgical outcomes

The total operative time was significantly shorter in the Dual-bridge LRH group compared with the conventional LRH group (189.35 ± 33.27 vs. 221.22 ± 37.80 min, $p < 0.01$) (Table 2). Similarly, the mean duration of uterine artery and VUL dissection was notably reduced in the Dual-bridge LRH group relative to the conventional LRH group (41.73 ± 7.60 vs. 50.90 ± 8.79 min, $p < 0.01$). Moreover, the blood loss in the Dual-bridge LRH group was significantly less than the conventional group (107.12 ± 66.75 vs. 129.35 ± 66.39 min, $p < 0.01$). No significant differences were observed between the two groups in terms of surgical complications, including ureteral, bladder, bowel, and obturator nerve injuries.

Table 2
The surgical outcomes of two groups

Indicators	Conventional LRH (n = 93)	Dual-bridge LRH(n = 104)	*P* value
Total operative time (min)	221.22 ± 37.80	189.35 ± 33.27	< 0.01
Operative time of VUL resection (min)	50.90 ± 8.79	41.73 ± 7.60	< 0.01
Blood loss (mL)	129.35 ± 66.39	107.12 ± 66.75	0.02
Ureteral injury	2	0	0.22
bladder injury	2	1	0.60
Placement of ureteral stent	2	0	0.22
Bowel injury	1	0	0.47
Obturator nerve injury	2	1	0.60
Lymphocyst	7	8	1.00
LRH: laparoscopic radical hysterectomy; VUL: vesicouterine ligament.			

Discussion

Radical hysterectomy remains the gold standard for treating early-stage cervical cancer [2]. However, the surgical landscape was significantly altered by the Laparoscopic Approach to Cervical Cancer (LACC) trial, which reported inferior disease-free and overall survival for minimally invasive surgery compared with open surgery [8, 9]. Nevertheless, the LACC trial has faced criticism regarding its methodology, particularly the low requirement for participating surgeons to have performed only 10 laparoscopic cases. Additionally, survival outcomes are highly susceptible to intraoperative tumor-free techniques, such as the method of vaginal wall transection and the use of a uterine manipulator. As laparoscopic techniques continue to evolve and mature, their potential value in cervical cancer treatment may be underestimated. Recent studies have demonstrated no significant differences in survival or complication rates between open and laparoscopic radical hysterectomy [10–12]. Furthermore, laparoscopic surgery offers distinct advantages, including shorter hospital stays and improved postoperative quality of life [12]. One of the most technically demanding aspects of LRH is the dissection of the uterine artery and the VUL. The complex venous plexuses and dense connective tissue in this region often lead to hemorrhage and accidental ureteral injury during dissection [6]. In this study, we introduced the “Dual-bridge” technique to simplify the management of the ureteral tunnel. Our results showed that the Dual-bridge group had a significantly shorter operative time than the conventional group. Additionally, intraoperative blood loss was significantly lower in the Dual-bridge group.

The evolution of LRH has shifted from empirical dissection to a space-based or plane-based approach. Yuan et al. proposed the "two-space, two-plexus" technique to enhance surgical accessibility [13]. This method emphasizes systematic dissection of pelvic spaces and vascular plexuses. Similarly, Limbachiya et al. highlighted the value of uterine artery skeletonization. Using the intact artery for traction helps identify the "gateway" of the ureteral tunnel [14]. Subsequently, Yang et al. introduced the concept of the "ureteral space"[15, 16]. They defined it as a potential avascular space located medial to the ureter. This space lies both in the anterior and posterior leaves of the vesicouterine ligament. The anterior leaf extends from the axillary space to the fourth space of Yabuki. The posterior leaf is located between the paravesical and paravaginal spaces. The surrounding tissue contains a complex venous plexus. conventional operations often cause massive bleeding in this region. Consequently, Yang et al. proposed the "Karez" technique to develop these avascular areas [17]. This approach achieved shorter operative time, less blood loss, and improved survival outcomes. In contrast, our Dual-bridge method emphasizes a ureter-centric surgical philosophy, utilizing the natural avascular spaces surrounding the ureter for precise anatomical dissection to achieve complete resection of the parametrial tissue.

A critical point regarding the Dual-bridge technique is the extent of ureteral skeletonization. Both bridges revolve around the ureter, utilizing its natural fascial planes to minimize manipulation. We dissect strictly along natural anatomical gaps in the ureteral tunnel. This approach makes the ureter appear more "skeletonized" than in conventional methods. Theoretically, this might increase the risk of postoperative ischemia or ureteral fistula. However, these gaps are inherent, avascular anatomical planes. Dissecting within these planes is the essence of our Dual-bridge concept. This method avoids the blind electrocoagulation and thermal injury often caused by managing bleeding in obscured fields. In our study, no ureteral fistulas or major urological complications occurred in the 104 patients of the Dual-

bridge group. These results confirm that anatomically guided skeletonization preserves the blood supply and integrity of the ureter. Our findings are consistent with those who reported no ureteral injuries using similar space-dissection principles.

However, this study has several limitations. As a retrospective analysis from a single center, potential selection bias cannot be entirely excluded. While our short-term outcomes regarding operative efficiency and safety are encouraging, the LACC trial has underscored the vital importance of long-term survival data. Future studies with extended follow-up and multi-center prospective designs are necessary to confirm the long-term oncological safety and the impact on bladder functional recovery.

Conclusion

The Dual-bridge technique offers a safe, efficient, and anatomically precise method for managing the ureteral tunnel to minimize bleeding and avoid damaging the ureters.

Declarations

Ethical approval

This study was approved by the ethics committee of Chongqing Health Center for Women and Children, which waived the requirement to obtain informed consent (approval number: (2026)-076).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Author Contribution

Yuan, Xia: Conceptualization, Data curation, Formal analysis, Methodology, and Writing – original draft. Diao, Wu, Peng, Ren, Huang: Formal analysis and Methodology. Zhao: Supervision and Writing – review & editing.

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Not applicable.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Figures

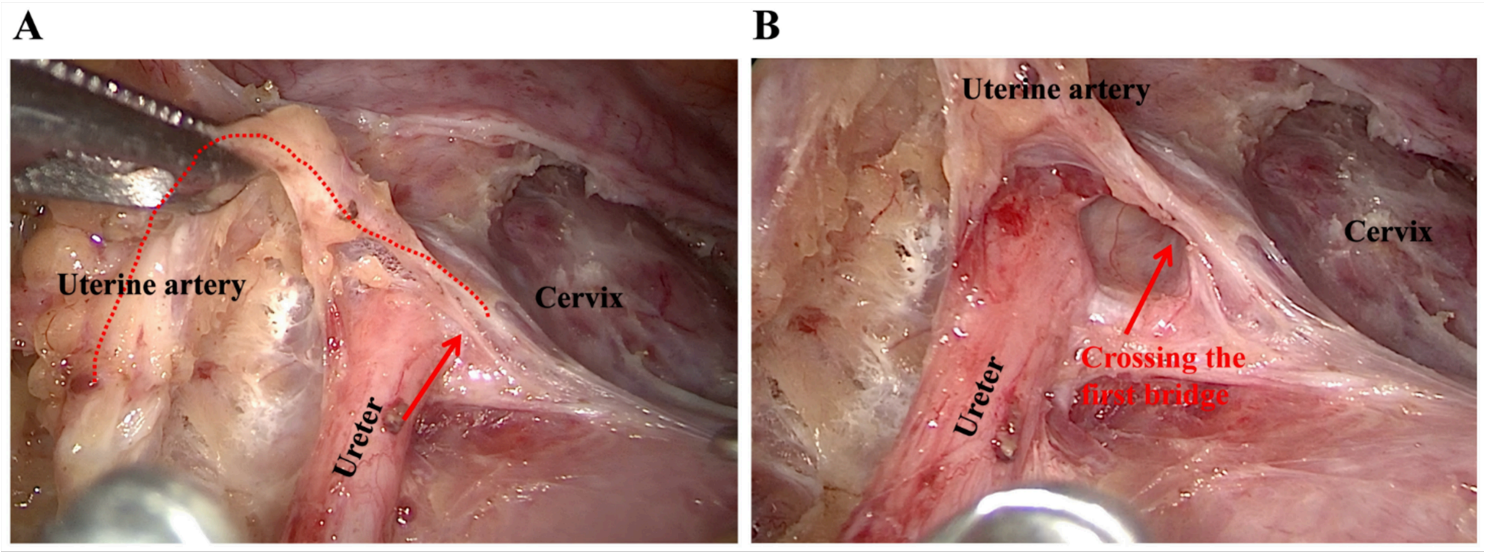


Figure 1

First bridge: dissection of the ureteral-uterine arterial plane.

(A) Identify the "ureteral nutrient branch" of the uterine artery. Bluntly dissect the avascular plane between the uterine artery, its nutrient branch, and the lateral peritoneum. (B) Ligate the uterine artery at

its origin and mobilize the ureter laterally and superiorly, creating continuity with the second bridge's plane.

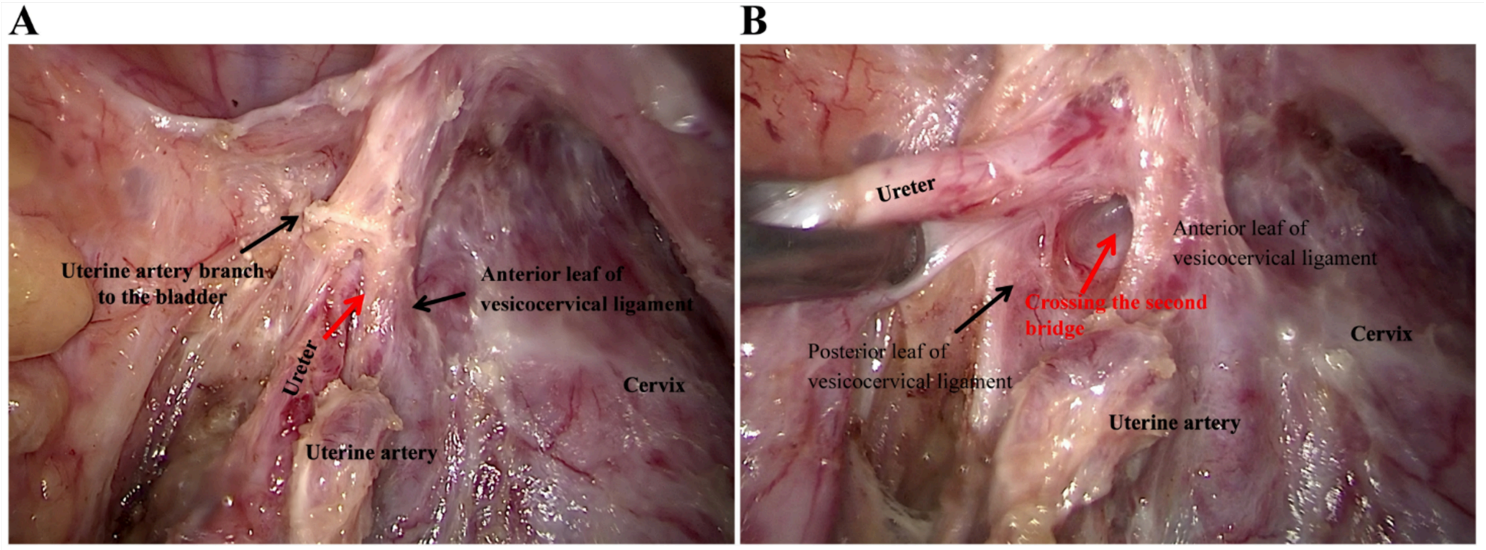


Figure 2

Second bridge: dissection of the vesicocervical ligament and bladder lateral space.

(A) After transecting the uterine artery and its bladder branch, retract the bladder downward to expose the bladder lateral space. (B) Bluntly dissect the anterior leaf of the vesicocervical ligament from the ureter in an outward and upward direction, followed by division of the posterior leaf of the vesicocervical ligament.