Robot-assisted laparoscopic ureteral reconstruction for ureter endometriosis: Case series and literature review

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Abstract

Background: The aim of this report was to review experience from a single hospital in treating ureteral obstruction related to endometriosis with robot-assisted laparoscopic ureteral reconstruction.

Methods: This retrospective analysis study (Canadian Task Force classification II-3) was conducted at an academic tertiary hospital. Five female patients with hydronephrosis without significant elevation of serum creatinine levels were enrolled. Ureteral endometriosis with obstruction was suspected on radiological images. Previous treatment with double-J stenting with or without medical treatment had failed in all of the patients. We performed robot-assisted laparoscopic segmental resection for ureteral endometriosis and reconstructed the ureter through ureteroureterostomy (RUU) or ureteroneocystostomy (RUC). The involved ureters included left lower ureter in three patients and right lower ureter in two patients. RUU was performed in four patients and RUC in one patient. All of the operations were completed smoothly without complications.

Results: All ureteral endometrioses were successfully resected, and follow-up sonography or intravenous pyelography showed resolution of hydronephrosis in all of the patients.

Conclusion: Our experience proves the feasibility and efficacy of a robot-assisted approach for this rare situation with good outcomes.

Keywords: Cystostomy; Endometriosis; Robotic; Ureterostomy; Urologic disease

1. INTRODUCTION

Urinary tract endometriosis is a rare form of endometriosis, which occurs in 1% to 12% of women with endometriosis, with 80% to 90% of these cases on the bladder and the rest on the ureter.[1,2] Ureteral involvement is a rare manifestation of endometriosis and occurs in only 0.1% of women.[3] It is classified as extrinsic, which affects the ureteral adventitia, and intrinsic, which is defined as invasion of the ureteral muscle.[4,5] It is mostly asymptomatic, but it can cause lower back pain, hematuria, and recurrent urinary tract infections. If left untreated, it may lead to silent loss of renal function. The diagnosis is challenging since up to 50% of patients are asymptomatic and may have already developed progressive renal function loss.[6]

In most cases, surgery through a laparoscopic or laparotomy approach can provide an accurate diagnosis of endometriosis[4] and also play an important role in treatment. Surgical treatment of bladder endometriosis usually involves excision of the lesion and primary closure of the bladder wall. Ureteral lesions may be excised after stenting the ureter. However, in the presence of intrinsic lesions or significant obstruction, segmental excision with end-to-end anastomosis or reimplantation may be necessary.

A previous study of 109 consecutive women who underwent laparoscopic ureterolysis for deep endometriosis found that conservative laparoscopic surgery for ureteral endometriosis was a safe approach when performed by experienced surgeons.[7] However, the presence of large endometriotic nodules or hydronephrosis grade 2 was associated with a higher risk of perioperative and long-term adverse outcomes. Difficulties with intracorporeal suturing and a prolonged operative time remain distinct disadvantages. A possible solution to overcome the technical difficulties of minimally invasive ureterolysis may be provided by new technologies, such as robotic-assisted surgery.

The management of ureteral stricture or deep infiltrated endometriosis in the ureter is an area where robotic-assisted laparoscopy is a viable option and has proven to be beneficial; however,

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Author Contributions: Dr. Zhi-Chen Hung and Dr. Tzu-Hsiang Hsu contributed equally to this study.

Conflicts of interest: The authors declare that they have no conflicts of interest related to the subject matter or materials discussed in this article.

Journal of Chinese Medical Association. (2020) 83: 288-294.

Received December 30, 2018; accepted April 22, 2019.

doi: 10.1097/JCMA.0000000000000249.

it has rarely been reported. Robotic-assisted laparoscopy is becoming more ubiquitous since it provides a three-dimensional highly magnified image, which is a significant improvement over a laparoscopic approach.[4,8,9] In a review comparing laparoscopic-assisted methods and robotic-assisted methods, Frick et al reported that multiple studies have also found that novices achieve competency in suturing and tying knots faster with robotic-assisted methods than with conventional laparoscopy since they provide greater accuracy and a more highly magnified image.[8] Thus, learning advanced laparoscopic procedures may be easier with robotic assistance than with conventional laparoscopy. Moreover, it is a more precise and advanced laparoscopic method, allowing for tremor-free movements and delicate suturing. Robot-assisted ureteroureterostomy (RUU) was first reported by Lee et al in 2010 in a case series of three adults.[9] Although subsequent reports have confirmed the feasibility and excellent outcomes of RUU, the literature regarding RUU is limited to a handful of small case series. Multiple small case series have substantiated the technical feasibility and excellent outcomes of RUU, with the added benefits of reduced hospital stay and improved patient quality of life. The only disadvantage of a robotic-assisted method is that they are more expensive than a conventional laparoscopic approach. However, despite the reported favorable success rate of RUU, no previous study has evaluated the complications associated with this technique.[2] Therefore, the aim of this study was to present our experience of five cases of robotic-assisted resection of the ureter with end-to-end anastomosis through RUU with regards to the feasibility, safety, and short-term results.

2. METHODS

We retrospectively analyzed five patients who underwent robot-assisted laparoscopic segmental resection for endometriosis involving the ureter with RUU or ureteroneocystostomy (RUC) reconstruction at Taipei Veterans General Hospital between January 2013 and November 2015. This study was reviewed and approved by the Human Investigational Review Board of Taipei Veterans General Hospital (VGH IRB: 2017-07-012BC). All five patients had hydronephrosis, which was diagnosed incidentally in two patients and due to ipsilateral flank pain as the initial presentation in three patients. All of the patients had normal serum creatinine levels (range 0.62-0.97 mg/dL) preoperatively (Table 1), and they all underwent either magnetic resonance imaging (MRI) (Figure 1A, B) or computerized tomography (CT) for preoperative diagnosis and planning. Stricture of the left lower ureter was seen in three patients and the right lower ureter in two patients, which were highly suspected of being endometriosis lesions. All five patients had previously received treatment with double-J stenting with or without medical treatment. One patient underwent laser endoureterotomy with double-J stenting. The hydronephrosis resolved 3 months later but recurred soon after removal of the double-J stent. The remaining four patients had persistent hydronephrosis or hydroureter despite the presence of double-J stents. Preoperative ureteroscopy was performed in all five patients, but only one patient had endometriosis tissue invasion confirmed by an ureteroscopic biopsy. All of the patients had pathologically confirmed ureteral endometriosis postoperatively, and we reviewed the perioperative data and postoperative outcomes.

Under general anesthesia, the patients were placed in the Trendelenburg position, with a urinary catheter and uterine manipulator placed before the surgery. After a pneumoperitoneum had been created by carbon dioxide insufflation pressure using a transumbilical Veress needle (Gimmi, Germany), five bladeless trocars were placed in the patients' abdomen as follows: one 12-mm central port, three 8-mm ports for the

Table 1

Patient characteristics and operative parameters

Case no.	Age, year	BMI, kg/m²	Hb, g/dL	BUN, mg/dL	Crea, mg/dL	CA-125, u/mL	Initial symptoms	GYN history	Parity	rAFS (score/ stage)	Lesion site	Method	Combined operation[a]	EBL, mL	OP time, min	POHS, day	Follow-up, month
1	32	20.7	13.4	14	0.62	12.87	Flank pain	Bilateral ovarian chocolate cyst	G0P0	29/III	Left	RUU	Nil	100	310	7	31
2	29	21.5	12.6	15	0.97	24.6	Flank pain	Adenomyosis	G0P0	25/III	Left	RUU	Myomectomy	150	325	11	15
3	48	22.4	13.2	16	0.73	75	Flank pain with fever	Left ovarian chocolate cyst	G0P0	29/III	Left	RUC	Hysterectomy, left adnexectomy	250	220	9	15
4	36	19.3	12.2	9	0.78	40.5	Dysmenorrhea	Nil	G0P0	14/II	Right	RUU	Nil	<30	240	8	12
5	36	21.5	10.2	10	0.86	74	Dysmenorrhea	Left ovarian chocolate cyst	G0P0	71/IV	Right	RUU	Right ovarian cystectomy	N/A	404	8	12

BMI = body mass index; BUN = blood urea nitrogen; Crea = creatinine; EBL = estimated blood loss; G = gravidity; GYN = Gynecologic; Hb = hemoglobin; N/A = not available; OP = operative; P = parity; POHS = postoperative hospital stay; rAFS = revised American Fertility Society classification; RUC = robot-assisted laparoscopic ureteroneocystostomy; RUU = robot-assisted laparoscopic ureteroureterostomy.

[a]The operation time include the combined gynecological surgery.

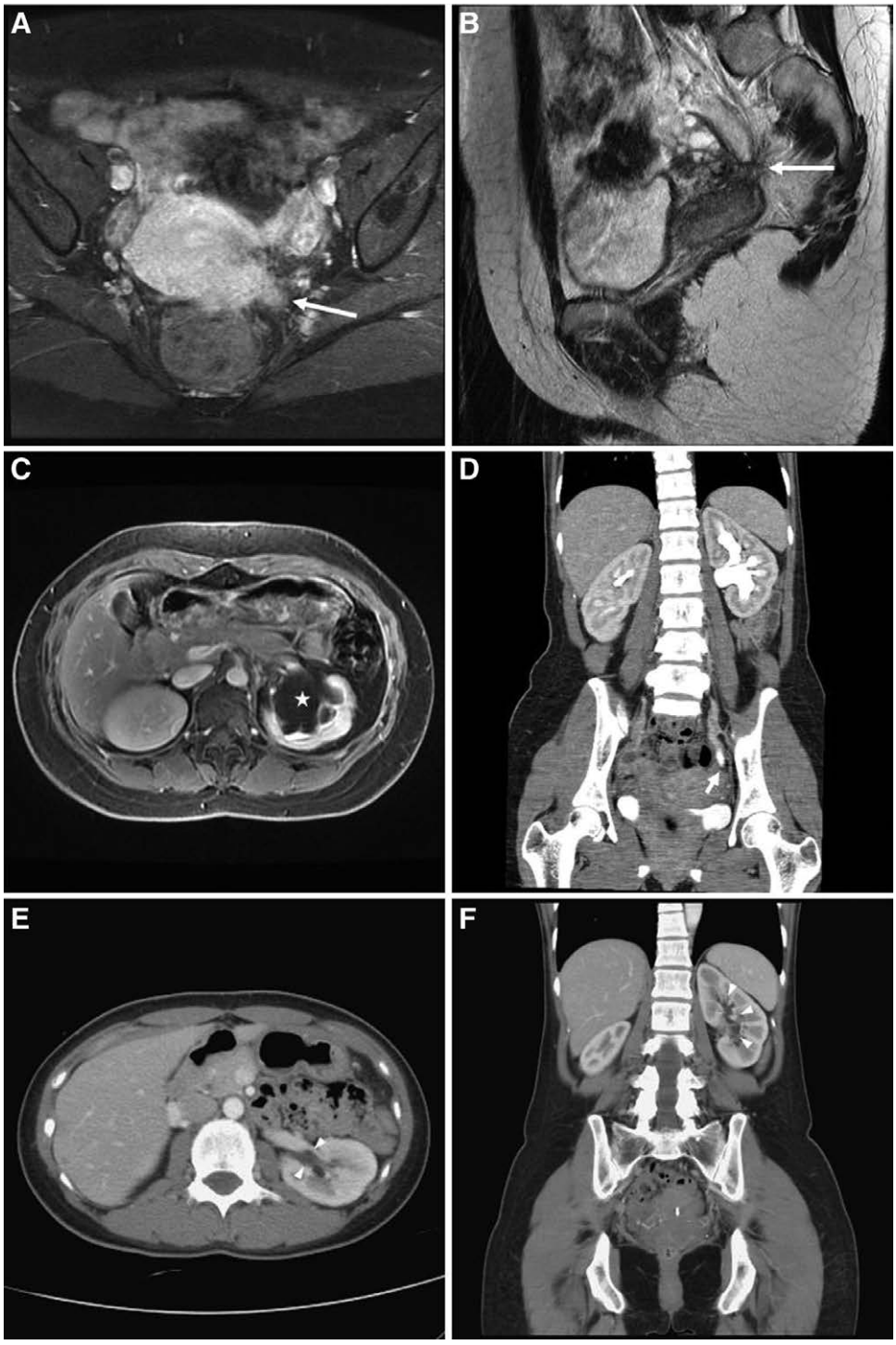

Fig. 1 A 31-year-old woman with endometriosis in left pelvic cavity. A, The preoperative MRI (postcontrast fat-saturated T1-weighted image, axial view) demonstrated a 3.5-cm infiltrative soft tissue (arrow) at left posterior aspect of uterus, involving cervix, left parametrium, cul-de-sac and left internal iliac region, in favor of endometriosis. B, An irregular low signal lesion (arrow) encasing left distal ureter on sagittal T2-weighted image, causing hydroureter and hydronephrosis (*) on axial T1-weighted image (C); A 36-year-old woman with incidental finding of left hydronephrosis. D, The preoperative CT urography disclosed abrupt narrowing at left distal ureter (arrow). E and F, Three months after operation, the CT scan showed marked resolution of hydronephrosis (arrowheads) without double-J stenting. CT = computerized tomography; MRI = magnetic resonance imaging.

robotic arms, and one additional 12-mm port for the assistant (Figure 2). Following docking of the robotic arms (da Vinci Surgical System, Intuitive Surgical, United States), the three-dimensional zero-degree stereoscopic endoscope and EndoWrist instruments were then inserted into the robotic ports, including monopolar scissors, PK forceps, and a large/mega needle driver (Intuitive Surgical, United States). The surgeon then moved to the console and controlled the robot remotely.[10] For the three patients with gynecologic lesions, the operations were initially performed by gynecologists to resect

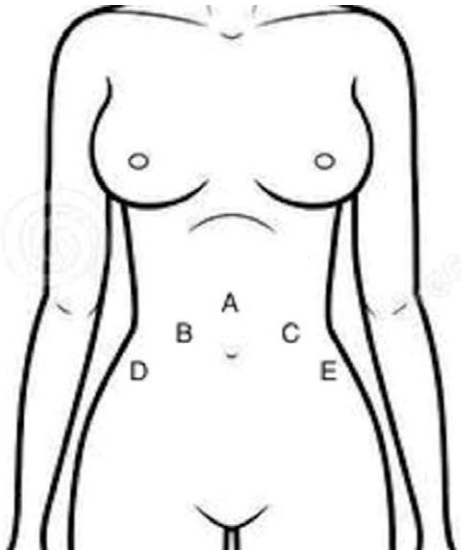

Fig. 2 Port placement: Point A, 12-mm camera port through the Lee–Huang point (located in the middle upper abdomen between the xiphoid process and umbilicus). Point B–D: 8-mm ports for robotic arms. Point E: 12-mm assistant port. The intervals between successive trocars are all approximately 10 cm.

all of the endometriosis tissues, followed by ureteral reanastomosis performed by urologists.

3. RESULTS

The mean age of the patients was 36.2 years (range 29-48 years), and the mean time from initial diagnosis of hydronephrosis to definitive treatment was 27.8 months (range 5-78 months). Prophylactic antibiotics were given before the surgery and repeatedly given if the operations took more than 4 hours. During the surgery, one patient received myomectomy, one received right ovarian cystectomy, and another received hysterectomy and left oophorectomy performed by the gynecologists with the robotic-assisted devices. The urological procedures then started with identification of the involved ureters followed by the careful release of the adhesive parts by the urologists. After dissecting out the normal ureter proximal and distal to the adhesive parts, the diseased ureters were segmentally resected (Figure 3A–C). The proximal and distal ureteral cut-ends were examined by frozen section intraoperatively to ensure they were free of endometriosis tissue. After spatulation of both cut-ends of the ureter, end-to-end anastomosis was performed with interrupted sutures (Figure 3D). For one patient with adhesion close to the urinary bladder, distal ureterectomy was performed, followed by reimplantation of the ureter (Figure 3E, F). Double-J stents were reinserted for all patients intraoperatively, and the mean time to double-J stent removal was 6.7 weeks (range 6.0-8.1 weeks) after surgery. Four of the patients received RUU and the other received RUC, all of which were performed successfully (Table 1). Finally, a closed wound vacuum reservoir was placed in the cul-de-sac. All trocars were removed under direct visualization. Adequate suturing was performed to approximate the fascia and subcutaneous tissues. Two patients without obvious endometriosis tissue other than ureter adhesion did not undergo gynecological procedures. Permanent pathology confirmed endometrial glands in the ureteral wall in all of the patients. The mean total operative time was 299.8 minutes (range 220-404 minutes), and the mean total blood loss was 132.5 cm^3 (range <30-250 cm^3). All of the patients suffered from severe endometriosis and adhesion. The total operative time was longer due to adhesiolysis and ureteral reanastomosis, which is a relatively delicate procedure. The Foley catheter was removed on postoperative day one. Jackson-Pratt drains were used and removed before the patients were discharged from the hospital. All cases were treated with gonadotropin-releasing hormone agonists postoperatively for 6 months. The outcome measures were estimated blood loss, transfusion rate, conversion rate, complications rate, and the duration of the postoperative hospital stay.

The mean postoperative follow-up period was 17 months (range 12-31 months). Follow-up sonography (Figure 4) or intravenous pyelography all showed resolution of hydronephrosis 3 months postoperatively (Table 2), and no recurrence was noted at the last outpatient department follow-up. A CT scan was performed within 6-12 months to compare the postoperative outcomes including the renal diameter and ureter diameter (Table 2). No complications were noted in any case, and no surgical conversions or blood transfusions were required during the hospitalizations.

4. DISCUSSION

Endometriosis is estimated to affect 10% to 15% of women of childbearing age,[10,11] with urinary tract endometriosis occurring in 0.3% to 12% of women with pelvic endometriosis and up to 52.6% in those with deep infiltrating endometriosis.[2,5,12] The most frequently involved site is the urinary bladder (85%), followed by the ureter (10%), kidney (4%), and urethra (2%).[5,13] The left distal ureter is the most commonly affected site.[1,14] About 64% of patients with ureteral endometriosis have lesions on the left side, which is compatible with our series, and the incidence of bilateral involvements is 10%. In addition, ureteral endometriosis frequently occurs on the same side as concomitant ovarian endometriomas.[1,15]

The symptoms related to ureteral endometriosis include pelvic pain, flank pain, dysmenorrhea, dyspareunia, dyschezia, hematuria, and urinary tract symptoms.[6,16] Most of these symptoms are nonspecific and may not be related to the ureteral endometriosis itself. In our series, 60% of the women presented with flank pain and 40% had incidental findings of hydronephrosis without subjective symptoms. Sonography can be used as the first-line screening tool to exclude urinary tract obstruction in patients with pelvic endometriosis, and periodic ultrasound follow-up after the diagnosis will detect early urinary tract obstruction and prevent further loss of renal function.[16]

Ureteral endometriosis may be primary or secondary. Primary is defined as spontaneous development without previous surgery, and secondary is defined as development after pelvic surgery. About 50% of patients with urinary tract endometriosis have previously undergone pelvic surgery.[2] In our series, two patients (40%) has previously received gynecologic surgery for ovarian endometriomas. Ureteral endometriosis can be classified into two main types: intrinsic and extrinsic. In the intrinsic type, endometriosis lesions occur within the ureter wall and invade the muscle layer of the ureter. The extrinsic type develops around the area surrounding the ureter with external compression to the ureteral wall. The extrinsic type has been reported to be four times more common than the intrinsic type[5,17]; however, the intrinsic type accounted for 60% of our cases with the extrinsic type accounting for 40%. This discrepancy may be due to case selection and may reflect the fact that we chose the more severe cases for surgery.

Ureteroscopy can be used to diagnose ureteral endometriosis. It provides direct visualization of the bladder and ureter and a biopsy for a pathologic diagnosis. In our study, ureteroscopy was performed preoperatively in all patients; however, histological confirmation was made in only one patient. Negative endoscopic findings do not exclude the diagnosis of ureteral

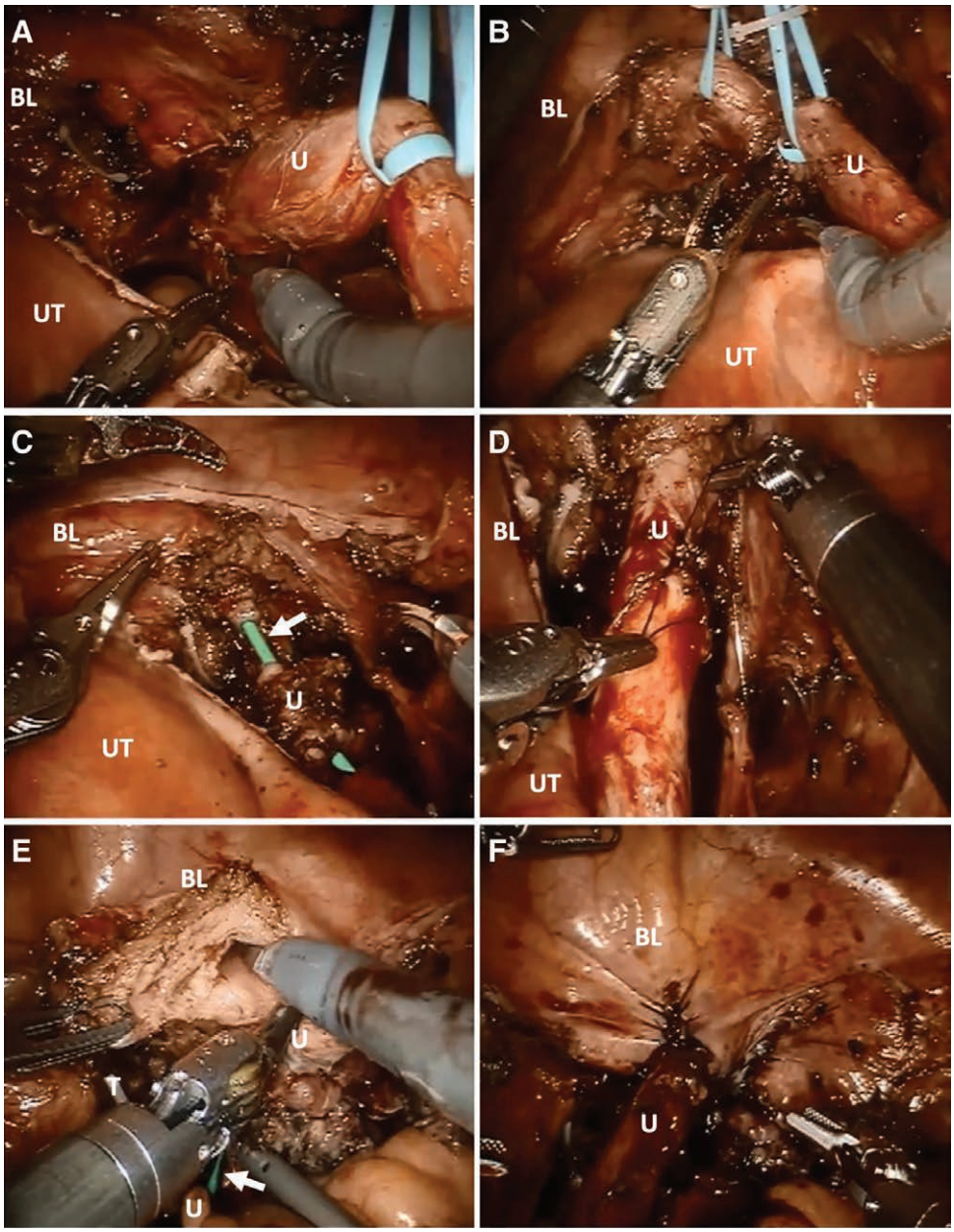

Fig. 3 A, The lesion was located at right lower ureter with severe adhesion. B, The normal part of ureter proximal and distal to the adhesive segment was dissected free and mobilized. C, The adhesive part of ureter was excision and the previously placed double-J stent was exposed. D, After spatulation of both cut-ends of ureter, end-to-end anastomosis was performed with interrupted sutures. E and F, In this case, the lesion was located at left lower ureter, which was too close to urinary bladder. Ureteroneocystostomy was performed instead of ureteroureterostomy. The ureter cut-end was spatulated and was anastomosed to urinary bladder after creating a submucosal tunnel (BL = bladder; U = ureter; UT = uterus).

endometriosis. Even in cases of intrinsic endometriosis, if the endometrial tissue does not extend beyond the ureteral adventitial layer, the role of ureteroscopy is limited.[18] However, it is still necessary and important to exclude malignancy. MRI has a moderate to good correlation with intraoperative findings and should be considered when ureteral endometriosis is clinically suspected.[8] In addition, MRI provides a more sensitive (91% vs 82%) but less specific (59% vs 67%) prediction of intrinsic or extrinsic disease than surgery.[19]

The optimal management for ureteral endometriosis has yet to be established, and it should be tailored according to the clinical scenario, for example the extent of disease, severity of obstruction, and renal function. Hormonal therapy may work for early-stage disease without fibrosis; however, the long-term outcome is still insufficient. Once fibrosis forms with disease progression resulting in ureteral obstruction, the effect of hormonal therapy as the sole treatment is limited. Endoureterotomy is a conservative treatment and seems to be beneficial for intrinsic ureteral endometriosis. However, a high recurrence rate has been reported within 6 months despite hormonal therapy, which is most likely due to inadequate cutting and decreases in estrogen and progesterone receptors.[20]

Surgical interventions for ureteral endometriosis include ureterolysis, ureteroureterostomy, ureteroneocystostomy, and nephrectomy. Several studies have reported that ureterolysis should be recommended solely for limited, extrinsic type and nonobstructive

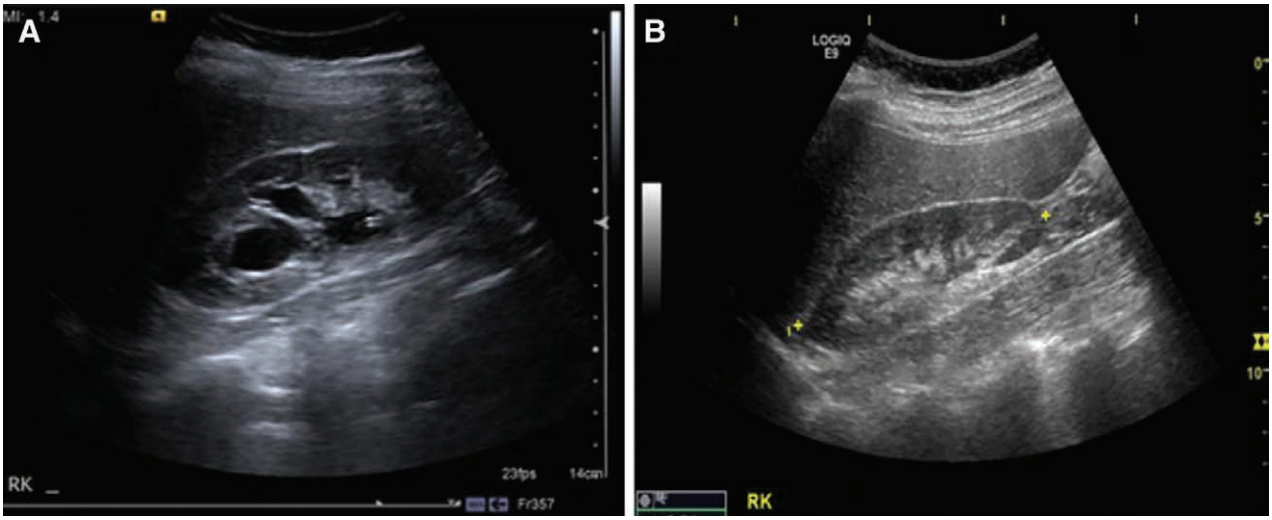

Fig. 4 A, Ultrasound before operation and moderate hydronephrosis. B, Ultrasound follow-up 6 months after operation, total resolution of hydronephrosis without double-J stenting.

Table 2

Changes of renal pelvis and ureter maximal diameter after surgery

	Renal pelvis diameter[a], cm		Ureter diameter[b], cm	
	Preoperative	Postoperative	Preoperative	Postoperative
Case 1	3.60	1.26	1.08	0.80
Case 2	4.55	2.49	1.11	0.46
Case 3	1.11	0.73	0.85	0.55
Case 4	3.49	0.97	1.60	0.51
Case 5	2.32	1.64	1.53	0.85

CT = computerized tomography; MRI = magnetic resonance imaging.
[a]The greatest longitudinal diameter of the renal pelvis from coronal CT/MRI image.
[b]The greatest transverse diameter of ureter from axial CT/MRI image.

ureteral endometriosis,[21–23] whereas other studies have shown that ureterolysis is beneficial for patients with obstructive uropathy.[12,24–26] Preoperative hydronephrosis grade ≥2 has been associated with a longer operative time and higher recurrence rate.[7] Although complete excision of ureteral endometriosis seems to provide better relief of urinary obstruction and lower local recurrence rate, anastomosis may be complicated with stricture. As mentioned, the optimal choice of management for ureteral endometriosis has not been well established due to its rarity. Maccagnano et al proposed a therapeutic algorithm that suggested ureteral resection is indicated for intrinsic ureteral lesions, endometriosis lesions >3 cm, and those localized below the iliac vessels, and that ureterolysis is indicated for nonobstructive extrinsic lesions <3 cm.[18] Obstructive ureteral lesions with resultant hydronephrosis were mainly noted in our patients, and ureteral resection was performed after identifying the sites of obstruction. Our management agreed with the algorithm proposed by Maccagnano et al. Ureterolysis only was not suitable for our cases, because the procedure cannot release intraluminal obstructions of the ureter.

Before the use of robotics, a laparotomy approach was favored for urinary tract endometriosis owing to the complexity of the surgery and concomitant gynecological surgery.[21] A laparoscopic approach is safe and efficient for ureter endometriosis with a low risk of complications and satisfactory long-term outcomes.[1,7] However, most previous studies regarding laparoscopic surgery have only focused on ureterolysis. Laparoscopic treatment for ureteral implantation is technically difficult, and a higher overall complication rate has been reported in patients undergoing ureteroureterostomy vs ureterolysis with a conventional laparoscopic approach for ureteral endometriosis.[27]

The outcomes of laparoscopic ureteroureterostomy have been reported to be comparable to open ureteroureterostomy, with a success rate of 94% for repair of iatrogenic ureteral lesions.[28] For distal ureteral lesions, ureteroneocystostomy is the traditional choice of management because ureteroureterostomy is associated with a higher complication rate. Nevertheless, Lee et al reported seven cases who received RUU with good short-term outcomes.[9] The length from the distal ureteral stricture to the bladder was >2 cm, and the anastomosis was spatulated, watertight, and tension-free. In our study, we dissected the distal ureter as low as possible and performed ureteroureterostomy when feasible. The advantages of ureteroureterostomy include the preservation of bladder integrity and anti-reflux mechanism.

With advances in science and technology, robot-assisted laparoscopic reconstructive surgery of the ureter has been shown to be safe and feasible.[30–32] Robot-assisted surgery provides three-dimensional magnified images and increases wrist flexibility with a reduction in tremors, and allows for more complex surgical procedures to be performed through a laparoscopic approach. However, robot-assisted laparoscopic ureteral reconstruction for ureteral endometriosis has rarely been reported. Our experience shows that robot-assisted laparoscopic reconstructive surgery for ureteral endometriosis is a good choice. However, this study is limited by its retrospective nature and small sample size.

In conclusion, our experience shows the feasibility and efficacy of a robot-assisted laparoscopic approach for this rare situation. The upper urinary tract should be evaluated in all patients with pelvic endometriosis to exclude asymptomatic ureteral involvement. A strong clinical suspicion is required for women of reproductive age, with left lower ureteral involvement, menstrual cycle-dependent symptoms, and previous abdominal/pelvic surgery. Our experience, although limited, shows promising results, which may warrant the application of this technique in such clinical scenarios.

ACKNOWLEDGMENTS

This study was supported in part by the Ministry of Science and Technology (MOST 104-2314-B-075-022, MOST

104-2314-B-075-058 and MOST 105-2314-B-075 -038 -MY2 for Yi-Jen Chen), Taipei Veterans General Hospital (V105C-061, V105EP-002, and VN105-13 V105C-061, V105EP-002, V106-EP-002, V106-C-065, V107-EP-001, V107-C-030, V108EP-001, VN108-13, and V108C-065 for YJC, V107EP-010 for Eric YH Huang), Yen-Tjing-Ling Medical Foundation (CI-104-15 for YJC) and Szu-Yuan Research Foundation of Internal Medicine (105002). This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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