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Surgery Alive

Robot-assisted uretero-enteric reimplantation for uretero-enteric anastomotic strictures following robot-assisted radical cystectomy: Surgical approach and outcomes over two decades

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KEYWORDS
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Abstract *Objective:* We described the technique and outcomes of robot-assisted repair of uretero-enteric strictures (UES) following robot-assisted radical cystectomy (RARC) and urinary diversion.

Methods: Retrospective review of our RARC database from November 2005 to August 2023 at Roswell Park Comprehensive Cancer center was performed. Patients who developed UES and ultimately underwent robot-assisted uretero-enteric reimplantation (RUER) were identified. Kaplan—Meier method was used to compute the cumulative incidence recurrence rate of UES after RUER. A multivariable regression model was used to identify variables associated with UES recurrence.

Results: A total of 123 (15%) out of 808 RARC patients developed UES, of whom 52 underwent reimplantation (45 patients underwent RUER [n=55 cases] and seven patients underwent open uretero-enteric reimplantation). The median time from RARC to UES was 4.4 (interquartile range 3.0—7.0) months, and the median time between UES and RUER was 5.2 (interquartile range 3.2—8.9) months. The 3-year recurrence rate after RUER is about 29%. On multivariable analysis, longer hospital stay (hazard ratio 1.37, 95% confidence interval 1.16—1.61, p<0.01) was associated with recurrent UES after RUER.

Conclusion: RUER for UES after RARC is feasible with durable outcomes although a notable subset of patients experienced postoperative complications and UES recurrence.

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1. Introduction

Robot-assisted laparoscopic surgery has gained widespread acceptance in urological practice, including radical cystectomy (RC). Irrespective of the surgical approach, RC is an extensively complex procedure associated with a high morbidity rate of approximately 60%, even when performed by experienced surgeons [1—3]. The reported complications are usually within 90 days after robot-assisted radical cystectomy (RARC), which might not accurately reflect the actual burden of the procedure. Our group has previously documented that a substantial proportion, up to two-thirds, of surgical interventions for complications after RARC occur beyond the 90-day window. Such long-term complications, including uretero-enteric strictures (UES), are often underreported. Regardless of the surgical approach, the UES occur in up to 25% of patients undergoing RC and represents the primary cause for reoperations [4—7].

While endoscopic management (such as percutaneous nephrostomy, stents with or without balloon dilation, or endoureterotomy) is usually tried initially, long-term success remains limited [8]. Some studies suggested that repeated endoscopic interventions can exacerbate scarring and make the subsequent surgical repair more challenging, and therefore, a period of "rest" has been suggested by some surgeons in which the kidney would be drained with a nephrostomy tube with no stent in place [9,10].

Open uretero-enteric reimplantation (OUER) is considered the gold standard treatment for UES, with durable long-term success rates of more than 80% [11,12]. While traditionally multiple prior surgeries have been considered a relative contraindication to minimally invasive surgery, more recently there has been a growing trend towards minimally invasive approaches for ureteral reconstructive procedures, especially with robot assistance. A recent multi-institutional study has reported that when performed by skilled surgeons, robot-assisted uretero-enteric reimplantation (RUER) was associated with low morbidity and low postoperative major complications (5%), as compared to the open approach [13]. In this context, we sought to describe the technique and perioperative outcomes of robot-assisted repair of UES.

2. Methods

We retrospectively reviewed our prospectively maintained Roswell Park Comprehensive Cancer Center quality assurance database for RARC between November 2005 and August 2023. We confirm that we have obtained explicit permission from the dataset owner to utilize the information within the specified databases/repositories for the purpose of our research. Patients who developed UES and were managed with RUER were identified. Data were reviewed for demographics and perioperative outcomes. Primary endoscopic management (balloon dilatation, endoureterotomy, stent, or percutaneous nephrostomy) was also reviewed. RUER procedures were described in terms of reimplantation side, conversion to open approach, operative time, use of intraluminal or intravenous indocyanine green (ICG), intra- and post-operative complications, and length of hospital stay. Treatment failure (UES recurrence) was defined as radiological and/or clinical signs of recurrent obstruction requiring renal drainage, endourological intervention, and revision of reimplantation or nephrectomy. All procedures were performed using the da Vinci Xi® surgical system (Intuitive Surgical, Sunnyvale, CA, USA). Our study is approved by the Ethics Committee of Roswell Park Comprehensive Cancer Center (approval number I79606). All patients were consented to participate into the research and the publication of the data.

Data were summarized using descriptive statistics. The Kaplan—Meier method was used to depict the time to recurrent UES after RUER. A multivariate stepwise COX model was used to identify predictors associated with UES recurrence after RUER. All statistical tests were two-sided with a significance threshold of $p<0.05$. All tests were performed with SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

2.1. Surgical technique

The patient was positioned in supine or lithotomy in a steep Trendelenburg. Four 8-mm robotic ports were placed transperitoneally in a triangulation pattern around the ileal conduit, or in the same way as RARC in the case of a neobladder. One assistant port of 12 mm and another of 5 mm could also be used (Fig. 1). Gaining access can sometimes be challenging. Veress needle can be placed away from the site of the surgery (*e.g.*, at Palmer's point, below the left costal margin), or using an open Hasson technique, or an optical trocar such as VisiPort™ (Medtronics®, MN, USA).

Extensive adhesiolysis is often necessary to identify the key anatomical structures. Intra-ureteral (through a nephrostomy tube or nephro-ureteral stent) or intra-diversion administration of ICG can help identify the ureter and the site of stricture [14]. Other methods would include distension of the ureter with saline or methylene blue. Once the ureter is identified, dissection continues while maintaining adequate peri-ureteral tissue in order not to further compromise the vascularity of the ureter. The ureter should be dissected enough to allow for tension-free anastomosis. The ureter is transected at the junction between the UES and the proximal dilated part and generously spatulated. The distal extent of the UES is excised and sent for pathology. Adequate vascularity of the distal end should be ensured before reimplantation. Further excision of the ureter can be performed until well-vascularized tissue is encountered. This can be guided by ICG given intravenously. It should be noted that intraluminal ICG can hamper the usefulness of intravenous ICG. The healthy spatulated end of the ureter is reimplanted at a new site

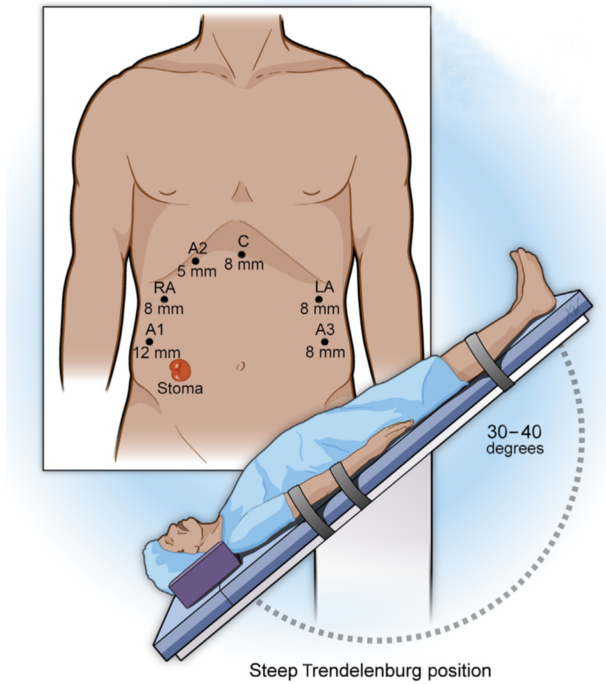

Figure 1 Robot-assisted ureteroenteric reimplantation—port placement. C, camera port; RA, right arm (8 mm, robotic); LA, left arm (8 mm, robotic); A1, assistant port (12 mm, laparoscopic); A2, assistant port (5 mm, laparoscopic) A3, assistant port (8 mm, robotic).

enterotomy site using monofilament absorbable running or interrupted sutures (4–0 or 5–0). Interrupted sutures might have less effect on vascularity especially for recurrent cases, despite insufficient evidence to support this claim.

After completing the posterior half of the anastomosis, a ureteral stent can be placed across the anastomosis. In our recent experience, we no longer place stents after revision, without increased risk of leakage or complications. Evidence is still premature to recommend for or against stenting.

The surgical technique is described in detail in the enclosed video (Supplementary Video 1).

Supplementary video related to this article can be found at https://doi.org/10.1016/j.ajur.2023.10.002

3. Results

Among the 808 RARC patients, a total of 123 (15%) patients developed UES after surgery, of whom 52 received reimplantation after failed initial endoscopic or percutaneous management (45 patients underwent RUER [n=55 cases] and seven patients underwent OUER). Among the 45 patients who received RUER (n=55) with the median age of 66 (interquartile range [IQR] 61–73) years, 8 (18%) patients had right-sided UES; 27 (60%) had left-sided UES; and 10 (22%) had bilateral UES. The median time from RARC to the diagnosis of UES was 4.4 (IQR 3.0–7.0) months and the median time between the diagnosis of UES and RUER was 5.2 (IQR 3.2–8.9) months. RUER was performed using Bricker's technique in 50 (91%) cases and using Wallace in 4 (7%) cases; there was single transuretero-ureterostomy where the left ureter was anastomosed to the right ureter due to the short length of left ureter (Table 1). Seven cases of RUER were performed on neo-bladder and all of them were using Bricker's technique; 48 cases of RUER were performed on ileal conduit with 43 cases using Bricker's technique, four cases using Wallace's technique, and one case using left-to-right technique.

The median estimated GFR before RUER was 43 (IQR 36–66) mL/min and the median operative time was 174 (IQR 135–189) min. The median estimated blood loss was 50 (IQR 25–120) mL. No conversion to open or blood transfusions was reported. The median length of stay after RUER was 3 (IQR 2–4) days (Table 1). Pathology was benign in all cases. One patient experienced leakage at the site of RUER and another from the ileal conduit. Nine patients (10 cases of RUER) reported urinary tract infection after surgery in 90 days (Table 2).

After a median follow-up of 42.4 (IQR 16.9–56.6) months, 13 (24%) cases developed recurrent UES after with, with a median time of 16.3 (IQR 8.6–26.0) months. The 3-year recurrence rate after RUER was 29% (Fig. 2). Comparing RUER with OUER, there was no significant difference in recurrence rates at 3 years (RUER 29% *vs.* OUER 29%, p=0.99) (Supplementary Fig. 1). We found that patients who experienced recurrence after RUER had higher estimated blood loss (150 mL *vs.* 50 mL, p<0.01) and experienced more postoperative overall complications (85% *vs.* 48%, p=0.03). On multivariable analysis, longer hospital stays (hazard ratio 1.37, 95% CI [1.16–1.61], p<0.01) was associated with UES recurrence after RUER (Supplementary Table 1).

4. Discussion

Reconstructive surgery even after major surgery has undergone a significant transformation from being predominantly open to an increasingly minimally invasive approach. Robot-assisted surgery has played a significant role in this transition by addressing some of the limitations of traditional laparoscopy. Due to these ongoing advancements in robotic technology, along with improved training and expertise, there has been a significant expansion in the range and intricacy of cases suitable for robot-assisted surgery, even among older patients with multiple comorbidities. By employing a minimally invasive approach, there is potential to reduce the associated morbidity in this part of the population [15].

The development of benign UES is a common complication after RC, which can adversely impact the quality of life and lead to various health issues. UES have been reported in up to 19% of patients following RC, with varying frequencies and follow-up durations across previous studies that also differed in surgical technique or experience [16]. The prevalence of UES after RARC in the current study is 15%. UES are more common within the first 2 years after RARC, and the risk tends to diminish beyond 2 years [17]. In the current study, the median time to UES was 4.4 (IQR 3.0–7.0) months, which is comparable to previous reports (range 4–18 months) [18–20].

In the current study—in agreement with many previous studies [21,22]—the majority of UES occurred on the left

Table 1 Demographics and perioperative outcomes of 45 patients who developed UES and underwent RUER after RARC.

Variable	No UES after RUER (*n*=42)	UES after RUER (*n*=13)	Total (*n*=55)	*p*-Value
Parameters at the time of RARC				
Gender (male)	38 (90)	11 (85)	49 (89)	0.62
African American	0 (0)	0 (0)	0 (0)	–
Charlson Comorbidity Index	5 (4–6)	4 (3–5)	4 (4–6)	0.4
Neoadjuvant chemotherapy before cystectomy	19 (45)	7 (54)	26 (47)	0.75
History of abdominal surgery before cystectomy	20 (48)	10 (77)	30 (55)	0.11
History of radiation before cystectomy	2 (5)	1 (8)	3 (5)	0.56
Intracorporeal approach urinary diversion at cystectomy	41 (98)	12 (92)	53 (96)	0.42
Neobladder urinary diversion	7 (17)	0 (0)	7 (13)	0.18
Ileal conduit urinary diversion	35 (83)	13 (100)	48 (87)	–
Type of ureteral anastomosis[a]				
Bricker	36 (88)	13 (100)	49 (91)	0.32
Wallace	5 (12)	0 (0)	5 (9)	–
Stent placement at cystectomy	37 (88)	12 (92)	49 (89)	1
Parameters at the time of RUER				
Age at RUER, year	69 (61–73)	65 (61–69)	66 (61–73)	0.51
BMI at RUER, kg/m^2	29 (27–34)	27 (23–32)	29 (25–33)	0.21
Months from RARC to UES	4.5 (3.3–7.5)	3.9 (1.9–5.5)	4.4 (3.0–7.0)	0.18
Months from UES to RUER	4.8 (2.5–8.9)	5.3 (4.1–9.4)	5.2 (3.2–8.9)	0.33
Estimated blood loss, mL	50 (20–88)	150 (100–150)	50 (25–120)	0.001
Type of ureteral anastomosis				
Bricker	40 (95)	10 (77)	50 (91)	0.08
Wallace	2 (5)	2 (15)	4 (7)	–
Left to right	0 (0)	1 (8)	1 (2)	–
Stent placement at RUER	19 (45)	7 (54)	26 (47)	0.75
Operative time, min	163 (129–186)	179 (170–279)	174 (135–189)	0.03
Transfusion	0 (0)	0 (0)	0 (0)	–
Conversion to open	0 (0)	0 (0)	0 (0)	–
Laterality of RUER				
Left side	31 (74)	6 (46)	37 (67)	0.09
Right side	11 (26)	7 (54)	18 (33)	–
LOS, day	3 (2–4)	6 (2–7)	3 (2–4)	0.03
ICU admission	6 (14)	1 (8)	7 (13)	1
ICG intraoperative use	10 (24)	1 (8)	11 (20)	0.27
GFR, mL/min				
Before RUER	44 (37–67)	41 (34–56)	43 (36–66)	0.59
Day 90 after RUER	46 (34–58)	41 (35–48)	43 (34–56)	0.59
Number of conservative managements before RUER	2 (2–3)	2 (1–3)	2 (2–3)	0.67

BMI, body mass index; ICG, indocyanine green; ICU, intensive care unit; GFR, glomerular filtration rate; LOS, length of stay; RUER, robotassisted uretero-enteric reimplantation; RARC, robot-assisted radical cystectomy; UES, uretero-enteric strictures; –, not available.

Note: the data are presented as n (%) or median (interquartile range), and the percentages may not add up to 100% due to rounding.

[a] The number of no UES after RUER is 41 because the information of one RUER missed.

side (67%), which is probably related to the mobilization of the left ureter beneath the sigmoid mesentery, and more length needs to be dissected to reach the conduit, which is usually constructed on the right side, and can result in reduced vascular supply [21,22]. Interestingly, one study suggested that the lack of haptic feedback during robot-assisted surgery may lead to more traumatic ureteral dissection compared to open approaches, and may contribute to the higher incidence of UES in robot-assisted surgery or intracorporeal diversion [9]. However, the other studies contraindicated these findings and reported that neither operative approach nor patient characteristics impacted the risk of UES [16,23].

Managing UES can be challenging, as in the majority of cases, significant scarring owing to previous cystectomy and urinary diversion (possibly other surgeries and radiation) can impair the vascularity of tissue and healing. Endoscopic or percutaneous approaches are less invasive but less durable, and most patients will ultimately require surgical revision. Open revision is considered the gold standard

Table 2 Complications after RUER in 90 days.

Variable	No UES after RUER (*n*=42)	UES after RUER (*n*=13)	Total (*n*=55)	*p*-Value
Any complication	20 (48)	11 (85)	31 (56)	0.03
Wound (incision hernia)	0 (0)	0 (0)	0 (0)	—
Gastrointestinal (ileus)	1 (2)	1 (8)	2 (4)	0.42
Genitourinary (ureteral leakage)	0 (0)	2 (15)	2 (4)	0.05
Infectious				
Sepsis	1 (2)	1 (8)	2 (4)	0.42
UTI	8 (19)	2 (15)	10 (18)	1
High-grade (Clavien—Dindo Grade 3 or higher) complication	9 (21)	3 (23)	12 (22)	1
Re-admission	6 (14)	1 (8)	7 (13)	1

RUER, robot-assisted uretero-enteric reimplantation; UES, uretero-enteric strictures; UTI, urinary tract infection; —, not available.
Note: the data are presented as *n* (%).

treatment for UES, with durable outcomes in up to 85% of cases [24] [12,25,26]. However, the presence of intra-abdominal adhesions, the risk of bowel injury, and the surrounding major vessels could deter surgeons from performing this procedure.

The current study showed that after a median follow-up of 42.4 months, 76% of cases remained UES-free after RUER. Previous studies have reported similar durable outcomes [9,14,19,20]. In a large multi-institutional study, Carrion et al. [13] demonstrated that 76% of cases remained UES-free for 19 months after RUER, suggesting that the robot-assisted approach is a feasible and viable alternative to open surgery. They reported a lack of prior abdominal radiation therapy, as the only variable significantly associated with being stricture-free after RUER. They also reported 36% postoperative complications in their cohort and 5% high-grade complications [13]. In the current study, we reported 56% overall complications in 90 days and 22% high-grade complications, after RUER. Notably, the urinary tract infection rate was higher in our study as compared to Carrion et al. [13] (18% *vs*. 12%), but the rest of the complications, such as ileus (4% *vs*. 8%), urine leak (4% *vs*. 11%), and incisional hernia (0% *vs*. 11%), were lower [13]. On the other hand, Packiam et al. [3] reported a 48% postoperative

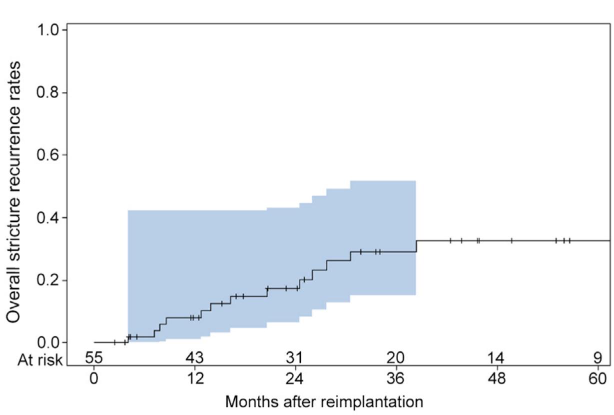

Figure 2 Overall stricture recurrence rates after robot-assisted uretero-enteric reimplantation.

complication rate in a large series of open revision patients, of which 12% were major. Gin et al. [25] compared postoperative complications in patients who underwent open and robot-assisted revisions. They found that patients (*n*=45) who underwent open revision had a 33% postoperative complication rate, whereas the complication rate was zero for the patients (*n*=5) with robot-assisted repair. On the other hand, an earlier report from our group that included six open and 16 robot-assisted revisions showed comparable perioperative outcomes [19]. Another study of eight patients who underwent RUER reported that five patients experienced postoperative complications. They concluded that revisions are associated with significant morbidity regardless of the operative approach [14]. The small sample, heterogeneity of studies, patient population, and experience of surgeons may affect complications' reporting and limit the generalizability and strengths of the available evidence. Another potential advantage of the robot-assisted approach is the shorter hospital stay as suggested by multiple studies [12,25,27].

In patients with UES, identifying the ureters and urinary diversion can be challenging due to intraperitoneal adhesions and periureteral fibrosis. The use of ICG, a non-toxic tracer, can aid in identifying the ureter and the site of the stricture. Two studies involving a total of 18 patients who underwent RUER with intraureteral injection of ICG reported that this approach provided quick and precise identification of the ureter and reduced the risk of vascular and bowel injuries [14,20]. However, Carrion et al. [13] did not observe any cases of conversion to open surgery or intraoperative complications, although only 17% of their patients received intraureteral ICG. Limitations of robot-assisted surgery include the difficulty of access in previously operated abdomens and lack of tactile feedback. However, Dangle and Abaza [9] suggested that patients who had undergone previous RARC instead of open RC may have reduced intraperitoneal adhesions, potentially facilitating uretero-enteric reimplantation.

Based on our findings, skilled surgical facilities have demonstrated the ability to perform robot-assisted reimplantation procedures for the treatment of UES following RC with both safety and efficacy, resulting in an acceptable and durable success. However, it should be noted that the current study has limitations, including a small sample size, retrospective design, and the lack of assessment of the effect of learning curve. Further research is needed to address the optimal approach and management of UES recurrence after initial treatment.

5. Conclusion

RUER is feasible with durable outcomes, but up to 24% of the cases that underwent RUER may develop recurrent UES and 22% may develop high-grade complications.

Author contributions

Study concept and design: Abdul Wasay Mahmood, Ahmed A. Hussein, Khurshid A. Guru.
Data acquisition: Grace Harrington, Abdul Wasay Mahmood, Zhe Jing.
Data analysis: Zhe Jing.
Video editing and narration: Abdul Wasay Mahmood, Ahmed A. Hussein.
Drafting of the manuscript: Abdul Wasay Mahmood, Zhe Jing, Ahmed A. Hussein.
Critical revision of the manuscript: Ahmed A. Hussein, Qiang Li, Khurshid A. Guru.

Conflicts of interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajur.2023.10.002.

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