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RESEARCH

A multicenter study of perioperative and functional outcomes of open vs. robot assisted uretero-enteric reimplantation after radical cystectomy

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Abstract

Introduction Open ureteroenteric reimplantation (OUER) of ureteroenteric strictures (UESs) is related to important morbidity. Robot-assisted ureteroenteric reimplantation (RUER) has been proposed to provide similar outcomes with lower morbidity. We aimed to compare perioperative and functional outcomes between RUER and OUER.

Methods A retrospective multicenter study of 80 patients, who underwent 82 ureteroenteric reimplantations (17 OUER vs 65 RUER) at 8 institutions between 2009–2021 for benign UESs after radical cystectomy. All the open procedures were performed by the same center in order to compare the robotic approach with a standardized technique. Data were reviewed for demographics, stricture characteristics, and perioperative outcomes. Complication and stricture recurrence rates were compared between both groups.

Results Among 82 reimplantations, 44 were left sided (54%) and 12 bilateral (14%). Median time from cystectomy to diagnosis of stricture was 6 months (range 3–18). Baseline characteristics (gender, age, BMI, side, type of urinary diversion and previous abdominal radiotherapy) were comparable between RUER and OUER groups, except for ASA score and rates of prior robotic cystectomy. The 30-day overall postoperative complication rate was 37% in RUER compared to 70.6% in OUER ($p=0.026$). Patients who underwent a RUER had statistically significant lower rate of intraoperative blood transfusion (0% vs 12%, $p=0.041$), urinary tract infection (12% vs 53%, $p<0.001$), bowel injury (0% vs 12%, $p=0.041$) and high-grade complications (Clavien III-IV) (4.6% vs 23.5%, $p=0.031$). RUER patients had shorter median length of hospital stay (3 days IQR[1–6] vs 6 IQR[3–9], $p=0.018$) and lower readmission rate (4.6% vs 29.4%, $p=0.008$). After a median follow-up of 23.5 months (8.7–43), 80% of RUER cases were stricture free compared to 90% of OUER ($p=0.42$).

Conclusions RUER achieved a success rate comparable to that of open revisions and may provide some advantages in terms of perioperative outcomes. Prospective and larger studies are warranted to prove its superiority compared to the standard open technique.

Keywords Robot-assisted ureteroenteric reimplantation · Ureteroenteric stricture · Radical cystectomy · Postoperative complications · Bladder cancer

Introduction

Bladder cancer is the most common urinary tract cancer after prostate cancer, and about 30% of these patients are diagnosed with muscle invasive bladder cancer or very high risk non muscle invasive tumor for which radical cystectomy with urinary diversion (RCUD) is the standard treatment. Nevertheless, RCUD is a complex procedure that has significant morbidity of 58% and mortality reaching 4.7% during the first 90 days [1]. Ureteroenteric stricture (UES) is one of the urinary complications after RCUD, with a reported incidence of 10–30% and occurring mainly during the first

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two years after surgery. This complication presents elevated morbidity, including increased risk of infection, renal function loss, readmissions and need for further procedures [2].

Management of UES presents a challenge, as the ideal treatment should offer durable results with less invasive and morbid procedures and minimal detriment on health-related quality of life, especially during the first months after cystectomy [3]. Advances in endourology have permitted the development of novel techniques for stricture treatment, including endoureterotomy, balloon dilation, or placement of stent. Nevertheless, these techniques are more successful for short and early strictures, and their patency rates are not durable compared to the open approach [2, 4]. On the other hand, open ureteroenteric reimplantation (OUER) is often challenging due to dense adhesions resulting from prior cystectomy or radiotherapy-induced fibrosis in patients and could pose significant morbidity risks. Currently, there is an emerging use of minimally invasive technique in the field of ureteral reconstruction, aiming to mitigate the morbidity associated with traditional open surgery. Multiple series have described the robotic approach technique showing favorable outcomes [5]. Herein, we aimed to compare the perioperative and functional outcomes of robotic and open approach in a multi-institutional series.

Patients and Methods

Study population

A retrospective multicenter study was conducted including 80 patients who underwent 82 ureteroenteric reimplantation (17 OUER vs. 65 RUER) for benign strictures after radical cystectomy. Data were collected from 8 high volume institutions between 2009 and 2021 after institution board review approval was obtained. All the open procedures were performed by the same center in order to compare the robotic approach with a standardized technique. Patients eligible for the study had a RCUD for muscle invasive bladder cancer or high risk non muscle invasive BC. The urinary diversion method included ileal conduit or orthotopic neobladder. Ureteroenteric anastomosis was performed using either Bricker or Wallace techniques. Patients who developed malignant strictures or extrinsic ureteral compression were excluded from the study. UEs were diagnosed using CT scan or pyelogram. Renal scintigraphy was used to confirm obstruction in case of no deterioration of renal function or urinary infection. Endoscopic management of the stricture, including ballon dilation or endoureterotomy, prior to definitive treatment was permitted. The open approach for ureteroenteric anastomosis is done through midline laparotomy, lysis of adhesions and the identification of the conduit or reservoir. Surgical technique for the robotic approach was described in a previous publication [5]. Intravenous ICG was utilized in some cases to identify healthy vascularized ureteral tissue.

Patients underwent postoperative surveillance with serial imaging and serum creatinine levels. Treatment failure (stricture recurrence) was defined as presence of either obstruction on renogram, need for renal drainage, surgical revision, or nephrectomy.

Study outcomes

Data were reviewed for demographics, stricture characteristics, and perioperative outcomes. Preoperative characteristics such as prior abdominal surgery, prior pelvic radiotherapy, perioperative chemotherapy, surgical approach for the RC and overall comorbidities, assessed by ASA (American Society of Anesthesiology) score, were compared between both groups. Primary endpoint was defined as recurrence of the stricture. Secondary endpoints encompassed other perioperative outcomes, including operative time, blood transfusions, length of stay, complication rates and 30 days readmissions.

Statistical analysis

Descriptive data was reported as median values with interquartile range for continuous variables and proportions for categorical ones. Comparisons were done using Man-Whitney U test and Fisher exact or chi-squared tests. Survival outcome for time to stricture recurrence was illustrated using Kaplan Meyer curve analysis. Statistical analyses were performed using SPSS version 29.0.2.0 (IBM corp., Armonk, NY, USA). All tests were 2-sided and statistical significance was considered for $p < 0.05$.

Results

Baseline characteristics

Patients' baseline characteristics are illustrated in Tables 1 and 2. Median age of included patients was 67.5 years old; 65 patients (79%) underwent robotic ureteral stricture repair (RUER) while 17 (21%) had open approach. No differences between both groups were found in terms of age, gender, BMI, prior treatments (pelvic surgery or radiation, neoadjuvant chemotherapy) or the type of urinary diversion. However, the robotic cohort had higher proportions of patients with ASA III scores as compared to the open group (47.7% vs. 29.4%, $p = 0.038$). Notably, rates of prior robotic radical

Table 1 Baseline clinical characteristics of open and robotic groups

Median (IQR), *N* (%)	Overall cohort (*n*=82)	Open UER (*n*=17)	Robotic UER (*n*=65)	*P* value
Age	67.5 (60–73)	69 (62–69)	67 (59.5–72.5)	0.58
Gender				
Male	71 (87%)	17 (100%)	54 (83%)	0.109
Female	11 (13%)	0	11 (17%)	
BMI	28 (25–32)	25(24–25)	28.3 (25-33.65)	0.155
ASA score				
I	7 (8.5%)	0	7 (10.8%)	0.038
II	39 (47.6%)	12 (70.6%)	27 (41.5%)	
III	36 (44%)	5 (29.4%)	31 (47.7%)	
Prior abdominal surgery	38 (46%)	8 (47%)	30 (46%)	1
Prior pelvic radiotherapy	5 (6.1%)	0	5 (7.7%)	0.57
NAC	28 (35.4%)	2 (13.3%)	26 (40%)	0.071
Cystectomy approach				
Open	20 (24.4%)	10 (58.8%)	10 (15.4%)	<0.001
Lap	5 (6.1%)	3(17.6%)	2 (3.1%)	
Robotic	57 (69.5%)	4 (23.5%)	53 (81.5%)	
Urinary diversion				
Ileal conduit	56 (68%)	9 (53%)	47 (72%)	0.15
Neobladder	26 (32%)	8 (47%)	18 (28%)	
Type of neobladder				
Studer	12 (46.2%)	2 (25%)	10 (55.6%)	0.49
Padovana	6 (23.1%)	3 (37.5%)	3 (16.7%)	
Hautmann	8 (30.8%)	3 (37.5%)	5 (27.8%)	
Urinary diversion approach*				
IC	49(86%)	4 (100%)	45 (84.9%)	1
EC	8 (14%)	0	8 (15.1%)	
Creatinine	1.15 (0.88–1.5)	1.38 (1.16–1.52)	1.07 (0.85–1.47)	0.027
GFR	64 (46–86)	54 (46–65)	70.9 (46.5–88.3)	0.141
Overall death	11 (13.4%)	3 (17.6%)	8 (12.3%)	0.69
Follow up since cystectomy	46.5 (24.25–74.75)	69 (45–79)	38 (21.5–69)	0.029

ASA: American Society of Anesthesiology. BMI: body mass index. EC: extracorporeal. GFR: glomerular filtration rate. IC: intracorporeal. NAC: neoadjuvant chemotherapy. UD: urinary diversion

* Only robot-assisted radical cystectomies were considered

Table 2 Preoperative characteristics of ureteroenteric strictures of open vs. robotic UER

Median (IQR), *N* (%)	Overall (*n*=82)	Open UER (*n*=17)	Robotic UER (*n*=65)	*P* value
Reimplantation side				
Right	26 (31.7%)	3 (17.6%)	23 (35.4%)	0.103
Left	44 (53.7%)	9 (53%)	35 (53.8%)	
Bilateral	12 (14.6%)	5 (29.4%)	7 (10.8%)	
Time to stricture (months)	6 (3–18)	13 (2.5–51.5)	5 (3-11.5)	0.376
Preoperative urinary drainage	77 (93.9%)	13 (76.5%)	64 (98.5%)	0.006
Nephrostomy	62 (80.5%)	13 (100%)	49 (76.6%)	0.061
Ureteral catheter	15 (19.5%)	0	15 (23.4%)	
Prior endoscopic procedure	31 (37.8%)	3 (17.6%)	28 (43%)	0.09

cystectomy were significantly higher in patients who eventually had robotic repair (81% vs. 23%, $p<0.001$).

Both groups had similar rates of left sided strictures (53%), while the proportion of bilateral strictures were higher in the open group (29% vs. 10.8%). No statistically significant differences were found regarding time to stricture development after cystectomy in both groups (13 months in open vs. 5 months in robotic group, $p=0.37$). 43% of the patients in the robotic group had a failed attempted endoscopic procedure as compared to 17.6% in the open group ($p=0.09$).

Intra- and post-operative outcomes

Table 3 summarizes perioperative and outcomes of both groups. Median operative time was 140 (IQR 101–207) minutes for OUER and 195 (IQR 168–260) minutes in the robotic group ($p=0.43$). No statistically significant differences in the rates of intraoperative complications were found. However, none of the patients in the robotic group received intraoperative blood transfusion compared to 11.8% in the open one ($p=0.041$). Moreover, open group had high overall postoperative complications (70.6% vs. 37%, $p=0.026$). The rates of postoperative infection and bowel injury were statistically lower in the robotic cohort (12.3% and 0%, vs. 52.9% and 11.8% in the open cohort, $p<0.001$ and 0.041 respectively). Overall, high grade complications (Clavien-Dindo III-IV) were more frequent in the open cohort (24% vs. 5%, $p=0.031$).

Notably, patients who underwent robotic repair had shorter length of stay (3 vs. 6 days, $p=0.018$) and less rates re-admission rates at 30 days after surgery (4.6% vs. 29%, $p=0.008$).

As for the main endpoint, both groups were comparable in terms of failure rate (stricture recurrence) (11.8% for OUER vs. 16.9% for RUER, $p=1.00$). No differences were found regarding time to recurrence of stricture after reimplantation (18 months vs. 13 months for open and robotic approaches, respectively). After a median follow-up of 23.5 months (8.7–43), 80% of RUER cases were stricture free compared to 90% of OUER ($p=0.4.$) (Fig. 1).

Table 3 Perioperative outcomes of open vs. robotic ureteroenteric stricture reimplantation

Median (IQR), *N* (%)	Overall (*n* = 82)	Open UER (*n* = 17)	Robotic UER (*n* = 65)	*P* value
Operative time (min)	183 (140–245)	140 (101–207)	195 (168–260)	0.431
Intra operative complications	3 (3.7%)	2 (11.8%)	1 (1.5%)	0.107
Intraoperative blood transfusion	2 (2.4%)	2 (11.8%)	0	0.041
30 day-Post operative complications	31 (37.8%)	12 (70.6%)	24 (37%)	0.026
Blood transfusion	3 (3.7%)	0	3 (4.6%)	1
UTI	17 (20.7%)	9 (52.9%)	8 (12.3%)	<0.001
Wound infection	2 (2.4%)	1 (5.9%)	1 (1.5%)	0.37
Hernia	8 (9.8%)	1 (5.9%)	7 (10.8%)	1
Urine leak	8 (9.8%)	1 (5.9%)	7 (10.8%)	1
Bowel injury	2 (2.4%)	2 (11.8%)	0	0.041
Ileus	10 (12.2%)	4 (23.5%)	6 (9.2%)	0.204
Clavien Dindo				
0	46 (56.1%)	5 (29.4%)	41 (63.1%)	0.031
I-II	29 (35.4%)	8 (47.1%)	21 (32.3%)	
III-IV	7 (8.5%)	4 (23.5%)	3 (4.6%)	
Length of stay (days)	4 (2–6)	6 (3–9)	3 (1–6)	0.018
30 days Readmissions	8 (9.8%)	5 (29.4%)	3 (4.6%)	0.008
30 day creatinine	1.35 (1.05-1-87)	1.34 (1.06–1.9)	1.35 (1.03–1.82)	0.955
30 day GFR	50.5 (36.8-64-7)	56 (32–75)	50 (37–64)	1
Overall success	69 (84.1%)	15 (88.2%)	54 (83.1%)	1
Urinary drainage after recurrence	10 (12.2%)	2 (11.8%)	8 (12.3%)	1
Time to failure	13 (4–32)	18 (4–18)	13 (4–30)	1
Follow up since reimplant	23.5 (8.75-43)	37 (14.5–43.5)	19 (8.5–42.5)	0.102

Discussion

UES is a challenging complication after cystectomy that may require multiple interventions and inflicts directly on patient´s quality of life. It may accelerate worsening of kidney function and end up in total loss in 10% of these patients are reported in previous series [6]. Several factors have been associated with the development of benign UES; the modifiable factors of interest are the ones related to the surgical technique during radical cystectomy. Anastomosis technique, use of intraoperative stent to bridge the anastomosis, type of urinary diversion, and surgical approach are factors that have been investigated [7, 8].

Multiple strategies have been proposed for the management of the UES, depending on the onset time, length of the stricture, perioperative characteristics and radiologic features [9]. Currently, endoscopic treatment is the preferred initial treatment option. However, strictures longer than 1 cm are more challenging to treat endoscopically. In these cases, an upfront surgical revision is the preferred option. Nevertheless, the real-world practice differs as multiple factors influence decision making for treatment strategy, and a non-negligible underreported proportion of patients may undergo repetitive endourologic procedures or permanent stents exchange. In our cohort, 37% underwent prior endoscopic procedure. Brandt et al. [6] reported a median number of 2 attempted interventions per patient. Factors that delay or overturn definitive treatment include patient´s comorbidity, borderline kidney function, and morbidity of open approach. In our cohort, open repair had 24% of high grade complications, in line with prior published series 15–30% [10]. On the other hand, the robotic approach presents an alternative option, with fewer high-grade complication and faster postoperative recovery. These findings, along with outcomes published in prior descriptive studies of RUER [5, 11], may encourage towards earlier and upfront repair of UE stricture including, but not limited to, patients with higher comorbidities and suboptimal kidney function. In fact, in our cohort, the robotic group had higher comorbidities as evaluated by ASA score. The surgical approach for the radical cystectomy is also a factor to consider in assessing the outcomes of re-do surgeries. Open procedures are associated with more abdominal adhesions and peritoneal reaction. Moreover, open urinary diversion may require more ureteral mobilization and dissection [12]. Although these concepts are more experience-based statements rather than evidence-based, robotic approach for RC could be less traumatic and could facilitate future re-interventions. In our cohort, patients with robotic re-implants had a higher rate of prior RARC.

One of the critical steps in the preoperative management of UESs is ureteral resting. Nowadays, more evidence discourages any manipulation of the UE anastomosis prior to surgery to reduce inflammation, infection and fibrosis [10, 13]. This includes use of nephroureteral stent or even prior endoscopic procedures. In our cohort, the robotic group had higher proportion of preoperative drainage, but 23% had a ureteral stent placed and 43% had a prior endoscopic intervention. Therefore, the comparison of failure outcomes should be interpreted with caution as these factors could compromise the ureteral reimplantation.

There is a relative paucity of data related to robot-assisted ureteral reimplantation for benign stricture after radical

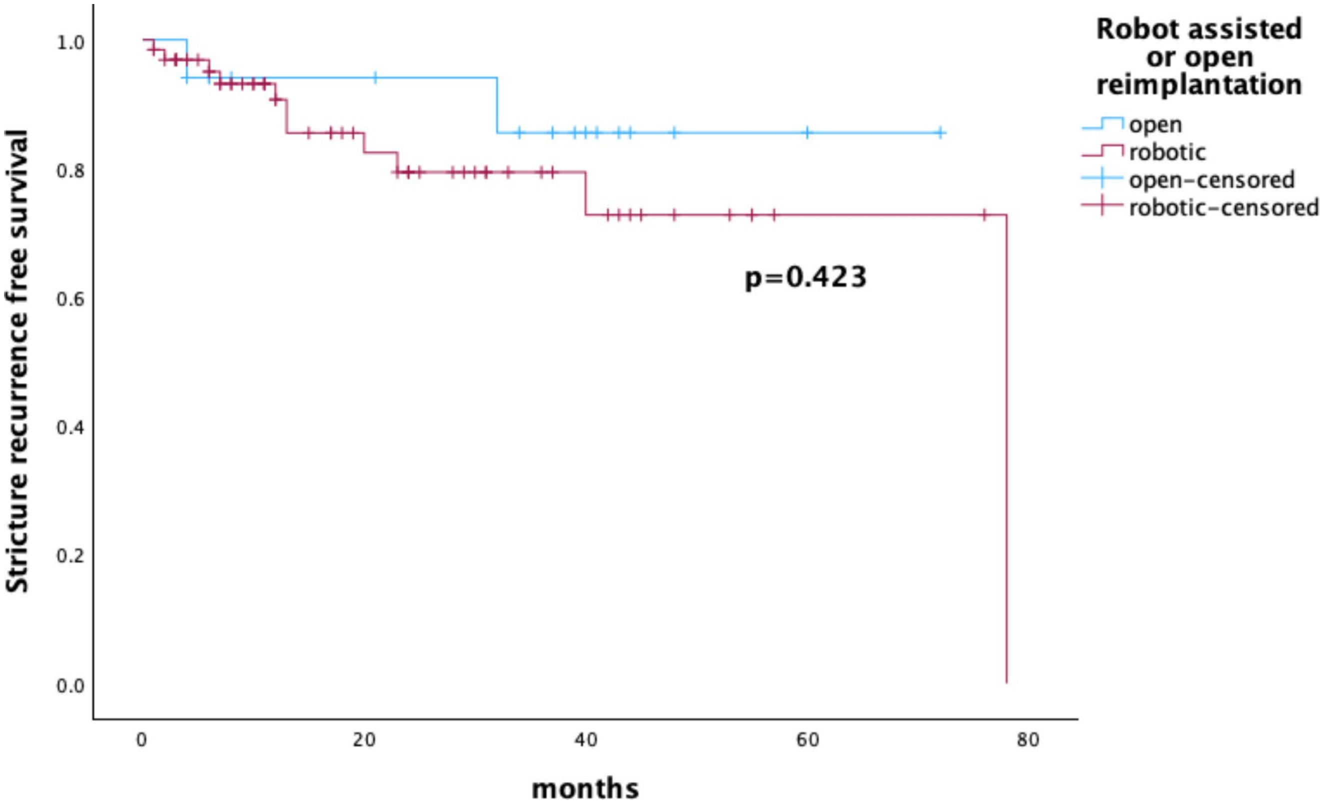

Fig. 1 Kaplan Meier Analysis of stricture recurrence free survival, stratified by surgical approach (open vs. robotic repair)

cystectomy [11, 14]. Most studies were limited to single center descriptive analysis [8, 15] and with smaller cohorts. Plenty of published data have explored the benefit of minimally invasive approach in ureteral reconstruction, with evidence supporting robotic techniques in reducing surgical morbidity [16]. Robotic approach allows the use of ICG to test the distal ureteral vascularity; however, no prospective studies are done to confirm its benefit in reducing stricture rate [17]. Furthermore, the use of novel techniques such as single port is gaining popularity, especially when operating in tight targeted surgical fields or in case of abdominal adhesions [18].

To our knowledge, this is the largest series of patients with uretero-enteric strictures comparing open and robotic approach. However, this study has several limitations. It is a retrospective non controlled study. In addition, both groups were heterogenous in terms of preoperative characteristics, mainly regarding the approach of the radical cystectomy, which would result in a selection bias. Besides, both cohorts are not contemporary, and the robotic cohort represents the initial experience of this technique despite being performed at high level academic centers. All the open procedures were performed by the same center using high-volume open surgeons who used the same standardized technique in order to avoid further biases. However, we understand the difficulty in designing a randomized or prospective study in this field, especially with the increased expansion of robotic radical cystectomy. Further studies with longer follow-up periods are warranted.

Conclusion

RUER achieved a success rate comparable to that of open revisions and may provide some advantages in terms of perioperative outcomes. Prospective and larger studies are warranted to prove its superiority compared to the standard open technique.

Author contributions Albert Carrion had full access to all the data in the study and takes responsibility for the integrity of the dataand the accuracy of the data analysis. Study concept and design: T.A., A.C., C.R. Acquisition of data: T.A., M.M, A.H., JM.G., R.A., U.I., R.L., Z.L., M.L., F.L., F.V. A.B.Analysis and interpretation of data: T.A., A.C., E.T. Drafting of the manuscript: T.A., A.C. Preparation of figures and tables: T.A., A.C., ET. Critical revision of the manuscript f: T.A., A.C., D.E., K.G., AA.H., J.P., R.A. Statistical analysis: T.A., A.C., C.R.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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