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ORIGINAL PAPER

Robot-assisted segmental ureterectomy with psoas hitch ureteral reimplantation: Oncological, functional and perioperative outcomes of case series of a single centre

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Summary

Introduction: *According to the Urology guidelines, in selected cases of distal upper tract urothelial carcinoma (UTUC) segmental ureterectomy (SU) can be offered. There is no consensus in the surgical technique of preference. Robot-assisted SU could be an option to overcome all the limitations of open and laparoscopic techniques. We describe our first experience of robot assisted SU with psoas hitch ureteral reimplantation (RAPHUR).*

Materials and methods: *11 patients underwent RAPHUR for distal UTUC between 2013 and 2017 in a single centre. Pre-, intra-, and postoperative outcomes were assessed. Conventional imaging was performed after 1, 3, 6 months and 1 year from surgery as follow up protocol. We retrospectively evaluated the technical feasibility, oncological and functional outcomes.*

Results: *Median age was 71 years (57-91). The median length of the ureteral defect was 23 mm (10-40). Median preoperative creatinine level was 1.22 mg/dl (0.7-1.85) and median eGFR was 57.5 ml/min/1.73m^2 (31-80). Five (45.5%) patients were symptomatic and 7 (63.6%) had hydronephrosis. Median operative time was 185 min (120-240), with a median blood loss of 100 ml (50-300). No case required conversion to open surgery. Overall, only 1 (9%) patient developed Clavien Dindo ≥ 3 postoperative complications. Average hospital stay was 7 (2-9) days. Mean postoperative creatinine was 1.05 mg/dl (0.8-1.85) and mean postoperative eGFR was 72 (36-83). During a median follow up time of 25.5 months (12-53), 4 (36.4%) patients experienced recurrence of urothelial cancer at conventional imaging follow up and 2 (18.2%) died due to its progression.*

Conclusions: *In our initial experience RAPHUR can be proposed to selected cases of distal ureteral carcinoma with optimal perioperative and functional outcomes. However, cancer control may be undermined compared to nephroureterectomy. Thus, further prospective studies are needed to confirm our findings.*

KEY WORDS: Robotics; Segmental ureterectomy; Ureter; Urothelial carcinoma; Psoas hitch reimplantation.

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INTRODUCTION

Open radical nephroureterectomy represents the treatment option for the management of distal *upper tract urothelial carcinoma* (UTUC) (1, 2). However, segmental ureterectomy (SU) with ureteral reimplantation could be an option in selected cases with low grade distal ureteral tumour or impaired renal function and high grade distal UTUC (2-4). In these cases, the ureteral reimplantation became challenging due to the reduction of length of the ureter necessary for oncological radicality. The advent of robotic surgery with its 3-D magnified view, 7 degree of freedom and steadiness of instruments and camera, allowed to overcome the limitations of the conventional laparoscopic and open approaches for the reconstruction. Thank to this more complex robotic tension-free ureteral reimplantation procedures have been described, such as *Psoas Hitch* (PH) techniques (5).

The feasibility and safety surgical profile of the robot-assisted SU with ureteral reimplantation was reported by several authors (6-12). However, some of these studies focused on surgical technique and functional outcomes concentrating patients with heterogeneous aetiology and short follow up. While other studies focused on oncologic outcomes with no consistent on surgical technique considered. Under this light, we aim to assess intra-, peri-, postoperative and oncological outcomes of a single centre series of patients with distal UTUC, exclusively treated with RAPHUR tension-free reimplantation, with a minimum follow-up of one year. The safety of the procedure was evaluated in agreement with the standardized methodology to report complications proposed by *European Association of Urology* (EAU) guidelines (13).

MATERIALS AND METHODS

Study population

We retrospectively analyzed 11 patients with distal UTUC treated with RAPHUR between October 2013 and 2017. All patients presented non-metastatic disease. All surgeries were performed by two surgeons with extensive experience in robotic surgery. The study protocol was approved by the institutions' medical ethics committees and all patients provided informed consent.

Surgical techniques of Robot-assisted segmental ureterectomy with Psoas Hitch ureteral reimplantation

The ureter is identified at the bifurcation of the common

No conflict of interest declared.

iliac artery and cautiously mobilized caudally until the identification of the disease segment. After mobilization of the bladder, the segment of the ureter involved by cancer is clipped before its dissection in order to avoid tumor seeding, then the disease segment is dissected and sent for frozen section. A formal bladder cuff is excised for oncological radicality and a regional lymph nodes dissection is also performed. The ureter is spatulated anteriorly for 2 cm. To perform a PH, a 2-0 non-absorbable suture is used to fix the external part of the ipsilateral dome of the bladder to the psoas muscle and its tendon. This allows to perform a tension-free reimplantation and to provide a strong and durable fixation with a low risk of genito-femoral nerve and iliac vessel injury (14). A longitudinal incision of 3-4 cm is made at the level of the bladder dome along the anterolateral surface. The ureter is spatulated and inserted inside a sub-mucosal tunnel developed at the cranial part of the bladder. Then a mucosa to mucosa anastomosis is performed using 4-0 Monocryl suture in a running way. A double J stent is placed in a retrograde fashion using a guide wire. Thereafter, the bladder is closed with 30 cm 2-0 V-lock suture in double layer.

Variable definition and follow-up

Preoperative variables consisted of age at surgery, gender, comorbid conditions (Charlson comorbidity index) (15), previous abdominal surgery, preoperative haematuria, preoperative hydronephrosis at *computer tomography* (CT) scan, side of the disease, length of the ureteral disease at preoperative CT scan, preoperative symptoms, preoperative serum creatinine and *estimated glomerular filtration rate* (eGFR). Follow-up consisted of control visit at 1, 6 months and then annually with consecutive serum creatinine, eGFR analysis and clinical evaluation of symptoms.

Conventional imaging such as abdominal CT scan, abdominal ultrasound and cystoscopy were performed to exclude cancer recurrence after 1 month, 3, 6 months and yearly or in case of lower urinary tract symptoms and haematuria after surgery.

Study outcomes and statistical analysis

Intraoperative outcomes (operative time, blood loss, intraoperative complications) were assessed and reported according to Satava classification, perioperative outcomes (length of stay, urinary catheter and stent removal) were also assessed (16). Intermediate-term postoperative functional outcomes (postoperative serum creatinine and eGFR), hydronephrosis at conventional imaging and presence of symptoms were also evaluated.

Postoperative complications were collected according to *Clavien-Dindo* (CD) classification system, moreover the quality criteria of accuracy recommended by the EAU guidelines on reporting and grading of complications were fulfilled (Supplementary Table 1) (13).

90-day readmission rate was also evaluated. Pathological reports were assessed. Cancer recurrence and mortality was assessed.

Medians and ranges, as well as frequencies and proportions were reported for continuous or categorical variables, respectively. For all statistical analyses, SPS software environment for statistical computing was used.

Table 1.
Baseline characteristics.

Variables	Overall (n = 11)
Age (yr), median (range)	71 (57-91)
Gender, n (%)	
· Male	9 (81.8)
· Female	2 (18.2)
Charlson comorbidity index, n (%)	
0	2 (18.2)
1	3 (27.3)
≥ 2	6 (54.5)
Abdomen previous surgery, n (%)	9 (81.8)
Aetiology, n (%)	
· Low-stage urothelial tumour	6 (54.5)
· High-stage urothelial tumour	5 (45.5)
Side, n (%)	
· Left	8 (72.7)
· Right	3 (27.3)
Length disease (mm), median (range)	23 (10-40)
Preoperative hydronephrosis at CT scan, n (%)	7 (63.6)
Preoperative haematuria, n (%)	4 (36.4)
Pre-operative symptoms, n (%)	
· Yes	5 (45.5)
· No	6 (54.5)

Table 2.
Intraoperative and perioperative outcomes.
Post-operative outcomes.

Intra and perioperative outcomes	
Variables	Overall (n = 11)
Operating time (min), median (range)	185 (120-240)
Blood loss (ml), median (range)	100 (50-300)
Intra- operative complications, n (%)	0
Length of stay (days), median (range)	7 (2-9)
Catheter removal (days), median (range)	10 (2-20)
Stent removal (days), median (range)	21 (15-44)
Post-operative outcomes	
Variables	Overall (n = 11)
90-day postoperative complications Clavien ≥ II, n (%)	2 (18.2)
Post-operative Creatinine (mg/dL), median (range)	1.05 (0.8-1.85)
Post-operative eGFR (mL/min/1.73 m^2), median (range)	72 (36-83)
Post-operative hydronephrosis, n (%)	1 (9)
Readmission, n (%)	1 (9)

Table 3.
Summary of 90 day postoperative complications.

Overall complications (n = 4) 36.4%		
Category	**Type of complication**	**N**
Clavien Dindo I	Prolonged catheterization due to leakage at cystography	1
(n = 3, 27.3%)	Transitory sensory loss of the leg (femoral or saphenous nerve damage)	2
Clavien Dindo III	IIIa: Lymphocele* treated with percutaneous drainage	1**
(n = 1, 9%)		

**Lymphocele was defined as any clearly definable fluid collection and was considered clinically significant when requiring treatment. Ultrasound examination was used to detect lymphoceles. ** Patient readmitted.*

RESULTS

All the descriptive characteristics of the study population are recorded in Table 1. Median follow-up was 25.5 months (12-53). Nine (81.8%) patients were male and 2

(18.2%) female. Disease side was right in 3 (27.3%) patients and left in 8 (72.2%). Median age was 71 years (57-91). The median length of the ureteral defect was 22.6 mm (10-40 mm). Median pre-operative creatinine level was 1.2 mg/dl (0.72-1.50) and median estimated glomerular filtration rate (eGFR) was 58,00 ml/min/1.73m^2 (31-80). 5 (45.5%) patients were symptomatic, 4 (36.4%) presented macrohematuria and 3 (27.3%) had ipsilateral flank pain. 7 (63.3%) had preoperative hydronephrosis at abdomen CT scan. Median operative time was 185 min (120-240), with a median blood loss of 100 ml (50-300) (Table 2). All surgeries were completed without conversion to open technique. No intraoperative complications were recorded. Overall, 1 (9%) of the patients developed a postoperative complication classified with Clavien Dindo ≥ 3, the patient developed a lymphocele after few weeks from surgery and he was readmitted to the hospital to insert a percutaneous drainage through radiological intervention (Table 3). Median hospital stay was 7 (2-9) days. The VAS score was optimal (0) at discharge moment. Bladder catheter was removed after cystogram and with a median of 10 (2-20) days while the double J ureteral stent was removed after a median of 21 (15-44) days. Median postoperative creatinine was 1.05 mg/dl (0.8-1.85) and median postoperative eGFR was 72 ml/min/1.73m^2 (36-83). Pathological stage was pTa in 4 (36,4%) cases, pT1 in 4 (36.4%) cases, pT2 in 1 (9%) case and pT3 in 2 (18.2%) cases (Table 4). Only 1 (9%) patient had positive lymph nodes after surgery (pT2 N2). No positive surgical margins were found. During a median follow up time of 25.5 (12-53) months, 4 (36.4%) patients experienced recurrence of urothelial cancer at conventional imaging or cystoscopy. Three (27.3%) of these cases experienced intravesical cancer recurrence, and the patients underwent trans-urethral resection. Adjuvant chemotherapy was performed on 3 (27.3%) patients. Two (18.2%) patients died due to its progression; 1 (9%) patient died due to cardiological problems after 1 year from surgery.

Table 4.
Pathological report and oncologic outcomes.

Pathological report		
pTa n (%)	G1 G2	3 (27.3) 1 (9)
pT1 n (%)	G2 G3	2 (18.2) 2 (18.2)
pT2 n (%)	G3	1 (9)
pT3 n (%)	G3	2 (18.2)
N0 n (%)	10 (89)	
N1 n (%)	0	
N2 n (%)	1 (9)	
Positive surgical margins	0	
Oncologic outcomes		
Cancer recurrence n (%)	4 (36.4)	
Adjuvant chemotherapy n (%)	3 (27.3)	
Trans-urethral resection n (%)	3 (27.3)	
Mortality n (%)	2 (18.2)	

Discussion

The *International Associations of Urology* identified open radical nephroureterectomy as the gold standard treatment for UTUC (1). However, evidences showed how the management of UTUC should be individualized to tumor's risk and patient's characteristics. In this scenario the kidney sparing surgery could be an option in selected cases with low grade distal ureteral tumor or impaired renal function and high grade distal UTUC, thus SU gives the similar oncological outcomes with the advantage of renal function preservation (2-4). In these cases, the ureteral reimplantation became challenging due to the reduction of length of the ureter necessary for oncological radicality. With the advent of robotic surgery, and the advantages it brings, its use for UTUC management is increasingly widespread worldwide. Our first experience of distal UTUC treated with robot assisted SU and subsequent psoas hitch ureteral reimplantation provides new data confirming the feasibility and safety profile of this procedure in selected cases. Furthermore we fulfilled the 14-item standardized reporting tool for postoperative complications as supported by EAU guidelines (13).
Unlike the study of *Campi et al.* on robotic SU and robotic nephroureterectomy our study standardized the surgical

Supplementary Table 1.
Postoperative complications: quality criteria for accurate and comprehensive reporting of surgical outcome.

Criteria	
1. Define the method of accruing data*	Retrospective data collection based on chart review and patient interview
2. Define who collected the data	Data were collected by dedicated data manager
3. Indicate the duration of follow-up*	90 d
4. Include outpatient information*	Outpatient information were collected
5. Include mortality data and causes of death*	Mortality and cause of death were collected
6. Include definitions of complications*	Complications were defined as any deviation from the ideal postoperative course
7. Define procedure-specific complications*	Procedure-specific complications were defined and collected
8. Report intraoperative and postoperative complications separately	Intraoperative and postoperative complications were reported separately
9. Use a severity grading system for postoperative complications*	The Clavien-Dindo system was used
10. Postoperative complications should be presented in a table either by grade or by complication type	Postoperative complications were presented in a table by complication type
11. Include risk factors*	The Charlson Comorbidity-index was prospectively collected for all patients.
12. Include readmissions and causes	Data on readmissions were collected
13. Include reoperations, types and causes	Data on reoperation, types and causes were collected
14. Include the percentage of patients lost to follow-up	0 patients were lost to 90d follow up

**Outcomes in common with the Martin Criteria.*

Table 5.
Series on distal ureteral robotic reimplantation for UTUC.

Study	Procedure	Centre (n)	Overall number of patients (n)	Number of patients treated for distal UTUC	Length of the stricture mm (median or mean)	TCC Recurrence rate (%)	Operative time (min)	Blood loss (ml)	LOS (days)	Follow up (months)	Stent time (days)	Catheter removal (days)	Post-operative complications rate (%)	Post-operative symptoms evaluated with VAS score	Postoperative functional outcomes (mean serum creatinine and eGFR)	Hydronephrosis and/or ureteral stenosis at postoperative imaging
Campi et al. 2019	RNU, RAPHUR, Ureteroneocystostomy	Multicentre (3), 8 surgeons	81 (robotic): 15 (ureterectomy) 66 (nephroureterectomy)	10: 4 (RAPHUR)	17 (10-46)	46,7% of 15 pts 26,7% intravescical 20% ipsilateral ureter	Median: 140 (110-220)	Median: 180 (100-210)	Median: 4 (3-7)	Median: 21 (14-38)	Not reported	Not reported	60, overall	Not reported	ΔeGFR: -1	Not reported
McClain et al. 2012	Ureteroneocystostomy, RAPHUR, Ureteroureterostomy	Single centre	6 (robotic)	4: 3B (RAPHUR)	Not reported	16.7	Mean: 268.5 (188-400)	Mean: 72.5 (< 30-150)	Mean: 1.8 (1-2)	Mean: 33 (28-39)	28-56	7 to 10	16.6	Not reported	Not reported	Not reported
Fifer et al. 2014	RAUR, RAPHUR, RABFUR, end-to end anastomosis, Ureterolysis, Ureterolithotomy	Single centre	55 (robotic): 35 RAPHUR	10	Not reported	40% of 10 pts	Median: 224 (184-254) of 10 pts	Median: 50 (25-100) overall	Mean 1.6 overall	Median: 6 overall	Not reported	Not reported	3.6 overall	Not reported	Not reported	3 pts (hydronephrosis)
Elsamra et al. 2014	Ureteroneocystostomy, RAPHUR, RABFUR	Single centre 5 surgeons	20 (robotic): 6 (RAPHUR) 85 (laparoscopic) 25 (open)	6 (robotic)	Not reported	Not reported	Median: 236 (219-305) of 20 robotic	Median: 100 (63-200) of 20 robotic	Median: 2 (2-4) of 20 robotic	Median: 4 of 20 robotic	Median: 38 (29-45) of 20 robotic	Median: 8 (8-10) of 20 robotic	Not reported (9,5% of major complications)	Not reported	Δ Creatinine median: 0	Not reported
Musch et al 2013	RAPHUR, RABFUR, ureteral end-to-end anastomosis, Lich Gregoir, ureteroneocystostomy	Single centre 3 surgeons	16	4: 2 (RAPHUR)	Not reported	25% of 4 pts	Median: 250 (153-320) Median: 320 (218-320) lymphadenectomy)	Not reported	Median: 7.5 (5-35) overall	Median: 11 overall	Not reported	Not reported	75 overall, 100 of 4 pts	Not reported	Not reported	Not reported
Hemal et al. 2010	RAUR, RAPHUR, endo-to end anastomosis, (nephroureterectomies and nephroureterectomies)	Multicentre (2)	44: 18 (distal) 12 (proximal) 10 (ablative) 4 (miscellaneous)	5	Not reported	Not reported	Mean: 190 (160-240) of 5 pts	Mean: 100 of 5 pts	Mean 3,5 of 5 pts	Mean: 10 of 5 pts	Not reported	Not reported	4.5 overall	Not reported	Not reported	0 (radionuclide scintigraphy)
Schimpf et al. 2009	RAUR, RAPHUR, RABFUR	Single centre	11	6: 1 (RAPHUR)	Not reported	Not reported	Mean and median: 189 (145-240) overall	Mean: 81 (25-300) overall	Mean: 2.4 Median 2 (1-5) overall	Median: 12 (1-53 range) overall	42 days	Range (7-10)	27 overall	Not reported	Not reported	Not reported

procedure of ureteral reimplantation after SU (9). Indeed, they presented 15 patients who underwent robot-assisted SU, out of them 5 patients were treated with primary ureteroureterostomy, 4 with ureteroneocystostomy, 4 with psoas hitch ureteroneocystostomy and 2 were tumor of the pelvis treated with robotic pyeloplasty (9). This factor generalizes the feasibility and safety results of the surgical technique but confirms that SU can be a valid option in terms of oncological outcomes. Previously *McClain* collected a series of robotic SU with long follow up, demonstrating the efficacious and durable management of robotic surgery on distal UTUC, but they reported only 6 patients treated with different procedures (10). A direct comparison with other available robotic series on distal ureteral reimplantation is difficult because these studies are clustering outcomes for different ureteral reimplantation techniques and patients with different etiological disease, considering also other pathologies besides urothelial carcinoma (Table 5) (6-8). Furthermore, there is a lack of data in terms of postoperative evaluation (i.e.: symptoms evaluation, functional outcomes, radiologic imaging follow-up, oncological outcomes) which does not allow an adequate analysis of use of robotic platform in case of ureteral cancer. Our study, with a minimum of one year follow-up and complete postoperative data, aims to validate the use of SU exclusively with RAPHUR techniques for distal UTUC, supporting its feasibility, safety and reproducibility. Our results were reported below. First of all, we reported good operative and perioperative outcomes: the median OT, blood loss and LOS were 185 min (range: 120-240 min), 100 ml (range: 50-300 ml) and 7 days (range: 2-9) respectively; median catheter and DJ stent removal were respectively 10 (range: 2-20 days) and 21 days (range: 15-44 days). These findings cannot fairly be compared with other available robotic series given the heterogeneity of the ureteral reimplantation techniques included and the clustering of the outcomes reported (Table 5). Second, we fulfilled the standardized methodology recommended by EAU guidelines on grading and reporting postoperative complications (13) (Supplementary Table 1). This confirms high reliability of data report on postoperative complications. The overall rate of complications was 36.4%. Of these, only one complication requiring additional percutaneous intervention (CD IIIa) for lymphocele drainage. The safety profile of RAPHUR techniques is also supported by the absence of intraoperative complication.

All postoperative outcomes (i.e. symptoms, functional outcomes and oncological outcomes) were assessed. Renal function improved with a $\Delta = 0.2$ in median serum creatinine and with median eGFR becoming 72 ml/min/1.73 m^2 (range: 36-83) from 58. The VAS score at discharge and last follow-up were acceptable. All these findings strongly confirm that the robotic approach for distal UTUC is feasible and offers an excellent alternative to open surgery in terms of functional and oncologic outcomes with the benefits of minimally invasive surgery.

To the best of our knowledge, our study represents the largest series available so far (considering the rarity of the condition) from a single robotic high-volume centre of robot-assisted ureteral reimplantation for distal UTUC exclusively treated with RAPHUR (Table 5).

Despite these results, our study has several limitations. The retrospective nature of the current analysis and the small sample size, considering the rarity of the condition and the exclusivity of the treatment, are the main limitations. Furthermore, there is a lack of a control group treated with open or laparoscopic approach for direct comparison on surgical terms, or a control group of nephroureterectomy for comparison on oncological outcomes. However, it must be considered that the main goal of the current study was to report these refined robotic surgical techniques for distal UTUC with psoas hitch ureteral reimplantation.

Conclusions

In our experience RAPHUR can be proposed to selected cases of distal ureteral carcinoma of low-grade disease or in patients with impaired renal function and high-grade disease with optimal perioperative, functional and oncologic outcomes. However, cancer control may be undermined compared to nephroureterectomy. Thus, further prospective studies are needed to confirm our findings.

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