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Post-kidney transplant robot-assisted laparoscopic ureteral (donor-receiver) anastomosis for kidney graft reflux or stricture disease

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Abstract

Objectives: To report our experience with robot-assisted ureteral anastomosis for kidney graft. Kidney graft complex ureteral strictures and/or symptomatic vesico-ureteral reflux may require complex reconstruction. This is classically done through an open surgical access, which adds to the morbidity of kidney transplantation. The da Vinci robot enables to perform complex laparoscopic procedures, and may hence be used for such reconstructions.

Methods: we retrospectively reviewed all patients undergoing robotic surgical revision for stricture or reflux disease over a three years period. Contemporary patients who underwent open surgery were used as a control group.

Results: 10 patients underwent a robotic attempt, of which 4 needed conversion to open surgery. Seven patients underwent an open surgery. Pre-operative demographics were similar in both groups. Median operative time was 293 min, with a shorter operative time in the open group. The group of patients who could be completed robotically had a significant lower post-operative length of stay (5 vs 9 days), quicker return to normal food intake (post-operative day 1 vs 3) and quicker control of pain without opiates (post-operative day 1 vs 4) than the converted or open group. Morbidity was comparable with one late Clavien IIIb complication in each sub-group (open, converted and robotic group). After a median follow-up of 43 months, renal function was stable and there were no recurrent graft infections.

Conclusions: Robotic ureteral reconstruction for kidney graft patients is feasible and efficient, and offers the classical advantages of minimally-invasive surgery with outcomes comparable to open series.

Introduction

Urologic complications represent a significant mid-term morbidity for patients receiving a kidney graft. Of these, anastomotic strictures and vesico-ureteral reflux are frequently encountered. Ureteral obstruction is reported in 3-6 % of series[1,2], whereas the prevalence of reflux may be depicted in up to 86 % of patients[3,4]. However, only a low proportion (4-5 %) of this group may become symptomatic with recurrent pyelonephritis and/or chronic progressive decrease of graft function and later need surgical management[5].

Whereas minimally invasive endo-urologic procedures may be successful for short strictures[6,7] their long-term efficiency remains questionable for those longer than 1cm and equally for ureteral reflux[8]. Hence open surgical revision is still the gold standard treatment of a significant proportion of ureteral complications, by means of uretero-cysto-neostomy or uretero-pyelic/uretero-ureteral anastomosis[9,10]. When available and healthy, the native ureter is frequently used[9], especially when addressing reflux, since it offers the protective efficiency of the native uretero-vesical junction. However, such open reconstructions require significant abdominal wall incisions[10] which are associated with a lengthy hospital stay and expose graft receivers to potential abdominal wall complications.

Over the last 20 years laparoscopy has significantly modified urologic surgery, offering patients minimally invasive solutions in a wide array of uropathologies. Reconstructive urology has remained however a challenge, related to the technical difficulty of laparoscopic suturing in remote locations. Over the last decade, the da Vinci robot has helped to bridge this gap[11,12], and now allows urologists to perform efficient reconstructions of the upper urinary tract, such as pyeloplasty, ureterocysto-neostomy or ureteral anastomosis[13,14]. To date however, laparoscopic reconstruction of the kidney graft urinary tract has not been addressed with the same enthusiasm. To our knowledge, only 2 reports provide information on 3 cases[15,16]. However, the robotic access appeared beneficial both on a functional graft outcome and on a minimally invasive basis to these 3 patients. Nevertheless, whereas these case reports proved that the technique was feasible, they also highlighted the difficulty of identifying the graft ureter and dealing with local fibrosis, which are certainly the two major reasons that have deterred urologists from performing robotic reconstruction more frequently.

Following our initial two cases[16], we have attempted robot-assisted laparoscopic ureteral or uretero-pyelic anastomosis (donor-receiver) for kidney graft reflux or stricture disease on a larger basis. The goal of this study is to review this experience, identify means to facilitate the procedure, outline the patients characteristics that may select those best suitable to benefit from this minimally invasive operation and compare it to a contemporary open approach.

Patients and methods

Patients' selection and demographics

We included in this study all kidney graft patients on which was attempted a robotic uretero-ureteral or uretero–pyelic anastomosis for ureteral stricture or vesico-ureteral reflux over a period of 3 years. Patients who underwent open surgery during the same period were used as a control group. After institutional ethical committee approval, patient files were reviewed. Classical demographic parameters were recorded, as well as indication, overall operative time, pneumoperitoneum time, ureters stented, post-operative length of stay, serum creatinine, Clavien complications > II and their treatment. All patients had their robotic procedure completed by the senior author, who already benefitted from extensive robotic experience (> 300 procedures, including over 40 operations on the ureter).

The preoperative evaluation included voiding cysto-urethrogram for all patients with suspicion of reflux disease based on recurrent graft infections or indirect sign of renal function deterioration on graft biopsy. Patients with suspected stricture due to hydronephrosis were diagnosed by retrograde or antegrade pyelogram, depending on their initial drainage technique.

Robotic surgical technique

All patients underwent general anesthesia and received intravenous cefuroxime. After the second case, all patients underwent previous insertion of ureteral catheters in order to facilitate both kidney graft and native ureter identification during the robotic sequence of the procedure. This was performed during the same anesthesia (before beginning the laparoscopic part) using a rigid or flexible cystoscopic access, depending on the location of the reimplanted ureteric orifice. For the graft ureter, the catheter used was luminous (Karl Storz, Germany), whereas it was standard for the native ureter.

For the laparoscopic part of the procedure patients were placed in a 30-45° lateral decubitus position. Pneumoperitoneum was attempted in the ipsi-lateral upper abdominal quadrant where an initial 5 mm trocar was positioned through which a 0° endoscope was passed to assess the peritoneal status. Accordingly, a further trocar was installed where possible, and adhesiolysis was performed when needed. Three supplementary trocars were then positioned in a fan array oriented towards the iliac fossa containing the graft, as depicted in figure 1. The upper limit of the pneumoperitoneum was set at 12 mmHg throughout the operation. The laparoscope trocar was placed approximately in the middle of a line drawn between the anterior iliac spine and the umbilicus, whereas the auxiliary da Vinci arm was located in a lower position. A 4 Si or Xi da Vinci robot was then docked, coming from the low lateral side of the patient.

The first step was mobilization of the ipsi-lateral colon in order to expose the retroperitoneum and the native ureter proximal to the iliac vessels. In cases where tissues were significantly adherent, transurethral mobilization of the corresponding ureteral catheter facilitated ureteral identification. After dissecting it in an extra-serous fashion, the ureter was clipped proximally and cut at its lower lumbar segment, since all patients had inexistent residual native kidney function.

The peritoneum was then incised further down which permitted uncovering the medial aspect of the graft and its hilum. The peritoneum covering the area between the lower pole of the graft and the bladder dome was then further mobilized in order to identify the graft ureter. This proved to be the most tedious and challenging step, since the surrounding fat was significantly fibrotic in all patients, except the first one, whose graft happened to have been placed intra-peritoneally.

Once the graft ureter was identified, it was clipped distally as close as possible to its bladder implantation and dissected proximally to identify the kidney pelvis. The native ureter was then further mobilized preserving as much extra-serous tissue as possible, so as to allow it to reach the post-junctional graft ureter or the kidney pelvis. According to local anatomy, a uretero-ureteral or uretero-pyelic anastomosis was constructed using 6 to 8 6.0 Safil® (braided and coated suture made of pure polyglycolic acid) interrupted sutures. The anastomoses were performed in an end-to-end fashion after spatulation of both ureteral ends for uretero-ureteral anastomoses. The uretero-pyelic anastomoses were performed end (ureter) to side (kidney pelvis). The anastomosis was stented with a 6 Fr double-J stent once the posterior anastomotic layer had been completed, the bladder stent extremity being inserted first. The peritoneum was then closed with clips, as the local situation permitted it. After having undocked the robot, the procedure was completed in a standard fashion without intra-peritoneal drainage. We provide a video clip summarizing the main steps of the procedure which can be found in the supplementary material.

A transurethral bladder catheter was left in place for 5 days, and the double-J stent was removed cystoscopically between the 3th and 4th postoperative week. If a nephrostomy tube had been inserted pre-operatively, it was clamped two days before double-J stent removal and an antegrade pyelogram was performed thereafter to check for anastomosis patency (see figure 2).

Statistical analysis

Data was analyzed with SPSS Statistics program (IBM, USA), and expressed as medians unless otherwise stated with their first and third interquartile (IQR) ranges. Depending on the variable analyzed, the comparisons between the groups were done using a Kruskal-Wallis, Fischer-exact or chi-square test.

Results

Ten patients (7 men and 3 women) underwent a robotic approach and 7 an open approach (2 men and 5 women). Their mean age was 54 (43-67), and their body mass index (BMI) 26 (23-30). Operative indication was a stricture for 6 patients and symptomatic vesico-ureteral reflux (recurrent pyelonephritis and/or decrease of graft function associated with biopsy lesions related to reflux) in 11. All patients sustaining a stricture had already undergone an unsuccessful endoscopic treatment attempt. In the robotic-intent group, we had two patients with an anastomotic stricture (10mm and 8mm), and one patient with a 10mm stricture located 20mm distal to the pyeloureteral junction. In the open group, one patient had a 10mm stricture located at the pyeloureteral junction whereas two had anastomotic strictures (12mm and

10mm). The median stricture lengths were therefore similar between both groups (respectively 9.3 vs 10.7mm). Except for robotic patient # 10, we avoided using endoscopic submucosal meatal bulking agents when addressing reflux, since their long term efficiency is questionable[8]. Relevant patient data is summarized in Table 1. Twelve patients (70%) were classified ASA 3, the remaining being ASA 2. All patients had a first graft, except for robotic patient # 1 and # 10 (second graft). Demographics were comparable in the robotic intent and open groups (see Table 1). Notably median pre-operative kidney function was satisfactory (serum creatinine of 146µmol/l), and similar in both groups.

Two procedures were quickly converted to open surgery due to major adhesions compromising the safety of the procedure (robotic # 4 and 5). Out of the remaining 8, 6 (75%) were completed using robotic access while the 2 remaining patients (robotic # 3 and 7) also required conversion because of failure to identify the graft ureter or pelvis owing to the surrounding fibrosis. Interestingly, the single patient with previous history of Tenckhoff catheter insertion (robotic # 8) had a robotic procedure conducted successfully. Median total operative time for the robotic, converted and open group was 320 (267-352), 409 (271-602) and 205 minutes (187-225) respectively. There was a statistically significant difference in total operative time between the open group and the robotic-intended group ($p = 0.03$).

The patients received an uretero-ureteral or an uretero-pyelic anastomosis depending on the location of the stricture or the difficulty to dissect the distal part of the graft ureter or pelvis, with no incidence on peri-operative or late results. In the post-operative period, no patient showed significant decrease of renal function (see table 2). One patient required transfusion in the open group, but none in either the robotic or the converted group.

The sub-group of 6 patients who could have their operation completed robotically had a median post-operative length of stay of 5 days while that of the 4 converted patients was statistically significantly longer (9 days; see table 2), similar to the length of stay of patients who underwent an open surgery (p = 0.84). Return to normal oral food intake was quicker in the completed robotic approach group (post-operative day 1 versus day 3; see table 2), as well as absence of opiates-mediated analgesia (post-operative day 1 versus day 4; see table 2). These parameters were similar in the converted and open groups (p = 0.79 for analgesia between open and converted group, and p = 0.87 for return to normal food between open and converted group).

Three patients (17%) had immediate post-operative complications (> Clavien II); two in the open surgery group and one in the robotic-intended group (converted group, p = 0.4). These included two grade IIIb (one urinoma due to JJ obstruction requiring JJ-replacement and one anastomotic leak requiring open revision) and one grade IIIa (prolonged ileus requiring insertion of a naso-gastric tube). Three patients (17%) showed grade IIIb late complications (anastomotic stricture with successful endoscopic management; table 2), one in each of the sub-groups. These failures occurred within two months after removal of the double-J stent.

After a mean follow up of 43 months (30-64), post-operative kidney function remained stable in comparison to pre-operative values (see table 2). However, two patients showed significant deterioration of renal function (robotic # 5 and open # 6). Both were proved by renal biopsy to be linked to a recurrence of IgA glomerulonephritis. Overall, patients treated for reflux had no episode of clinical pyelonephritis following the surgical procedure.

Discussion

This study shows that robotic reconstruction of the kidney graft ureter was feasible in 60 % of cases attempted robotically and allows a quicker recovery and a significant decrease of hospital stay when compared to patients who were converted to open surgery or operated directly using an open approach. The efficiency of the robotic repair was comparable to that of reported historical open surgery series, such as Schult et al, who reported a normal function in 40 of 48 grafts who underwent open surgical repair[17,18]. As could have been expected and witnessing for the minimally-invasive advantages of robotics, the open-surgery group and the converted group had a longer post-operative length of stay, return to normal food intake and analgesia control.

We attempted to identify factors that could explain the high foreseen conversion rate (40 %). Two patients were converted because of the fibrosis surrounding the graft, one of them probably related to an infected local urinoma which developed in the immediate post transplantation period. In all other patients, intra-peritoneal adhesions were no obstacle for working laparoscopically. Two conversions were due to the failure of identifying the graft ureter. This is a challenging operative step which is indeed hampered by the fibrosis and altered quality of tissues surrounding the graft, well known to be related to graft placement and immunotherapy. In both patients converted because of failing to achieve this step, the graft ureter could not be catheterized cystoscopically before attempting robotic reconstruction. This was due to difficult access related to the axis of the graft ureter reimplantation site. On the contrary, in the robotic completed group, catheterization of the graft ureter was achieved in 4 of the 5 patients in whom ureteral stenting may have helped its identification (robotic patient # 1 would not have benefited from graft ureteral stenting, since he had an easily identifiable intra-peritoneal ureter). Hence, it appears likely that achieving kidney graft ureteral stenting is an important prerequisite for achieving the procedure robotically.

Also, there was a 60 % conversion rate to open surgery during the first 5 robotic-attempted patients, whereas this ratio fell to 20 % in the last 5 (one single patient converted). Although this difference is not statistically significant ($p = 0.22$), it certainly reflects a learning curve effect. This not only entails the classic progressive overcoming of technical challenges but also the increased precision and care of the pre-operative work-up. Two pre-operative pieces of information proved valuable. First, the kidney donor side of the graft allowed us to better understand anatomic relationships between the vascular and collecting system, namely whether the latter was in front or behind the graft vessels. Second, 3-D imaging of the graft ureter course significantly contributed to its ease of identification. Pre-operative pelvic MRI or CT was increasingly performed over the series and contributed decisively to ureteral graft identification in our last patient. However, intra-operative laparoscopic echography was not convincing; it permitted identification of the kidney pelvis area and the graft vessels, but was unhelpful in showing where the ureter was traveling from kidney down to bladder. Besides these 2 factors, no other cause for conversion could be identified. Average BMI of the converted patients was slightly higher (29) than that of the robotic group (27), however without statistical significance.

Technically, all anastomoses except five were from ureter to ureter. This approach was preferred to that of a pyelo-ureteral repair because in the majority of cases the proximal graft ureter was healthy and much easier to expose than the kidney pelvis. However, this sometimes rendered the positioning of the proximal part of the ureteral double-J stent delicate, this being safer performed retrogradely with the help of a flexible cystoscope.

Regarding graft function, there was no difference between both groups neither on a short or a long-term basis. Although this function was slightly decreased pre-operatively (median serum creatinine 146 µmol/l), it did not worsen post-operatively, as could be feared. Indeed, possibly owing to decreased kidney veinous return, partially jeopardized kidney function may suffer immediately postoperatively from lengthy laparoscopic procedures[19]. Post-operative stability of renal function may be ascribed to sufficient per-operative intravenous crystalloid filling, so as a per-operative pneumoperitoneum pressure maintained to the reasonable level of 12 mmHg. Only two cases of protracted deterioration over time were observed, related to recurrence of IgA-glomerulonephritis.

Considering the lessons learned throughout this small patient sample, we would like to emphasize on the following caveats which both concern identification of the graft ureter. First, always obtain pre-operative meticulous imaging of the graft ureter (according to serum creatinine: CT or MRI) with 3-D reconstruction of its portion traveling down to the bladder. Second, the achievement of retrograde catheterization of the graft ureter with either luminous or standard ureteral catheter is also of great utility; it allows the assistant-surgeon to transurethrally mobilize the ureter which can also be felt and recognized more easily. Interestingly, identification of the graft ureter was greatly enhanced for the last robotic patient by using the near-infrared robotic light (normally used for indocyanine depiction, however not injected intravenously in this patient)[20]. The ureteral catheter light was switched on and the robot light was permuted to near-infrared mode, which allowed immediate isolation and consecutive dissection. Together, these two issues appear to constitute the cornerstone of a successful procedure.

To our knowledge, this the first series of laparoscopic robot-assisted ureteral reconstruction for kidney graft. This procedure is feasible, efficient and associated with low morbidity comparable to open series, namely reducing hospital stay significantly whilst witnessing the speeding up of postoperative recovery. The small sample size and the mono-centric non-randomized design of the study prevent our results to be widely extrapolated so far. The extra costs of the robotic procedure and the access to the robot itself are also two significant obstacles for generalization of the procedure, whose option may nevertheless be considered by experienced robotic teams.

Conclusion

Robot-assisted ureteral reconstruction for kidney graft patients is a complex procedure which requires meticulous preparation, but is feasible, safe and efficient. It offers to patients the classical advantages of minimally-invasive surgery with graft functional outcomes comparable to open reconstructive series.

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Figures legend

Figure 1: Trocar placement for a left-side graft. Red: on site assistant trocar. Green: laparoscope. Blue and white: working and exposure da Vinci trocars.

P: pubic bone. ASIS: anterosuperior illiac spine

Figure 2: Antegrade pyelogram of robotic patient # 2. Pre-operatively (left picture), a tight anastomotic stricture is observed; 4 weeks post-operatively (right picture), the anatomic course of the native newly anastomosed ureter is noticeable.

Table 1 : pre-operative demographics. Values are median and IQR range

	all patients	robotic intent approach	open approach	p value
n	17	10	7	-
Age	54 (43-67)	51 (40-68)	52 (45-67)	0.76
Sex				
men	9	7 (70 %)	2 (29 %)	0.15
women	8	3 (30 %)	5 (71 %)	
BMI	26 (23-30)	27 (23-28)	23 (21-27)	0.07
ASA score	3 (2-3)	3 (2-3)	3 (3-3)	0.95
Operative indication				
stricture	6	3 (30 %)	3 (43 %)	0.64
reflux	11	7 (70 %)	4 (57 %)	
Graft history				
1st graft	15	8 (80 %)	7 (100 %)	0.48
2nd graft	2	2 (20 %)	0 (0 %)	

Table 2 : peri-operative and late results. Values are median and IQR range

	All patients	Robotic intent approach		Open group	p value
		completed	converted		
n	17	6	4	7	-
Anastomosis					0.34
uretero-ureteral	12	4	4	4	
uretero-pyelic	5	2	0	3	
Preoperative creatininemia (umol/l)	146 (123-176)	163 (132-183)	155 (143 - 176)	145 (122-177)	0.30
Total operative time (min)	293 (220-348)	320 (267-352)	409 (293-563)	205 (187-222)	0.07
Follow-up (months)	43 (30-64)	38 (30-47)	37 (30-45)	44 (35-65)	0.67
Change from baseline creatinine after surgery	-1% (-7% - +3%)	+3% (-10% - +5%)	-4% (-9% - -1%)	-1% (-6% - +2%)	0.53
Change from baseline creatinine at last follow-up	-13% (-22% - +4%)	-16% (-26% - -11%)	-22% (-24% - +1%)	3% (-10% - +8%)	0.25

Early > Clavien II complications	3 (17%)	0	1 (25%) IIIb	2 (29%) 1 IIIa and 1 IIIb	0.40
Late > Clavien II complications	3 (17 %)	1 (20%) IIIb	1 (25%) IIIb	1 (14%) IIIb	1
Post operative length of stay (days)	8 (5-9)	5 (4-5)	9 (9-11)	9 (8-13)	0.003
Return to normal food intake at day	2 (2-4)	1 (1-2)	3 (2-4)	3 (3-4)	0.012
Analgesia without opiates at day	4 (1-5)	1 (1-1)	4 (4-5)	5 (4-5)	0.0035