Quality assessment of robotic repair of benign ureteral strictures: A Canadian, single-center experience

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KEY MESSAGES

- Success rates for robotic and open repair of complex ureteral reconstruction are similar in a Canadian context.
- Robotic repair of complex ureteral obstruction is safe and associated with shorter length of stay.
- Robotic techniques will continue to evolve as experience grows and platforms advance.

ABSTRACT

Introduction: Endourologic treatments are first-line interventions for short ureteral strictures. With long strictures and endourologic failures, open repair has historically been; however, robotic-assisted approaches have recently been shown to be efficacious. As a quality measure, we wanted to assess the performance of robotic ureteral reconstruction compared with open surgical repair during our transition to robotic surgery at a Canadian tertiary care center.
Methods: From 2011–2024, 43 complex ureteral stricture cases (19 open, 24 robotic) were performed. Primary outcome was six-month success defined by a composite of stent/pain-free status and renogram T½ . Secondary outcomes included length of stay, operative time, estimated blood loss, and complications.
Results: Success rates at six months were non-significantly different between robotic and open repair (83% vs. 79%, p=0.36). Length of stay was shorter in the robotic group (3.1±1.9 vs. 4.9±3.3 days, p=0.018). Estimated blood loss (231±84 vs. 244±170 mL, p=0.30) and operative time (220±67 vs. 214±74 minutes, p=0.40) were comparable between groups. Complication rates

were similar between groups.
Conclusions: Overall, robotic reconstruction yields equivalent six-month success to open repair with shorter length of stay. These findings support continuing robotic-assisted ureteral reconstruction as a safe and effective alternative to open surgery, offering equivalent short-term success and reduced hospital stay.

INTRODUCTION

Urinary obstruction secondary to benign ureteral stricture is a leading source of patient morbidity, with up to 10% of patients developing a stricture after ureteroscopy.[1] Benign etiologies are varied including, radiation, stones, congenital anomaly, and iatrogenic injury.[2] Prompt urinary drainage is critical to preventing irreversible renal dysfunction.[3,4] While endourologic techniques such as balloon dilation, endoureterotomy, or stenting are classically first line, their failure is not uncommon. A longitudinal single-center study found that the overall success rate of endourological treatment was 51.6%.[5] Failure of endourologic techniques necessitates definitive surgical reconstruction, chronic stenting, nephrostomy tubes, or nephrectomy. Reconstructive surgical options include reimplantation (with or without Boari flap), reanastomosis, or ureteroplasty with flaps or grafts.[3]

Historically, open reconstruction has been the gold standard for long (>2 cm) ureteral strictures and those that are refractory to endourologic approaches. Open approaches offer high success rates, but are frequently associated with increased pain, prolonged hospital stays, and complications associated with larger incisions.[6,7] The emergence of laparoscopic and robot-assisted laparoscopic techniques across surgical specialties have consistently offered advantages, including reduced length-of-stay (LOS), and estimated blood loss (EBL).[8,9] Notably, the highest volume American centre specializing in ureteral repair has reported an 87% success rate for robotic buccal graft ureteroplasty.[10]

Until now, there have not been any Canadian studies assessing robotic capacity or efficacy compared with open procedures for complex ureteral reconstruction, despite its appeal in high volume centres in the United States.[11] Furthermore, these referral centres have shown success with robotic repair following failure of open approaches.[12] As a quality measure during our intentional transition from open to laparoscopic-assisted robotic approaches, we study the efficacy of robotic versus open repair of complex ureteral strictures at our low volume Canadian centre utilizing the antiquated daVinci Si™ system. We hypothesize that robotic-assisted ureteral repair can achieve equivalent success rates to open surgery, with a reduced LOS and comparable perioperative outcomes.

METHODS

Study design and setting

With Institutional Research Ethics approval, we conducted a retrospective analysis of upper urinary tract reconstruction procedures from one tertiary intuition (London Health Sciences Centre) performed by a single urologist with more than two decades of experience of ureteral repair. Inclusion criteria were cases of upper tract urinary reconstruction from the first time we performed robotic ureteral reconstruction for stricture to our last case with 6 months of follow-up (2011-2024), age > 18 years, and complexity (defined as prior upper tract urinary reconstruction, multiple strictures, or ureteral defects requiring grafts or flaps). We excluded primary pyeloplasty. As well, ileal interpositions, autotransplants, and cases involving concurrent colorectal or gynecologic procedures were removed to eliminate comparison of cases that could not have been performed robotically. Utilization of robotic or open techniques during this period encompassed an intentional shift from open to robotic techniques based on surgeon preference. Initially, only renal pelvic/proximal ureteral reconstruction was performed robotically, with pelvic cases increasingly added over time, until post-transplant or hostile abdomen became the primary exclusion for consideration of robotic approach.

Surgical approach and techniques were selected based on clinical scenario, ureteral anatomy, and preferences of the surgeon or patient. The da Vinci Si Surgical System™ (Intuitive Surgical, Sunnyvale, CA, USA) was utilized, with multiport technique for all robotic-assisted procedures. In all cases, ureteral stents were placed intraoperatively and removed four-six weeks post-operatively. Ureteral anastomoses utilized running 4-0 PDS sutures in all robotic cases, and 5-0 PDS sutures in all open cases. Foley catheters were removed within seven days for distal repairs, and within two to three days for proximal reconstruction. Drains were removed prior to discharge if there was no evidence of urinary leak. In patients with preoperative nephrostomy tubes, tubes were left in situ and clamped immediately postoperatively as a safety measure. Stents were removed four-six weeks following discharge and nephrostomy tubes were removed if there was no obstruction or leak following nephrostogram two weeks after stent removal. Follow up was performed with in person visits as well as Lasix renogram assessments of function at 6 weeks and 6 months post-operatively. Renal ultrasonography was standardly used in follow-up (with cystogram in the case of Boari-Flap).

Data collection and outcomes

Data was collected for the following pre-operative characteristics: patient sex, age at date-of-surgery, etiology, and laterality. The following peri-operative parameters were also collected: type of surgical procedure, total operative time, LOS, presence of ureteral stent six months post-operatively, utilization of ureteral rest (nephrostomy tube drainage without stent pre-operatively for at least 1 week), presence of symptoms six months post-operatively, radiographic or nuclear evidence of obstruction, and complications graded via Clavien Dindo Classification.

Primary outcome was a success rate at six months, defined as a composite outcome: colicky pain (binary) and stent-free status six months post-procedure, and T½ < 20 minutes in the post-operative Lasix renogram if available. Secondary outcomes included operative time, estimated EBL and LOS. This definition mirrors existing literature on ureteral reconstruction, where success is characterized by symptom resolution or the absence of obstruction on post-operative imaging.[10,13]

Statistical analysis

Statistical analysis was performed using a two-sample t-test assuming unequal variances to compare outcomes between the open and robotic surgery groups. A two-tailed T test was utilized for our primary outcome. Statistical significance was set at $p<0.05$. One-tailed student's T tests were performed for our secondary outcomes with an alternative hypothesis of robotic technique superiority.

RESULTS

Patient and surgical characteristics

Our study identified a total of 119 patients, of which 43 (19 open, 24 robotic) met inclusion criteria. Seventy-six patients were excluded from the following cohorts: concurrent general surgery/gynecology (n=4), primary (non-complex) pyeloplasty (n=69), and ileal transposition/autotransplant procedures (n=3). Within the first five years, 100% of cases were performed in an open fashion, compared to 42% in the last five years (Supplemental Figure 1). Within the last four years, the reasons for open surgery included only bilaterality of proximal ureteral disease, and strictures in transplanted kidneys. Initial robotic cases were primarily recurrent UPJO, 2022 marked the start of the management of more distal lesions.

Lithotripsy and iatrogenic ureteral resection were identified as the primary etiology of stricture in more than half of all lesions. Patient age and sex appeared balanced (Table 1). Ureteral rest associated with removal of the ureteral stent was obtained in 79% of the robotic cohort compared to 53% of the open cohort (p=0.038).

The ureteral lesions appeared to have similar lengths across robotic and open techniques (3.6 cm vs 2.7 cm respectively, p=0.080). The distribution of ureteral lesions appeared to differ across treatment modalities as shown in Supplemental Figure 2.

Success rates

Our study identified very similar success rates of 79-83% (p=0.36) at six months across open and robotic ureteral reconstruction (Figure 1). Additionally, we evaluated success rates by approach over 5-year time intervals (Supplemental Figure 3), multi-variate regression found neither year nor group to significantly contribute to the model.

Failures within the open and robotic cohort occurred in the setting of prior ureteroscopy, transplant, ureteral resection and UPJO repair failure injury (2:1:1:0, 1:0:1:2, respectively). No failures occurred in the setting of prior radiation.

Perioperative course

Mean LOS was significantly shorter in the robotic group (3.1 vs. 4.9 days, p=0.018) (Figure 2). Complication rates were similar: two robotic patients developed urinary leaks requiring extended stenting (One Clavien-Dindo 2, one Clavien-Dindo 3); two open patients developed wound infections (Two Clavien-Dindo 2). Both groups had two patients with post-operative UTIs. No robotic cases required conversion to open surgery, and no patients in either group required early (<1 month) reoperation.

Estimated blood loss was comparable between both groups: 231 ± 84 mL in the robotic cohort vs. 257 ± 170 mL in robotic cases (p=0.30). No patients in either group required blood transfusion. Mean operative time was not significantly different between robotic and open groups: 220 ± 67 minutes and 214 ± 74 minutes (p=0.40), respectively (Figure 3).

DISCUSSION

As our centre pivots from open to robot-assisted repairs of complex ureteral injuries over ten years, we present the first Canadian report demonstrating equivalent efficacy between the two reconstructive modalities. Importantly, our cohort of strictures mirrors existing literature indicating iatrogenic trauma is the most common cause of ureteral injury requiring reconstruction.[14] Furthermore our open repair success rates appear comparable to data of a contemporary timeframe (19 open patients, 82% success), despite failure in our cohort also encompassing nuclear scans and stent status[15]. Although our robotic success rates are imperfect, 83% is similar to high-volume, leading world centres.[10,12,16] Notably, our retrospective review highlighted a relatively low rate of the utilization of ureteral rest, defined by the absence of the use of ureteric stents for at least four weeks prior to ureteral repair. As data from a multi-institutional cohort demonstrates a 13% absolute increase in operative success (90.7 vs 77.5%) with ureteral rest, we believe that improving upon our ureteral rest rate remains an area to address in our attempt at quality improvement over the next decade.[17]

Within the dataset, robotic procedures had a significantly lower LOS compared to open procedures despite similar operative times. Shorter LOS is known to correlate with patient satisfaction and lower costs for healthcare institutions, making it a valuable metric for evaluating and comparing surgical approaches.[18,19] The per-diem cost for inpatient services at London Health Sciences Centre is $2,666 as of April 2024, this would amount to almost $5,000 in per case savings[20]. These findings align with existing upper tract reconstruction literature, which indicate that robotic assisted versus open generally results in a shorter LOS.[13] Complication rates and EBL were comparable, with only one patient in the robotic cohort experiencing a Grade 3 complication. Within some high-volume centres in the United States, ureteral repair has evolved into a same-day or overnight stay procedure using a single-port system.[21]

Many tertiary care centres in the United States have state-of-the-art daVinci robots in their hospitals including the daVinci 5 and SP, with virtually all acquiring a daVinci Xi since its release in 2014. Conversely, most Canadian tertiary centres have only one to two robots per hospital. Despite having access only to the relatively antiquated and cumbersome daVinci Si system in our centre, we performed a combined robotic proximal (double buccal graft) and distal ureteral reimplant procedure, as well as a simultaneous robotic bilateral ureteral reimplant (Boari and direct reimplant). The recent replacement of the daVinci Si with the Xi system will transform our ureteral repair technique of choice to robotic in 90% of cases, since all transplant ureteral strictures will now be attempted in a robotic fashion. With increasing experience in robotic renal transplantation and cystectomy with intracorporeal diversion in Canada, ureteral repair using robotic autotransplantation and robotic ileal interposition will soon become realities in the Canadian systems.

Limitations

Our sample was from a single surgeon in a setting where complex ureteral reconstruction is not common. This weakened our ability to identify differences between subgroups. This limitation is consistent across the literature, even among multi-centre studies, given the specialized nature of complex ureteral reconstruction[16].

As a review of the quality of an intentional surgical pivot from open to robotic repair, this design introduces biases inherent to this retrospective design. The open cohort involved more distal ureteral injuries and therefore a high proportion of reimplants, while the robotic cohort involved a constellation of buccal mucosal grafts, appendiceal onlays, Boari and Scardino Prince flaps, direct reimplants, and uretero-ureteral/renal pelvic anastomoses. Nonetheless, both groups had comparable complexity as noted by a similar number of radiation or iatrogenic-induced etiologies.

As the majority of our patients had been referred in from other districts to our centre, follow-up beyond six months was limited in most patients. Although an endpoint of six months is consistent across much of the literature, it may not capture later recurrences.

Changing perioperative pathways and protocols, such as earlier catheter and drain removal, may have contributed to shorter LOS in the robotic cohort. However, we did attempt address era-related biases by performing a limited multi-variate regression including operative year and approach, neither of which could significantly contribute to a model. Clear differences in rate of ureteral rest exist between cohorts, which is likely an artifact of differences in procedure frequency per era.

We continue to favour open repair of distal transplant ureters, since we have been encumbered by exclusive access to the daVinci Si platform. This platform is associated with limited side docking ability and requiring greater space to be placed between robotic arms. Therefore, it can be argued that the more challenging and refractory strictures were performed with the open technique.

Our study did not evaluate patient intake of morphine-equivalents. During data acquisition it became clear that access to full pharmaceutical records in our electronic medical record were significantly limited in older patient encounters, to avoid bias we moved away from this evaluation. Furthermore back to work, and patient satisfaction scores were not recorded but could be very useful in a survey based prospective study.

CONCLUSIONS

Preliminary review of the first Canadian series of robotic assisted complex ureteral repair demonstrate short-term success rates comparable to traditional open surgery and to the success rates of high-volume tertiary centres. Robotic ureteral reconstruction is also associated with similar post-operative safety, with a shorter hospital LOS. This quality review provides us with data to support continued performance of robotic ureteral repair within the Canadian healthcare system.

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FIGURES AND TABLES

Figure 1. Success rate after ureteral reconstruction.

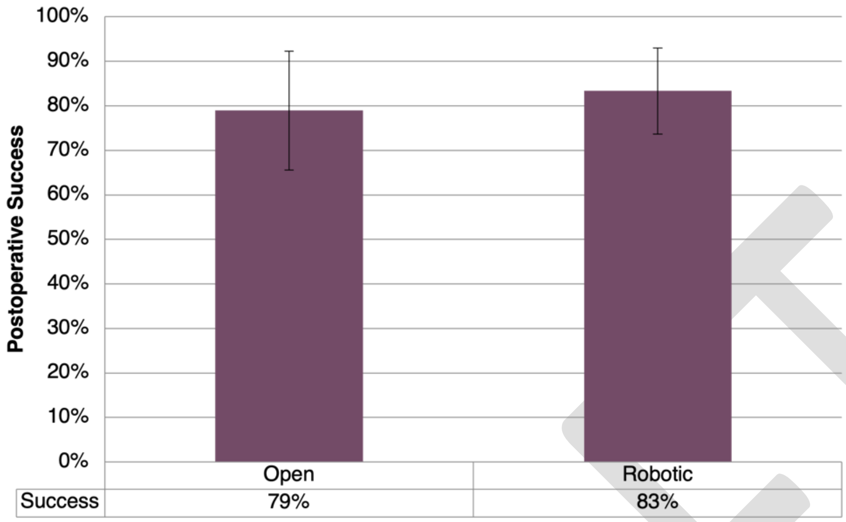

Figure 2. Difference in length of stay (days) by operative technique

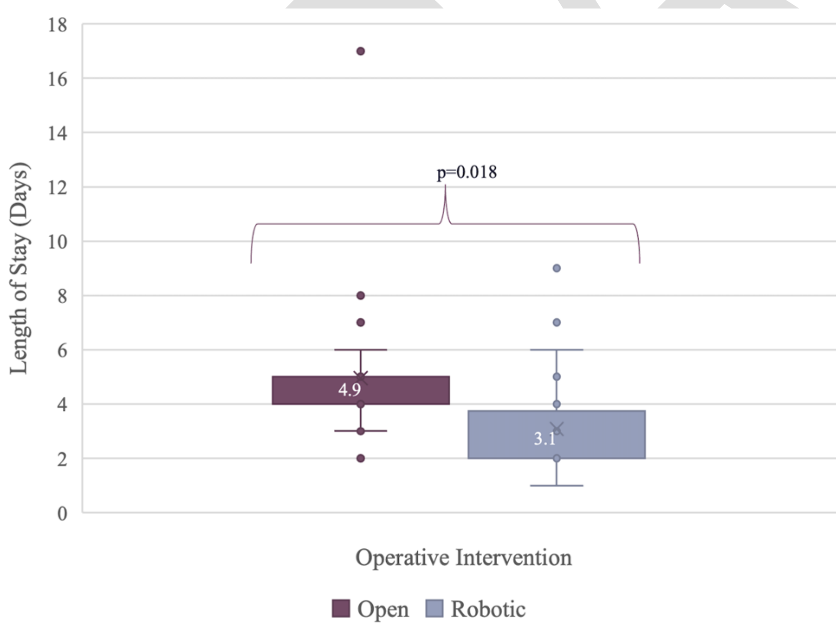

Table 1. Patient characteristics of those undergoing ureteral reconstruction		
	Robot-assisted reconstruction	**Open reconstruction**
Number	24	19
Age (median)	57	55
Male:female	11:13	10:9
Etiology	Ureteral resection: 6 Lithotripsy: 8 Radiation/RPF: 2 Redo pyeloplasty: 8	Ureteral resection: 8 Lithotripsy: 5 Radiation: 5 Infection: 1
Side (L/R/transplant/ bilateral)	14/9/0/1	7/6/5/1
Procedure	Boari flap: 5 Pyeloplasty: 9 Ureteral reimplant: 3 Graft/flap ureteroplasty: 10	Boari flap: 14 Ureteral reimplant: 3 Graft ureteroplasty: 1 Pyeloplasty: 2
Ureteral rest (%)	79%	53%
Post-op renogram available	63%	26%

Multiple procedures were performed for some patients. RPF: retroperitoneal fibrosis.