Laparoscopic and Robot-Assisted Laparoscopic management of iatrogenic ureteral stricture: preliminary experience

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ABSTRACT

Introduction and objectives
The incidence of iatrogenic ureteral strictures is low. However, their management remains challenging. We want to report our technique of laparoscopic and robot-assisted laparoscopic uretero-ureterostomy (LUU and RAUU) for adults with iatrogenic lumbar and iliac stricture and laparoscopic ureteral reimplantation for iatrogenic pelvic stricture.

Materials and methods
A descriptive study was conducted by our department to evaluate the outcomes of minimally invasive procedures on 9 patients. Six of these patients had developed lumbar or iliac ureteral stricture. In five cases the strictures were following ureterorenoscopy, while the sixth patient had pancreatic cancer and underwent pancreaticoduodenectomy and three developed pelvic strictures following ureterorenoscopy. The preoperative evaluation included a medical history review, abdominal ultrasound, and computed tomography (CT) scan. Success was defined as the absence of postoperative symptoms and evidence of no obstruction on the CT/urography at 1-year follow-up.

Results
Minimally invasive approaches were technically feasible in all nine patients. The average operating time was 105 minutes, and the median hospital stay was 4 days. No significant complications occurred. CT/urography or abdominal ultrasound confirmed the absence of stricture recurrence and no reduction of kidney function. At a mean follow-up of 26 months, all patients were asymptomatic.

Conclusions
Robotic and laparoscopic reconstructive ureteral surgery performed by expert surgeons in a tertiary referral center is a safe and feasible procedure with a low overall rate of post-operative complications. This minimally invasive approach may be a final alternative to endoscopic procedures for permanent stenting, autotransplantation, or distal ureteral reconstruction with a bladder flap in the Cassati Boari fashion.

Introduction and objectives

Ureteral reconstruction is a challenging task in the area of reconstructive urology, especially if previous ureteral surgery has been performed. In fact, fibrosis and obliterated surgical planes make the reconstruction of the ureter a difficult procedure. It is clear that both redo surgery and management of ureteral complications require a detailed preoperative history and diagnostic, combined with an accurate knowledge of the anatomic changes made during the primary procedure. Surgeons encounter varying conditions depending on the location of the ureteral stricture (upper, middle, or lower ureter). It is essential to ensure adequate blood supply after reconstruction to minimize complications such as ureteral necrosis or recurrent strictures. Consequently, there is an imperative need for techniques that ensure wide and tension-free anastomoses, with adequate blood supply to all parts of the ureter [1].

Ureteral strictures are observed in approximately 3.5% of cases following endoscopic procedures for stone treatment [2]. Depending on the location, there may be several reconstruction options. The most difficult injuries are those situated in the middle ureter. But even very long strictures are demanding to reconstruct because they may not be reached or bridged by the bladder or renal pelvis, and therefore represent a significant limitation to other procedures [1].

The first laparoscopic uretero-ureterostomy (LUU) was performed by Nezhat and colleagues in 1992 [3] and the first laparoscopic ureteral reimplantation by Ehrlich and Gershman in 1993 [4]. While LUU may be a challenging procedure in terms of suturing, it could serve as a viable option for open surgery. Since then, ureteroureterostomy has been the most frequently described procedure in the laparoscopic approach. Success rates have reached over 90% [5]. Especially with the widespread availability of robotic platforms, the laparoscopic approach is increasingly being replaced. Robotic surgery presents an alternative to the laparoscopic approach for reduced ureteral resection and intracorporeal suturing, particularly for surgeons with minimal laparoscopic experience [6].

Performing minimally invasive ureteroureterostomy on the lumbar and iliac segments can be demanding due to the need for precise intraoperative identification of the stricture site and the extent of the stricture to perform the anastomosis on healthy and vascularized tissue without any traction.

The purpose of this study is to describe our technique for managing iatrogenic ureteral strictures by minimally invasive approach.

Materials and Methods

Between 2014 and 2023, nine patients with iatrogenic ureteral stricture were admitted to our hospital. Eight patients developed ureteral stricture secondary to ureterorenoscopy with laser lithotripsy for stone treatment and one after pancreaticoduodenectomy performed for pancreatic cancer. Patients were diagnosed with urinary tract obstruction by their symptoms and radiographic findings. All patients with symptoms suggesting urinary tract obstruction were initially imaged by abdominal ultrasound and then by computed tomography (CT). The indications for LUU and RAUU were lumbar and iliac strictures. Out of the six patients, four had lumbar ureteral strictures, and two patients had iliac ureteral stenosis. Three developed pelvic strictures following ureterorenoscopy and underwent to laparoscopic ureteral reimplantation extravesical approach.

Assessment of the diseased ureteral segment, and determining the length of the potential defect to be bridged is essential for the planning of the required repair and to aid in preoperative counseling. The primary clinical outcome was to restore a patent ureter and treat symptoms. Technical success was defined as completing the laparoscopic or robotic procedure, while clinical success was defined as the absence of the stricture, recovery, or preservation of renal function, and no symptoms at the last follow-up. For the follow-up, we performed abdominal ultrasound, urinalysis, and urine culture at 1 month, and CT or urography and abdominal ultrasound at 6 months. We evaluated the complications using the Clavien Dindo classification [7].

Patients were treated with different laparoscopic and robotic techniques according to the level of stenosis: total ureterectomy or partial ureterectomy with end-to-end anastomosis for lumbar and iliac

strictures and ureteral reimplantation for distal ureteral strictures.

LUU and RAUU

The Da Vinci Xi system was used in one case (Intuitive Surgical, Sunnyvale, CA, USA) with a transperitoneal approach. After administration of intravenous antibiotics and general endotracheal anesthesia, a 16Fr urethral catheter was inserted into the bladder. The patient was placed in the left/right lateral decubitus position at a 45° angle. The pneumoperitoneum was induced using the standard mini-open access technique according to the Hasson method for the camera trocar. The camera trocar was placed along the right or left lateral edge of the rectus sheath, slightly cephalad to the umbilicus. The working 8-mm robotic trocars were placed in a triangulated position on either side of the camera port: at the midpoint between the anterior superior iliac spine and the umbilicus and on the pararectal line 2-3 cm beyond the costal arch. An assistant port of 12mm was placed in the midline, caudal to the umbilicus. The surgical procedure begins with docking the robotic surgical system. The non-dominant hand is equipped with bipolar Maryland forceps, while the dominant hand is equipped with Endoshears with monopolar cautery. A 30° optic was used.

In the laparoscopic approach, the patient is placed in the same position. We use also the transperitoneal approach. Laparoscopic ports are placed vertically along the midclavicular line from 2 finger breadths below the costal margin to 2-3 finger breadths above the iliac crest (Fig 1). A 30° optic was used routinely in all patients.

The colon was medialised with the white line of Toldt incision, Gerota's fascia was exposed and incised and the ureter was exposed (Fig 2).



Fig 1. Laparoscopic port placement



Fig 2. Isolation of the ureter with the stenotic segment and the dilatated upper ureter.

Following the isolation of the ureter, the stenotic segment was excised at both the lower and upper edges. The ureter was then opened to clearly identify all stenotic segments and healthy tissue. Once the stenotic segment was removed, the edges of the ureter were spatulated at least 5 mm to facilitate better suturing and reduce the risk of restenosis. The ureter was repaired using 4-0 polyglactin interrupted sutures. The anastomosis was completed by first performing the posterior aspect. Before completion of the anastomosis, a double J stent is placed under direct visualization through a peripheral venous catheter that is passed to the abdominal wall. A 0.889 mm (0.035 inch) polytetrafluoroethylene wire is advanced into the proximal ureter and the ureteral stent is advanced over the wire until resistance is encountered (Fig 3). The distal end of the ureteral stent is then advanced into the bladder. Once the stent was correctly positioned, the anterior part of the anastomosis was finished (Fig 4). A drain was left in place at the end of the procedure.



Fig 3. Ascending the ureteral stent to the renal pelvis



Fig 4. The ureteral stent is correctly placed and the posterior suture is performed.

For excised segments under 3 cm, we performed a direct anastomosis as described above. However, for segments longer than 3 cm, we mobilized the bladder and performed a psoas hitch using a 2.0 polyglactin suture, as well as mobilizing the ipsilateral kidney. We sutured through the renal capsule at the superior pole using 2 poliglecaprone sutures and fixed the ends tightly at the skin using a compress in the lower abdomen to avoid tension in the anastomosis. The suture that made traction of the kidney was removed on days 2-3 after surgery. This was used in 2 laparoscopic cases.

To prevent tension in the anastomosis during a robotic case, we utilized three 4.0 polyglactin sutures arranged in a triangular pattern. These sutures were gradually used to approach the healthy ureteral segments, with Hem-o-lock clips employed to avoid tension in the anastomosis. The remaining sutures were then applied, and the Hem-o-lock clips were removed at the end.

In one case we performed a longitudinal incision at the level of the stenosis and a transversal suture using interrupted 4.0 polyglactin sutures.

Ureteral reimplantation for distal ureteral strictures

We performed ureteral reimplantation for distal ureteral strictures by laparoscopic transperitoneal approach.

After induction, the patient is placed in a dorsal lithotomy position. A transperitoneal approach is used. Trocars are placed using the Hadson technique. The first trocar is placed in the midline cranial to the umbilicus and is the optic trocar. The laparoscopic trocars are placed similarly to a laparoscopic cystectomy approach to facilitate bladder mobilization. The other four trocars are placed symmetrically. Two working trocars of 10 mm are placed in the midclavicular line at the level of the umbilicus and the other two working trocars of 10 mm on the left side of the patient and 5 mm on

the right side of the patient above the ipsilateral anterior iliac spine. After trocar placement, the patient is placed in the Trendelenburg position.
First, we perform an incision of the white line of Toldt and medial reflection of the colon. After colonic retraction, the ureter is identified, and dissected free from its surrounding attachments, and circumferential access is achieved. It is important to preserve periureteral tissue during the ureter dissection to preserve the ureteral blood supply.

After mobilizing the ureter to the site of the stenotic segment, the distal end of the remaining healthy ureter is inspected and spatulated (Fig 5).
A double J stent is inserted as previously described (Fig 6).
The bladder is then filled with 200 to 300 mL of saline and a cystotomy is made at an optimal site, usually at the dome (Fig 7). The ureterocystostomy anastomosis is then performed with resorbable sutures.

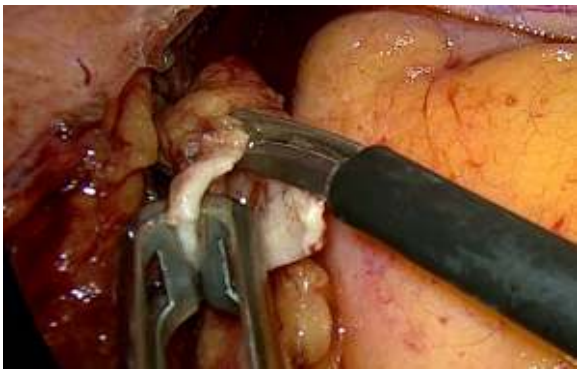


Fig 5. The healthy part of the ureter is inspected and spatulated.

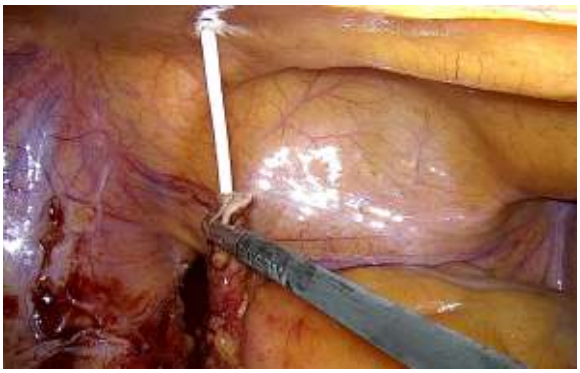


Fig 6. Ureteral stent insertion

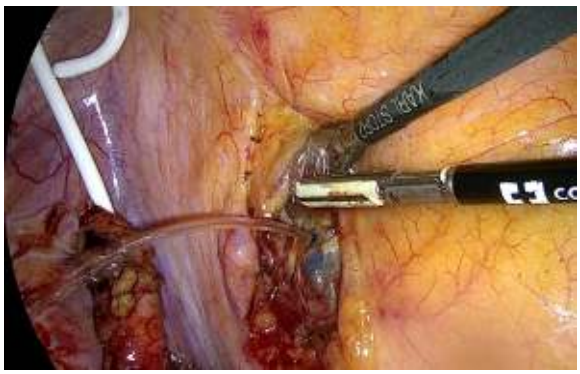


Fig 7. Cistotomy at the ureteral reimplantation site

After complete mobilization, the ureter is placed within the bladder and the detrusor muscle is approximated over it in an interrupted fashion with 4.0 polyglactin suture. We prefer an extravesical approach (Fig 8,9).



Fig 8. Ureteral reimplantation – extravesical approach.



Fig 9. The final aspect of the anastomosis.

We assessed the creatinine level in the drain output and removed the drainage if there was no increase in output and the creatinine level was low. In patients who underwent LUU or RUU, the bladder catheter was removed 2 weeks after surgery and the ureteral stents were removed 6 months after surgery. However, in the ureteral reimplantation procedure, we also placed a suprapubic catheter, which was removed 3 weeks after surgery, and the bladder catheter was kept only during the hospitalization period. The ureteral stents were also removed 6 months after surgery.

Results

A total of nine patients underwent a minimally invasive approach for ureteral reconstruction: one underwent a robotic approach and eight underwent a laparoscopic approach.
Table 1 summarizes the demographic and preoperative clinical characteristics of the nine patients. The minimally invasive approach was technically feasible in all patients without the need for conversion. The mean length of the ureteral stricture was 17 mm (range: 5-40 mm), calculated using the CT scan. Intraoperative and postoperativedata are presented in Table 2. The average operating room time was 105 minutes, and the median hospital stay was 4 days. The mean operating time, catheterization time, and hospital stay were similar in all patients, and no significant preoperative complications occurred. The double-J stent was removed at 6 months after surgery, after an endoscopic evaluation of the procedure (Fig 10). A CT scan or an abdominal ultrasound (Fig 11) was performed 12 months later to confirm the absence of stricture recurrence and normal ipsilateral renal function. All patients remained symptom-free during the average 26-month clinical follow-up.

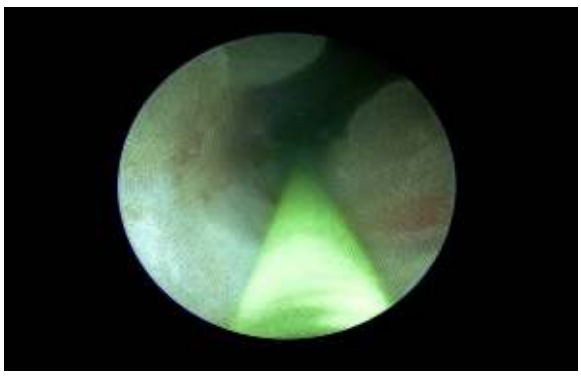


Fig 10. The endoscopic aspect of LUU.



Fig 11. Ultrasound evaluation of the kidneys.

We had 2 cases, one after LUU for lumbar stricture and one laparoscopic ureteral reimplantation after pelvic stricture, that remained with permanent double-J.

Table 1 – Demographic and preoperative clinical characteristics of patients

Patient, No. (male/female)	2/7
Mean patient age, yr (range)	42 (23-64)
Patients with right ureter stricture, No	4
Patients with left ureter stricture, No.	5
Concomitant stones, No	1
Median body mass index (range)	26.4 (21.7- 29.1)
Symptoms	9
Mean ureteral stricture length, mm	17 (5-40)

Table 2 – Operative and postoperative data

Operative time, min, median (range)	105 (42-120)
Postoperative complications, No. (type)	0
Bladder catheterization time, d, median – lumbar and iliac stricture	12.6 (10-14)
Bladder catheterization time, d, median – ureteral reimplantation	21.4 (19-24)
Hospital stay, d, median (range)	4.4 (3-5)
Recurrence, No	2
Follow-up, mo, median	26

Discussions

Iatrogenic stenosis of the ureter is a relatively frequent complication after urological surgery and may occur after open, laparoscopic, or robotic procedures, but also after endoscopic also after endoscopic surgery [8]. Fiori's letter highlights a 'dark side' of ureteroscopy. Ureteral stenosis, along with other complications that threaten the kidneys, can result from previous surgeries [9]. It is widely acknowledged that performing ureteral re-do surgery is particularly difficult due to the presence of fibrosis and scarring at the prior surgical site.
Laparoscopic and robot-assisted techniques have

been implemented as a substitute for open surgery to reduce morbidity and hospitalization. The advancements in surgical technology have enabled surgeons to integrate minimally invasive surgical options into their daily practice, including advanced procedures that were previously only possible through open incisions.

The initial successful LUU was conducted in 1992 by Nezhat et al. [10]. In the first retrospective trial comparing open and different laparoscopic procedures, Simmons et al. found lower estimated blood loss and shorter hospital stays in the laparoscopic group, but comparable patency and complication rates [11]. In a different comparative analysis, De Cicco and colleagues. [12] found a similar recurrence rate between the laparoscopic and open approaches, with success rates exceeding 90%. However, early success can be confusing as recurrent strictures typically develop up to 1 year after surgery. Recent published experience on LUU shows promising results. However, multicenter, randomized studies with longer follow-up periods are needed to support these technically feasible and safe procedures [13].

Reconstructing the ureter, by laparoscopic approach, is a technically demanding procedure that requires a high degree of high degree of skill and a long learning curve. Surgery is presently performed at specialized centers by experienced surgeons.

While laparoscopic surgery mimics open surgery, it is less flexible and becomes more technically challenging. However, the advent of robotic platforms has made a significant impact on ureteral reconstructive surgery. The implementation of the Da Vinci robot has in fact decreased the technical problems of laparoscopy, particularly in the reconstruction phase. The use of a robotic approach has been suggested to provide several advantages, including quicker tissue dissection, reconstruction, and intracorporeal suturing, as well as antegrade double-J stenting for the console surgeon. Robotic surgery offers the advantage of improved access to the entire upper urinary tract. This is particularly beneficial in cases where the ureter has already been resected, as robotic assistance allows for better mobilization of the ureter itself without the inconveniences and difficulties of laparoscopic assistance or larger surgical or larger incisions of the open approach. [14]. Minimally invasive surgery aims to reproduce all the key principles of open principles of open surgery while ensuring a watertight, tension-free, and well-vascularized anastomosis.

Our experience has shown that robotic assistance and laparoscopy are feasible and well-tolerated for ureteral reconstructive surgery with excellent perioperative and functional outcomes.

Hemal et al. conducted a retrospective analysis of data from seven patients who underwent RUU [15]. The results showed a mean operative time of 110 minutes, a mean estimated blood loss of 50 ml, and a mean hospital stay of 3 days. No recurrences were reported at a mean follow-up of 28 months. The largest case series, reported by Buffi et al. [5], included 17 patients with a mean operative time of 150 min and a 94% success rate. There were no complications reported that were higher than grade II. The most recent comparative study between the two techniques, involving 126 patients, suggests that RUU may be a better choice due to its shorter operative time, postoperative hospitalization time, and lower inflammation levels [16].

In a retrospective study, Schiavina et al. [17] compared robotic and laparoscopic approaches for the reconstruction of iatrogenic ureteral stenosis. The study reported a lower estimated blood loss for the robotic group, while no other significant differences were found between the two groups. They concluded that minimally invasive procedures for ureteral stenosis are safe and feasible with a high success rate (95%) at a median follow-up of 27 months. Tracey et al. [18] reported similar evidence comparing robotic and open approaches in the management of iatrogenic ureteral strictures. The study found that there was a significant decrease in estimated blood loss and hospital length of stay.

In 2014, a single-center retrospective study included 55 patients who underwent robotic ureteral reconstruction distal to the ureteropelvic junction [19].. At a follow-up of 181 days, they reported three failures (5.3%) and two postoperative complications (3.6%). This is one of the largest studies of patients undergoing robotic ureteral reconstruction. Various operative techniques were performed including ureteroureterostomy, ureterocystostomy with

psoas hitch, and Boari flap. The mean operative time was 221 minutes, there were no intraoperative complications, and a median estimated blood loss of 50 ml. The mean hospital stay was 1.6 days.

The use of a refluxing or non-refluxing technique is at the decision of the urologist as studies with open, laparoscopic, or robotic surgery have demonstrated similar rates of stenosis and preservation of renal function with either anastomotic technique [20,21]. Marien et al. included 31 ureteroneocystostomies performed using an extravesical approach with complete clinical and radiological improvement [22]. Another study that included 45 patients who underwent robotic reimplantation with or without psoas hitch, reported an overall success rate of 94%, no conversion to open surgery, and a major complication rate of 3.6% (Clavien grade>3) [23].

Conclusions

Robotic and laparoscopic reconstructive ureteral surgery performed by expert surgeons in a tertiary referral center is a safe and feasible procedure with a low overall rate of post-operative complications. This minimally invasive approach may be a final alternative to endoscopic procedures for permanent stenting, autotransplantation, or distal ureteral reconstruction with a bladder flap in the Cassati Boari fashion.

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