Case Report

Robotic appendiceal onlay flap ureteroplasty combined with Boari flap-psoas hitch ureteroneocystostomy for repair of the 20 cm ureteral avulsion: initial experience and case report

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Background: Ureteral avulsion is a rare but serious complication of ureteroscopic lithotomy. As a common treatment for long segment ureteral avulsion, ileal ureteral replacement has many complications, such as anastomotic site stricture and retrograde infection, and prolonged exposure of the intestinal mucosa to urine may result in postoperative metabolic acidosis. Autologous tissue is becoming increasingly popular in ureteroplasty, including oral mucosa, appendix and bladder. Recent advancements in ureteral reconstruction techniques have highlighted the utility of the appendix and bladder, but the length of autologous tissue is limited. In order to reduce complications and save autologous tissue, we propose a novel combined technique. This study aims to evaluate the feasibility and outcomes of appendiceal onlay flap ureteroplasty combined with Boari flap-psoas hitch ureteroneocystostomy in the treatment of long segment ureteral avulsion, with a 15-month follow-up.

Case Description: We report a 64-year-old male patient diagnosed with right ureteral avulsion. In this case, the ureteral reconstruction was accomplished through our new technique. Antegrade urography revealed no obstruction of the reconstructed ureteral segment at 7 weeks after surgery. After a 15-month follow-up period, no postoperative complications occurred, radiological resolution of hydronephrosis and improved renal function were observed.

Conclusions: Our initial experience demonstrated that appendiceal onlay flap ureteroplasty combined with Boari flap-psoas hitch ureteroneocystostomy is safe and feasible. This novel surgical method provides a promising option for treating long segment ureteral avulsion.

Keywords: Appendiceal onlay flap; Boari flap ureteroneocystostomy; ureteral avulsion; robotic ureteroplasty; case report

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Introduction

Ureteroscopy is used as a common examination and treatment for a variety of ureteral diseases, but possible complications that may arise during ureteroscopy examination such as mucosal injury and edema (1), and ureteral avulsion is one of the serious complications in ureteroscopic lithotomy. The etiology of ureteral avulsion is multifactorial, with several potential contributing factors. Inflammatory edema and scar hyperplasia induced by ureteral calculi lead to the changes in the anatomy of the ureter. Meanwhile, ureteroscopic lithotripsy with large rigid ureteroscope also increases the risk of ureteral avulsion (2). The management of long segment ureteral avulsion presents a significant clinical challenge. In recent years, the application of autologous tissue patch technology has been promoted and has yielded encouraging results. The application of appendix for ureteral reconstruction has a rich history spanning over a century, and ureteroplasty with an appendiceal onlay flap is safe and feasible for patients with complex ureteral strictures demonstrated by multiple institutions (3-5). Laparoscopic appendiceal onlay flap ureteroplasty has been used to repair ureteral strictures, maintaining the blood supply of the ureter and enlarge the lumen of the ureter (6). In patients with long segment ureteral avulsion, Boari flap technology has been developed into a useful treatment method for upper urinary tract reconstruction, but there are some adverse effects on bladder function (7). In order to avoid the potential damage of bladder function resulting from excessive use of bladder flap and minimize additional complications, the appendiceal onlay flap ureteroplasty combined with Boari flap ureteroneocystostomy was performed to repair ureteral avulsion. As far as we know, robotic ureteroplasty with appendiceal onlay flap ureteroplasty combined with Boari flap ureteroneocystostomy to repair ureteral avulsion has not been previously described. We herein present the novel technique and our initial findings. We present this case in accordance with the CARE reporting checklist (available at https://tau.amegroups.com/article/view/10.21037/tau-2024-655/rc).

Highlight box

Key findings

- A novel combined technique for the treatment of long ureteral avulsion is reported.

What is known and what is new?

- Current treatments for ureteral avulsion, such as ileal ureteral replacement, frequently result in a higher incidence of complications.
- We propose appendiceal onlay flap ureteroplasty combined with Boari flap-psoas hitch ureteroneocystostomy to treat long segment ureteral avulsion.

What is the implication, and what should change now?

- Our novel combined technique is a feasible option for treating ureteral avulsion.
- Various autologous tissue combination techniques can be considered for long ureteral injury.

Case presentation

Patient

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal. The patient was a 64-year-old male, who was diagnosed with right ureteral avulsion based on his medical history, clinical symptoms and antegrade pyelography. Ureteroscopic holmium laser lithotripsy and extracorporeal shock wave lithotripsy were performed previously. The ureteroscope body was locked during the ureteroscopic holmium laser lithotripsy and the ureteral avulsion occurred when the ureteroscopy was withdrawn from the ureter. The perioperative data were prospectively collected, and the surgical results were assessed (*Table 1*).

Preoperative preparation

Percutaneous nephrostomy was performed immediately to relieve pressure and preserve the renal function after ureteral avulsion. The location and length of the ureteral injury were demonstrated on anterograde and retrograde urography. Antegrade urography results indicated the absence of the middle and distal ureteral segment in the patient, and cystography revealed a maximum bladder capacity of approximately 400 mL. Moreover, computed tomography (CT) was used to visualize the regional anatomy surrounding the affected ureter (*Figure 1*). The patient received intravenous antibiotics to prevent a urinary tract infection. The specific medication regimen is: Etimicin,

Table 1 Characteristics of the patient

Parameters	Outcomes
Age, years	64
Gender	Male
Body Mass Index, kg/m^2	21.30
Surgical history	UHLL, ESWL
Location of ureteral calculi	Proximal
Laterality	Right
Length of ureteral avulsion, cm	20
Maximum bladder capacity, mL	400
Preoperative hydronephrosis, mm	35.6
Preoperative hydronephrosis in SFU, grade	3

ESWL, extracorporeal shock wave lithotripsy; SFU, Society for Fetal Urology; UHLL, ureteroscopic holmium laser lithotripsy.

100 mg, bid, iv drip. Antibiotics were administered from 3 days preoperatively to 5 days postoperatively. Preoperative oral laxatives and routine bowel preparation were performed to prepare for the possible change of surgical method to ileal ureteral replacement. The patient was informed of all possible plans, and understood the risks and complications of surgery.

Surgical technique

Patient positioning

Subsequent to the general anaesthesia with nasotracheal intubation, the patient was positioned in the 15° lateral decubitus with the diseased side facing upwards and in the 20° Trendelenburg position. Robotic ports placement is shown in *Figure 2*. The first 8 mm camera port was designed 1cm above the umbilicus marked 1. The second 8 mm port was placed below the costal margin of the right midclavicular line marked 2. The third 8 mm port were placed above the anterior superior iliac spine of the left midclavicular line marked 3. One of the 12 mm assistant ports was placed 5cm above the midpoint between port 1 and port 2, and the other one was placed 4cm above the midpoint between port 1 and port 3, marked as 4 and 5, respectively.

Exposure of the ureter

Five trocars were used, of which one was the camera port, two were the robotic ports, and two were the assistant port. The peritoneum was longitudinally incised at the level of the iliac vessels, and a careful dissection was performed to separate the right ascending colon mesocolon from the abdominal wall in order to accurately identify and isolate the residual ureter. Due to the severe adhesions surrounding the kidney and ureter, it presents a challenge to accurately discern the location of the ureter. Inject indocyanine green (ICG) dye into the renal pelvis through the nephrostomy tube, which helps to visualize the normal proximal ureter and confirm the presence of ureteral calculi. After locating the ureteral calculi along the dilated ureter, we made a longitudinal ventral incision with scissors from the site of the ureteral calculi to the proximal end of the ureteral avulsion, and the patency of the ureteral lumen was assessed using a 10 French (Fr) urinary catheter. The middle and distal ureter was not visible.

Dorsal ureteral reconstruction with Boari flap and residual ureter by end-to-end-anastomosis

A volume of 250 mL of saline was injected into the bladder through catheter. The anterior and lateral aspects of bladder were released completely, which will provide sufficient tissue to reconstruct the ureter. The left and right ejaculatory duct, as well as the adjacent blood vessels and nerves, were carefully protected during the surgical procedure. The bladder was brought to the outer layer of the right psoas muscle after dividing the urachus and contralateral medial umbilical ligaments. The seromuscular layer of the bladder and psoas muscle fascia were secured using a 3-0 absorbable suture. The ureteral reimplantation could not be performed directly because of the long segment ureteral avulsion. The length of the ureter requiring construction was measured by 5 Fr ureteral catheter, which facilitated accurate reconstruction of the ureter and minimizes unnecessary waste of bladder tissue. The distance between the distal end of the ureter and the fixed bladder was measured to be approximately 14 cm. The dimensions of the Boari flap were outlined using electrocautery, and the length-width ratio was 2:1. The Boari flap was incised and harvested with robotic electric scissors. Meanwhile, the bladder mucosal layer was incised with cold scissors as much as possible, which is more beneficial for preservation of the capillary. Reserve a 10cm long and 6cm wide Boari flap from the bottom of the bladder, the top of Boari flap was fixed onto the proximal stump of the spatulated ureter with 4–0 absorbable sutures and anastomosed to the dorsal side of proximal ureter with 5–0 absorbable sutures.

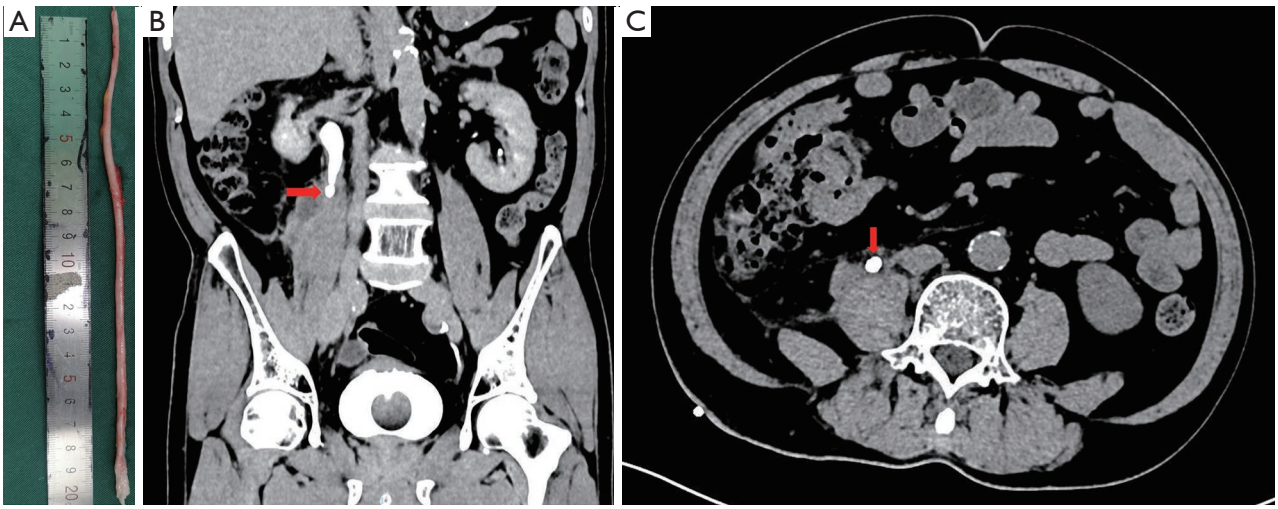

Figure 1 Avulsion of ureter and CTU. (A) The 20 cm right ureteral avulsion. (B,C) The coronal and axial planes of CTU show the presence of ureteral calculi (red arrows) and absence of the middle and distal ureter. CTU, computed tomography urography.

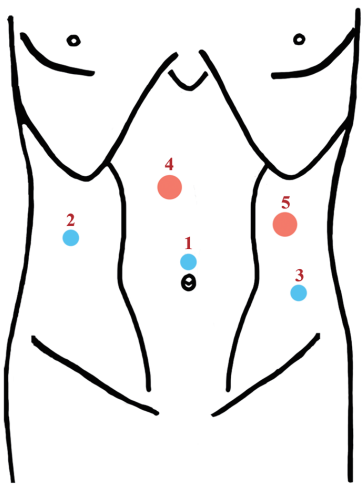

Figure 2 Robotic ports placement. The 8 mm camera port was designed at the position marked 1, the second and third 8 mm robotic ports were placed at the position marked 2 and 3, and the 12 mm assistant ports were placed at the position marked 4 and 5. The difference in colors represents the different sizes (8 mm/12 mm).

Obtain the appendiceal onlay flap and reconstruct the ventral side of the ureter

The appendix was located within the right side of the abdominal cavity without congestion or swelling. The appendix root was released and the root of the appendix was excised after ligation. The root of appendix was ligated by 1-0 silk braided non-absorbable suture, and excised from the caecum while preserving its mesoappendix. Then the appendix was trimmed and detubularised along its antimesenteric border and no inflammatory secretion and fecalith were found. Before anastomosing the appendix to the ureter, the appendix lumen and root were disinfected with iodophor gauze strips. The distal appendix was anastomosed to the ventral side longitudinal incision of the proximal ureter, and the appendiceal and ureteral mucosa were sutured from the proximal to the distal. The length of the appendiceal onlay flap was approximately 4 cm. The edges of the spatulated ureter and appendiceal onlay flap were anastomosed in a running fashion using 4-0 absorbable sutures. A 4.7-Fr D-J stent was placed into the ureter with a guidewire prior to suturing, which should reach the renal pelvis. The appendiceal onlay flap and Boari flap were anastomosed in an interrupted fashion using 4–0 absorbable sutures, which can provide more blood supply for Boari flap. The Boari flap was created and tubularized in a running fashion using 4-0 absorbable sutures, and the incision of bladder was closed by 3-0 absorbable suture in a running fashion. A drain was placed near the anastomosis in the pelvis at the end of the operation (*Figure 3*).

Results

The following summarizes the clinical characteristics and surgical results (*Table 2*). The surgery was performed successfully on the robotic platform without intraoperative complications. The operation time was 310 min, and the

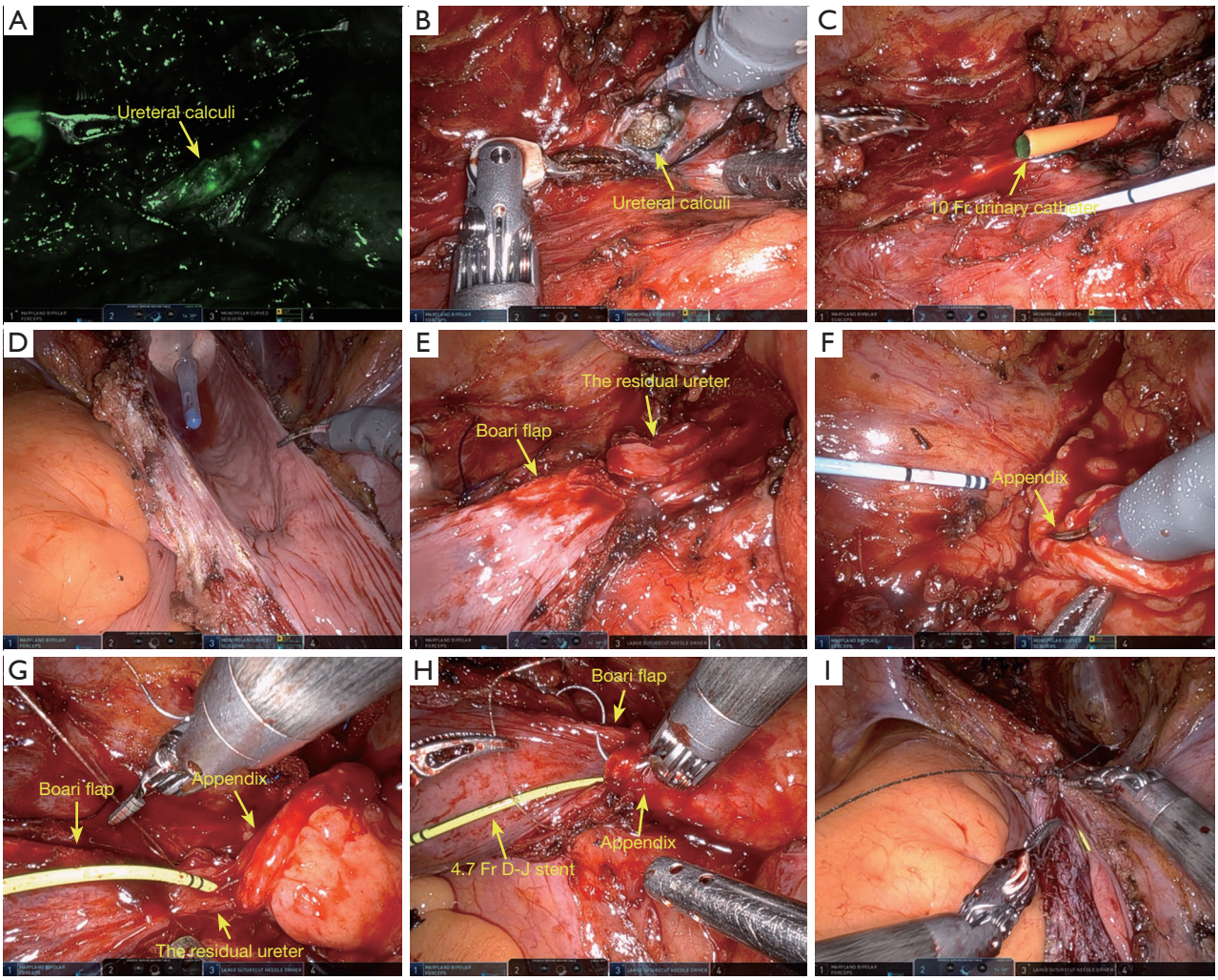

Figure 3 Pictures of the main steps of the surgery. (A) ICG was injected into the renal pelvis to visualize the normal proximal ureter and confirm the presence of ureteral calculi. (B) The ventral wall of dilated ureter was incised with scissors and the calculi within ureter was removed outside. (C) A 10 French (Fr) urinary catheter to examine the ureteral lumen patency. (D) The required Boari flap was marked and harvested. (E) The top of Boari flap was anastomosed to the dorsal side of the residual ureter. (F) The appendix was incised and detubularised on the opposite side of the appendix mesentery. (G) The appendiceal onlay flap was anastomosed to the ventral side of the residual ureter. (H) The appendiceal onlay flap and Boari flap were anastomosed. (I) The Boari flap was created and tubularized in a running fashion. ICG, indocyanine green.

estimated blood loss was 20 mL. The drain was removed on the sixth postoperative day after confirming no blood and urine extravasation, the Foley catheters was removed at 14 days postoperatively. The ureteral stent was removed 7 weeks after surgery and antegrade urography showed no obstruction of the reconstructed ureteral segment (*Figure 4*). During follow-up visits, a comprehensive symptomatic assessment, urinalysis, ultrasound, urography, computed tomography urography (CTU), and radionuclide renal imaging were conducted. After 15 months of follow-up, the right kidney's glomerular filtration rate (GFR) improved marginally from 24.1 to 24.9 mL/min postoperatively. The maximum capacity of the bladder was approximately 290 mL. No proximal ureteral dilatation or hydronephrosis was detected on the right side by ultrasonography and CT scan. The renal function did not exhibit further deterioration, and the previously dilated pelvis and calyces displayed distinct sharp appearances, indicating absence of upper urinary tract

Table 2 Summary of perioperative data

Parameters	Outcomes
Operation time, min	310
Estimated blood loss, mL	20
Length of the appendiceal onlay flap, cm	4
Length of the Boari flap, cm	10
Length of stay after surgery, days	7
Removal time of urinary catheter, days	14
Removal time of ureteral stent, weeks	7
Removal time of the nephrostomy tube, weeks	8
Preoperative maximum bladder capacity, mL	400
Postoperative maximum bladder capacity, mL	290
Postoperative hydronephrosis, mm	0
Postoperative hydronephrosis in SFU, grade	0

SFU, Society for Fetal Urology.

obstruction. Ureteroscopy 10 months after surgery also confirmed the patency of the ureteral lumen (*Figure 5*).

Discussion

Open urological procedures, such as ureterolithotomy and nephrolithotomy, used to be the leading cause of ureteral injuries, whereas nowadays majority of ureteral injuries occur during endoscopic ureteral procedures (8). Despite significant advancements in minimally invasive treatment for ureteral calculus, patients undergoing extracorporeal shock wave lithotripsy and ureteroscopic lithotripsy remain susceptible to iatrogenic ureteral injury (9). The incidence of ureteral injury was 0.2–6.0% in urological procedures (10,11). Furthermore, ureteral injury resulting from gastrointestinal or gynecological surgery is a prevalent etiology (7). The incidence of ureteral injury was 0.08–1.2% in gynecological surgery and 0.15–1.9% in colorectal surgery (12-15). The incidence of ureteral avulsion during ureteroscopy is minimal, typically ranging from 0.16% to 1.0% (11,16-18). The proximal portion of the ureter is at a higher risk of avulsion due to its relatively lower muscular tissue support (17).

The management of long segment ureteral avulsion is a significant challenge for urologists, as various treatment options currently present difficulties in achieving successful outcomes (19). The presence of ureteral calculi can induce inflammation and subsequent formation of strictures in the ureter mucosal, increasing fragility and reducing elasticity of ureteral tissue (1). Ureteral stricture segment may tightly constrict around the body of the scope during the movement of ureteroscope. The disparity in dimensions between the ureteroscope and the ureter can also serve as a potential contributing factor to ureter avulsion (20). Additionally, the inexperienced urologists have also been identified as potential risk factors in certain studies (21-23).

Close monitoring and prompt intervention are crucial in managing this potentially severe complication. The therapeutic principle of ureteral avulsion is to promptly reconstruct the ureter and perform ultrasound-guided percutaneous nephrostomy in order to prevent secondary renal function damage and maximize protection of renal function. Delaying the repair of ureteral avulsion may result in the loss of ureteral length due to subsequent fibrosis (17). The classical operation is laparotomy and ileal ureteral replacement. However, in cases where the operation room facilities or general condition of patients are limited, the initial management will only include percutaneous nephrostomy (2).

For long segment ureteral avulsion, there are two ultimate therapeutic approaches, including ileal ureteral replacement and renal autotransplantation. Ileal ureteral replacement has been proven to be a reliable method for complex urinary reconstruction, but the operation is complex, with many complications such as anastomotic site stricture, urinary tract obstruction, vesicoureteral reflux, and retrograde infection, which limit the clinical application (1). In a previous study involving 105 patients who underwent ileal ureteral replacement, 27 patients (25.7%) encountered short-term grade III and IV complications, while 49 patients (46.7%) experienced grade II complications (24). With advancements in surgical techniques and the enhanced visualization and meticulous dissection provided by robotic platform, the frequency of complications associated with ileal ureteral replacement has decreased (25). Renal autotransplantation is a viable, albeit less commonly utilized, approach for severe ureteral avulsion, but it is not be used as a routine treatment option except for severe trauma and organ loss related to nephrectomy (2).

With the continuous development of robot-assisted laparoscopic techniques, remarkable advancements have been made in the field of minimally invasive therapy for ureteral injuries (26). Robot-assisted laparoscopic surgery has a three-dimensional magnified view, high degree of freedom, and stability of the robotic arm compared

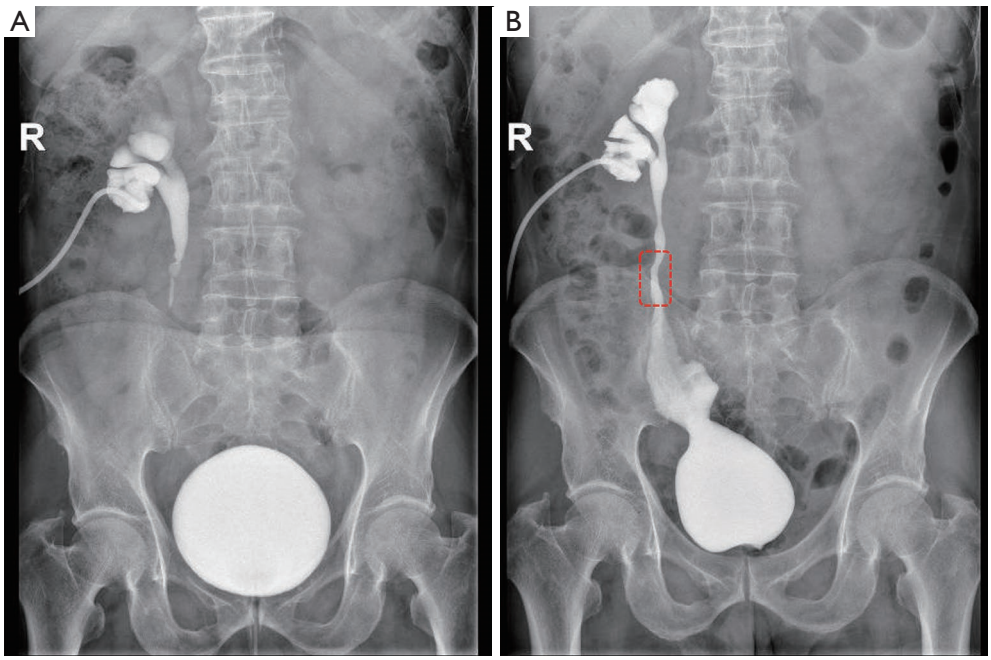

Figure 4 Antegrade urography and cystography. (A) Preoperative antegrade urography and cystography. (B) Antegrade urography 7 weeks after surgery. The reconstruction segment of the appendiceal onlay flap is marked by a red frame.

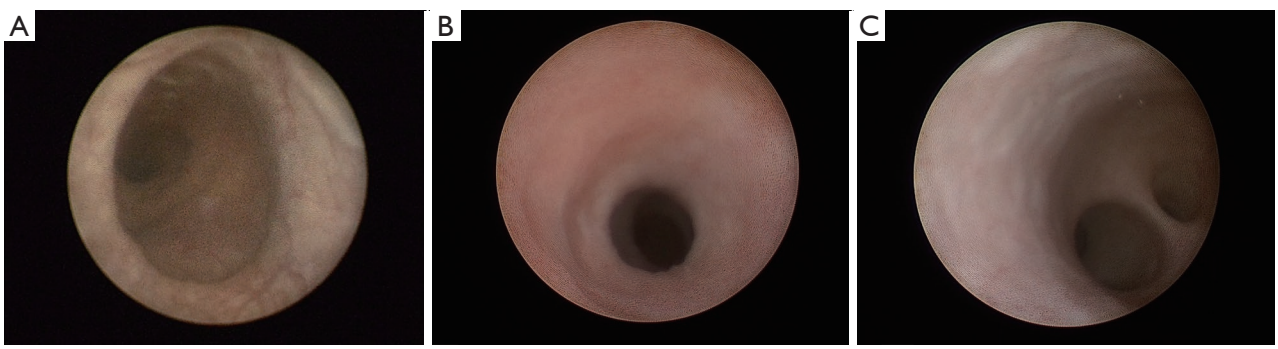

Figure 5 Images of ureteroscopy. (A) Initial segment of Boari flap. (B) Junction of appendiceal onlay flap and Boari flap. (C) The reconstructed ureteral lumen is unobstructed, and the renal pelvis is visible.

to traditional laparoscopic surgery (27). Robot-assisted ureteral reconstruction techniques have demonstrated favourable outcomes and fewer postoperative complications than open surgery (28,29). Based on the length and location of the ureteral injury segment, various treatment options can be employed for ureteral reconstruction. Appendiceal onlay flap has a long history of application in ureteral reconstruction, and has been proven to be an excellent treatment option for patients with complex right proximal and middle ureteral strictures (4,30). Appendiceal ureteral reconstruction avoids ileal ureteral replacement and reduces the risk of systemic acidosis due to its small metabolite absorption surface area (31). Nevertheless, the use of the appendix remains constrained by its restricted length, making it unsuitable for repairing long segment ureteral injuries. Furthermore, the appendix is primarily used for the repair of right ureteral injury, owing to its anatomical constraints. For distal ureteral injury, ureterovesical reimplantation or Boari flap combined with psoas hitch is feasible. However, Boari flap ureteroneocystostomy with

psoas hitch may cause the decrease in bladder capacity and function, and long segment lesions may result in an excessive amount of tension at the site of anastomosis (32).

To avoid the damage to bladder function caused by excessive use of bladder flaps, our team has used lingual mucosal graft ureteroplasty combined with Boari flap ureteroneocystostomy for patient with long complex ureteral strictures, and the short-term results suggest that it is a safe and feasible option (33). Moreover, we have also tried other combined techniques to repair complex long segment ureteral strictures, and achieved excellent results (34,35). The diameter and structure of the appendix resemble those of the ureter, and the blood supply of appendiceal onlay flap is excellent, making appendix a suitable alternative for the ureter. The bladder mucosal layer was carefully incised with cold scissors to maximize preservation of the capillary. Meanwhile, we secured the ileocecal region to the psoas muscle in order to prevent avulsion of the appendix mesentery and ensure adequate blood supply at the junction of the appendix and bladder flap. Different from the traditional Boari flap ureteroneocystostomy, the top of the Boari flap was anastomosed to the dorsal side of the residual ureter, and the appendiceal onlay flap was placed into the ventral defect, which help to save the use of the Boari flap, thereby protecting bladder function and capacity. We creatively proposed this idea based on past experience and it was proved to be safe and effective. While comprehensive perioperative data were collected, the study is limited by the small sample size and short follow-up duration. We will follow up to collect longer term data and accumulate more cases.

Conclusions

Appendiceal onlay flap ureteroplasty combined with Boari flap-psoas hitch ureteroneocystostomy appears to be safe and feasible for treating ureteral avulsion. Larger series with extended follow-up are needed to further validate the effectiveness of this technique.

Acknowledgments

None.

Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://tau.amegroups.com/article/view/10.21037/tau-2024-655/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tau.amegroups.com/article/view/10.21037/tau-2024-655/coif). B.L. was supported by Zhongnan Hospital of Wuhan University, China (No. rcyj20230102). The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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