Original Article

Experience managing distal ureteral strictures with Boari flap-psoas hitch and comparison of open and laparoscopic procedures

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Background: To summarize our experience with the Boari flap-psoas hitch and compare the indications, perioperative data and outcomes between open and laparoscopic procedures.

Methods: This study retrospectively reviewed 35 patients with complex distal ureteral stricture between January 2015 and April 2019. All patients were treated with Boari flap-psoas hitch by either an open or a laparoscopic procedure. Selection criteria were based on the etiology, comorbidities, medical history, and patient preference.

Results: All surgeries were performed successfully. The median operation time was 201 min (range, 120 to 300 min), and the median estimated blood loss was 50 mL (range, 20 to 400 mL). The median postoperative hospitalization was 9 days (range, 3 to 46 days). Nineteen patients were treated by the open procedure, and 16 were treated by the transperitoneal laparoscopic procedure. The surgical indication of open surgery was broader than that for laparoscopic surgery. For patients experiencing iatrogenic injury and ureterovesical reimplantation failure, no significant differences in sex, laterality, operative time, ASA score or postoperative hospitalization stay were observed between the two groups. The median estimated blood loss was lower in the laparoscopic group than in the open group (P=0.047). Patients in the open group had more surgical complications than patients in the laparoscopic group (P=0.049). The postoperative follow-up showed the radiological resolution of hydronephrosis in 33 patients.

Conclusions: With the appropriate surgical considerations, Boari flap-psoas hitch is a valid method to bridge distal ureteral defects. For select patients, laparoscopic surgery had advantages being a minimal invasive surgery with less estimated blood loss and fewer surgical complications.

Keywords: Adult; laparoscopy; reconstruction; ureteral stricture

Submitted Mar 23, 2020. Accepted for publication Sep 27, 2020.
doi: 10.21037/tau-20-789
View this article at: http://dx.doi.org/10.21037/tau-20-789

Introduction

Ureteral strictures can arise because of a variety of reasons, including trauma, iatrogenic injury, tumors, lithiasis or congenital disorders. Iatrogenic injury is the most common cause of ureter injuries (1), and the distal ureter is the most vulnerable site (2). Ureteral reconstruction surgery is always necessary to prevent further consequences. Successful ureteral reconstruction should achieve a wide, tension-free, water-tight anastomosis and preserve adequate vascular

perfusion (3-5). Depending on the etiology, localization, and length of the strictures, different techniques are required (6).

Since the Boari flap and psoas hitch were first described, both techniques have been extensively used to bridge mild and distal ureteral defects (3). The combination of the Boari flap and psoas hitch was first described by Kelâmi *et al.* (7). This procedure can prevent patients with a long segment ureter stricture from developing recurrent urinary tract infections and electrolyte disturbance, which are common following long ureteral reconstruction (8). With the development of medical techniques, laparoscopic surgery has been widely used in urologic surgery. For distal ureter strictures, laparoscopic surgery has similar functional outcomes compared to open surgery (6).

For urologists, ureteral reconstruction is always associated with high surgical difficulties and failure rates, especially reconstruction involving complicated ureteral strictures. In this paper, we described our experience with the Boari flap-psoas hitch, from surgical indications to technique considerations. We present the following article in accordance with the STROBE reporting checklist (available at http://dx.doi.org/10.21037/tau-20-789).

Methods

Patients

Between January 2015 and April 2019, 35 patients (26 females and 9 males) received a modified Boari flap-psoas hitch by the same surgeon (Dr. Li XS). The selection of an open or a laparoscopic procedure was based on the etiology, comorbidities, medical history, and patient preference. Patients in the open group mainly had diseases other than ureteral strictures. Concerning patients in the laparoscopic group, the lesion was usually limited to the distal ureter. Patients always presented at the clinic with flank pain, fever, haematuresis or hydronephrosis found by renal ultrasonography. The location and length of the ureteral stricture were assessed by preoperative radiological studies, including intravenous pyelography (IVP), retrograde pyelography (RGP) and computed tomography urography (CTU). Retrograde urography was used to assess bladder capacity. Renal function was assessed by dynamic radionuclide renography. For selected complicated ureteral strictures, a three-dimensional reconstruction by a high-resolution CT was used to diagnose the stenosis accurately. Postoperative follow-up was carried out at the clinic 3 and 6 months after surgery. Patients routinely underwent a clinical examination, and abdominal ultrasonography at each visit, and CTU at 6 months. We retrospectively collected the hospitalization data, including the demographics, perioperative data, surgical complications and postoperative outcomes. Complications were evaluated by the Clavien classification system (9). Surgical success was defined as the resolution or improvement in subjective pain levels and the improvement of hydronephrosis or resolution of obstruction in ultrasound and CTU. This study was approved by the Ethics Committee of Peking University First Hospital (China) (No.: 2020-SR-283). Informed consent was obtained from all participants. All research procedures were conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Statistical analysis

The software Excel (version 2019) was used for data management. All analyses were performed with SPSS® Statistics, version 24.0. The quantitative variables included age, operative time, estimated blood loss, postoperative hospitalization and follow-up. The qualitative variables included gender, laterality and surgical complications. The Mann-Whitney U test was used for the quantitative variables. The chi-square test and Fisher's exact test were used for the qualitative variables. A two-sided $P<0.05$ was taken to indicate statistical significance. For this analysis, the P value was used to indicate the statistical difference between the open and laparoscopic surgery groups.

Surgical technique

A 20 Fr three-way urethral catheter was placed at the beginning of the operation. The bladder was filled with 300 mL of saline. Patients were secured in the supine position with the affected side angulated 30° to the horizontal (the left side, for example).

For open surgery, a subumbilical midline incision was made to expose the bladder and the ureter. For laparoscopic surgery, a Veress needle was inserted 2 cm above the umbilicus to establish pneumoperitoneum and to place the camera. The pneumoperitoneum pressure was maintained at 14 mmHg. Under direct vision, 2 additional trocars were placed 5 cm below the umbilicus and 5 cm above the umbilicus at the lateral border of the left rectus muscle, serving as operative trocars.

Both open and laparoscopic procedures were performed

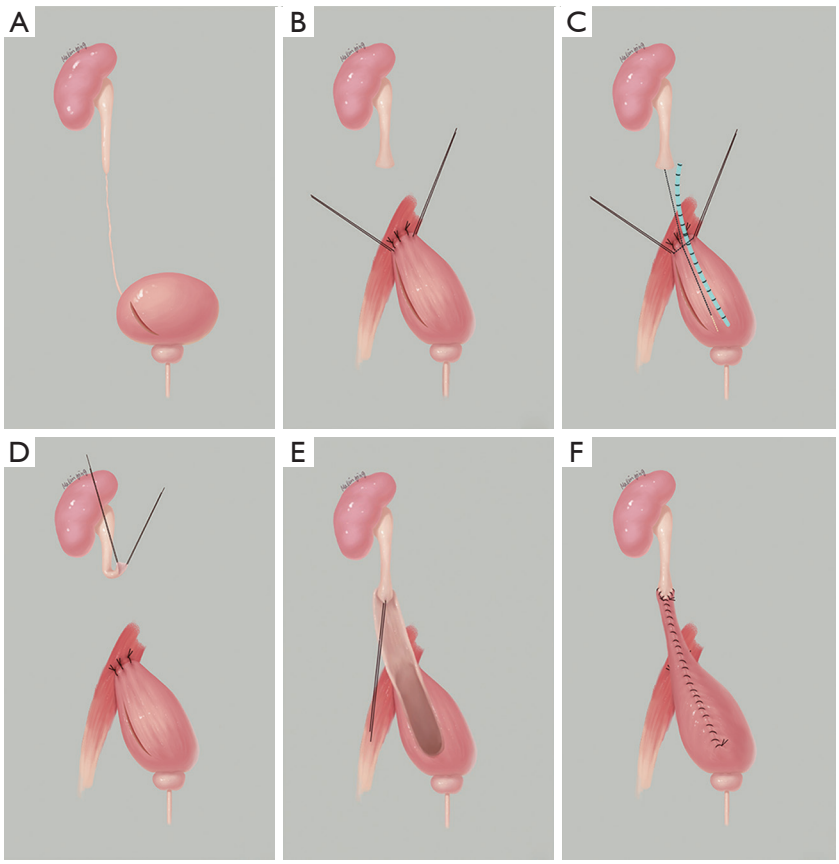

Figure 1 The schematic diagram of Boari flap-psoas hitch. (A) The anterior bladder wall was opened. (B) The bladder wall was fixed to the ipsilateral interior psoas muscle. (C) The distance from the proximal ureteral transverse section to the middle of the base of the bladder flap was measured with a stent. (D) A fine stay suture was placed on the distal aspect of the healthy ureter. (E) The spatulated ureter was sutured to the apex of the flap mucosal incision. (F) The bladder flap was tubularized.

using an intraperitoneal approach. The ureter was identified above the level of the bifurcation of the common iliac artery and mobilized from the stricture to the healthy portion. We then mobilized the anterior and affected lateral wall of the bladder. The anterior bladder wall was opened with a 4-cm transverse dissection (*Figure 1A*). Then, the ureter was cut off at the end of the healthy region, and the distal stump ureter was ligated. The ureter was cut longitudinally for approximately 1.5–2.0 cm for anastomosis. The full thickness of the bladder wall was fixed to the ipsilateral interior psoas muscle by three interrupted 2-0 Vicryl sutures. The fixed location was at the base of the flap for the bladder and at least 2–3 cm above the common iliac vessel for the psoas muscle (*Figure 1B*). A stent with a scale was used to measure the distance from the proximal ureteral transverse section to the middle of the base of the bladder flap (*Figure 1C*). The flap was fashioned to be 2 cm longer than the bridge defect, and the widths of the apex and base were approximately 2–3 and 4–5 cm, respectively. An oblique or S-shaped incision was considered if reconstruction required a greater length and the bladder capacity permitted. A fine stay suture was used in the distal aspect of the healthy ureter (*Figure 1D*). The apex of the flap mucosal incision was sutured to the spatulated ureter by interrupted 4-0 Vicryl sutures (*Figure 1E*), and the flap edges were sutured along the ureter edge with interrupted 4-0 Vicryl sutures. A 7-Fr double J ureteral stent was then inserted in the renal pelvis across the anastomosis. Finally, the flap was tubularized by running 3-0 barbed sutures, and was reinforced by interrupted 4-0 Vicryl sutures when necessary (*Figure 1F*). The bladder was refilled with 250–300 mL of saline to verify the integrity of closure. The urethral catheter was removed two weeks after surgery, and the double J stent was removed one to three

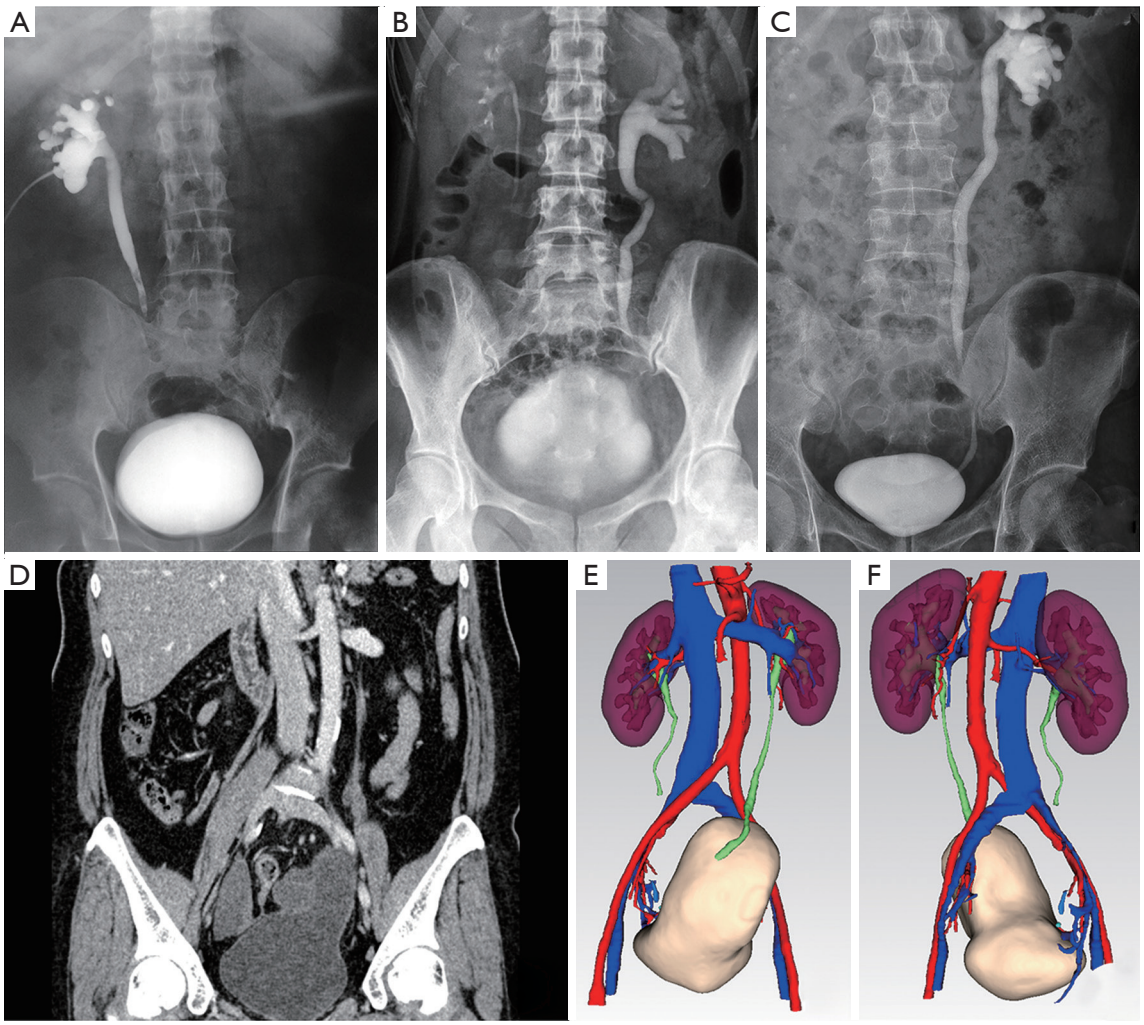

Figure 2 The preoperative and postoperative radiological results. (A) Preoperative antegrade nephrostogram showing a right ureteral stricture. (B) Intravenous pyelogram showing a left distal ureteral stricture. (C) Retrograde pyelogram showing a left ureteral stricture. (D) Postoperative CTU showing the shape of the Boari flap. (E,F) The three-dimensional reconstruction showing the shape of the Boari flap. (E) The anterior aspect of the Boari flap. (F) The posterior aspect of the Boari flap.

months postoperatively in the clinic.

Results

Based on the preoperative radiology examination, all patients presented with a solitary distal stricture, with 19 left-sided and 16 right-sided strictures (*Figure 2A,B,C*). The median age was 46.0 years (range, 20–71 years). The baseline characteristics were shown in *Table 1*. Nineteen patients underwent open surgery, and 16 patients underwent laparoscopic surgery. The median age of patients in the laparoscopic group was 32.0 years (range, 20–60 years), while the median age of patients in the open group was 49.0 years (range, 25–71 years). Patients in the laparoscopic group were younger than patients in the open group (P=0.034).

All the surgeries were completed without any complications or difficulties para operatively. The median operation time was 201 min (range, 120 to 300 min), and the median estimated blood loss was 50 mL (range, 20 to 400 mL). The median postoperative hospital day was 9 days (range, 3 to 46 days). 7 patients in the open surgery group suffered from surgical complications: 2 experienced partial ileus (grade 2), 1 developed a wound infection (grade 3a),

Table 1 The baseline characteristic in the open and laparoscopic surgery groups

Variables	Total
N	35
Median age, years	46 [20–71]
Gender, n	
Male	9
Female	26
Laterality, n	
Left	15
Right	20
Symptoms, n	
Flank pain	11
Abdominal pain	4
Hematuria	4
Fever	3
Nausea	2
No symptoms	18
Operating methods, n	
Laparoscopic surgery	19
Open surgery	16
Median operation time, min	201 [120–300]
Median estimated blood loss, mL	50 [20–400]
Median postoperative hospitalization, days	9 [3–46]
Surgical complications, n	7
Median follow up, months	11.9 (2.8–53.3)

2 developed urinary infections (grade 1) and 1developed transient pain of the genitofemoral nerve area (grade 1). The patients who developed a wound infection stayed in the hospital for approximately 46 days and ultimately recovered following wound debridement surgery.

The indications of ureteral reconstruction surgery are shown in *Table 2*. The most common etiology (12 patients) was iatrogenic injury, followed by failure of ureterovesical reimplantation failure, megaloureter, ureteral tumor, endometriosis, duplex kidney, ureteral tuberculosis and pelvic myofibroblastoma. Iatrogenic injury and ureterovesical reimplantation failure caused 20 cases of ureteric strictures. Among these patients, twelve underwent laparoscopic surgery, and eight underwent open surgery. The characteristic and perioperative data are shown in *Table 3*. There were no significant differences in sex, laterality, operation time, ASA score or postoperative hospitalization stay between the two groups. The median estimated blood loss was lower in the laparoscopic group than in the open group (35 *vs.* 75 mL, P=0.047). Patients in the open group had more surgical complications than patients in the laparoscopic group (P=0.049).

During follow-up, one patient died of rectal cancer, and one patient was lost. With a median follow-up time of 11.9 months (range, 2.8–53.3 months), 27 patients experienced complete pain resolution, 6 patients experienced an improvement in their pain level. An improvement in resolution of hydronephrosis was identified in 30 patients (90.9%), and 12 of these patients experienced complete hydronephrosis resolution (*Figure 2D*,*E1*,*E2*). None of the patients needed an interval procedure, such as replacement of the ureteral stent or nephrostomy tube.

Table 2 The indications for surgery in the open and laparoscopic surgery groups

Indication for surgery	Open group	Laparoscopic group	Total
Iatrogenic ureteric injury	6	6	12
Failure of ureterovesical reimplantation	2	6	8
Megaloureter	1	4	5
Ureteral tumor	5	0	5
Endometriosis	2	0	2
Duplex kidney	1	0	1
Ureteral tuberculosis	1	0	1
Pelvic myofibroblastoma	1	0	1
Total	19	16	35

Table 3 Perioperative data of patients in the open and laparoscopic groups

Variables	Open group	Laparoscopic group	P value
N	8	12	–
Median age, years	48.5 [36–60]	36 [20–60]	0.270
Gender, n			>0.999
Male	3	4	
Female	5	8	
Laterality, n			0.362
Left	5	4	
Right	3	8	
ASA, n			0.351
1	2	5	
2	5	7	
3	1	0	
Median operative time, min	197.5 [120–300]	214 [120–290]	0.427
Median estimated blood loss, mL	75 [20–300]	35 [20–200]	0.047*
Median postoperative hospitalization, days	7 [3–28]	9 [5–18]	0.734
Surgical complications, n	3	0	0.049*

*, P<0.05. ASA, American Society of Anesthesiologists.

Discussion

Ureteral stricture can lead to severe hydrops of the urinary tract and even renal failure. Upper urinary tract reconstructive surgery aims to restore the continuity of the urinary tract and protect renal function (1). Short lower ureteral strictures up to 4–5 cm (10) can usually be managed by ureteroureterostomy or ureteroneocystostomy (11). When a long segment of defect in the distal ureter is discovered, a simple ureteroneocystostomy and ureteroureterostomy results in tension on the anastomosis (12).

Since the psoas hitch was first described by Zimmerman (13) in 1960, it has gradually become an ideal method for distal ureteral reconstruction. The psoas hitch can bridge the distal ureteral gap up to 5–8 cm (14) or even 6–10 cm (10) above the ureteric orifice. For long distal and middle ureteral strictures, the Boari flap is an effective treatment option. The Boari flap allows the bridging of defects up to 12 to 15 cm (3,15). The potential length of the Boari flap depends on the patient's preoperative bladder capacity (16). In addition, the bladder flap originates from ureteral tissue, and it has a rich blood supply, ensuring that the flap can easily survive. Thus, the bladder flap is an ideal substitute material. In selected cases, Li *et al.* created a spiral bladder muscle flap to reconstruct full-length ureteral defects (17). For long distal ureteral strictures, the Boari flap-psoas hitch is a feasible way to bridge ureteral defects. This technique may bridge up to 18 cm of missing ureter with a tension-free anastomosis (3).

To the best of our knowledge, we are the largest research group in China to report the Boari flap-psoas hitch procedure. In our study, to minimize the incidence of recurrent strictures and/or ureteral necrosis, we considered several techniques, and we summarize these factors as the "4TB" principle: tension-free, water-tight, thin suture, no touching of the key area, and protecting the blood supply (18). First, with mobilization of the anterior and affected lateral wall of the bladder, the bladder was fixed at the psoas tendon to decrease the tension. The length of the flap is also an indispensable factor. When we constructed the flap, we measured the distance with a stent accurately (*Figure 3A*,*B*). Some authors have reported that the flap should be 4–5 cm (14) longer than the ureteral gap to make a submucosal tunnel. Simmons *et al.* (4) described that their modified Boari flap

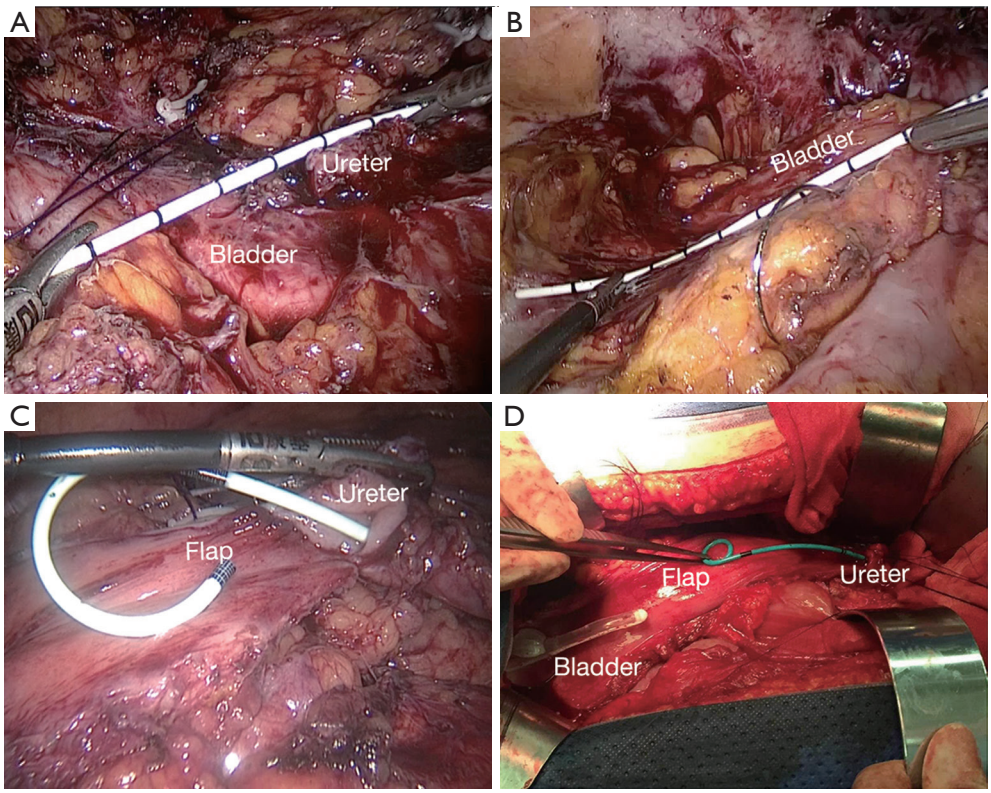

Figure 3 Intraoperative image depicting the Boari flap procedure. (A) Measuring the distance between the proximal ureter and the middle of the base of the bladder flap with a stent. (B) Measuring the length of the flap with a stent. (C) Ureteral-flap anastomosis in a laparoscopic procedure. (D) Ureteral-flap anastomosis in an open procedure.

was designed to be 1.5 times longer than the ureteral defect to ensure a tension-free anastomosis and to prevent tissue shrinkage. In our experience, the bladder flap should be at least 2 cm longer than the ureteral gap for anastomosis in the oblique plane. Because our bladder was fixed on the psoas tendon, our flap was settled, and the tissue would not shrink extensively. Second, the wide apex and base always preserve the vasculature of the flap. Some authors have reported that the length/width ratio of the bladder flap should be no more than 3:1, and the base of the flap should be no less than 4 cm (16). Based on our initial experience, the widths of the apex and the base should be approximately 2–3 and 4–5 cm, respectively (*Figure 3C,D*). Third, we preferred the psoas minor tendon as the recommended anchor for bladder suspension to avoid the femoral or genitofemoral nerve.

There are different precautions for distal ureteral strictures caused by different etiologies. Iatrogenic injury and previous surgical history always cause complicated ureteral strictures, with inflammation and fibroplasia developing around the ureter (2). Extra attention should be paid when exposing the ureter to protect the blood supply of the ureter. Recognition of the anatomical structure is quite important during surgery for benign and congenital diseases because some structures are unusual. For other reasons, such as tumors, surgeons need to rule out potential intrinsic or extrinsic malignancies and assess the viability of the lesion (19).

All patients in this study received the Boari flaps-psoas hitch successfully. However, this procedure is a still challenging if the length of the bladder flap is found to be insufficient during the operation. In our experience, we first extend the length of the bladder flap properly. Excessive prolongation may cause insufficient blood supply to the bladder valve and eventually lead to failure of the operation. Second, we try to free the kidney and fix it downward to reduce the length of the ureteral defect and reduce the tension on the anastomotic. Third, the ileal ureter is the last resort in ureteral repair. When necessary, the Boari flap-psoas hitch combined with ileal ureter can be used to shorten the length of the ileal graft so that the risk of

Table 4 Reports of laparoscopic ureteral reimplantation in adults

Authors	Year	LBF case/ LUR	Mean stricture length (cm)	Mean operation time (min)	Mean hospital stay (d)	Mean estimated blood loss (mL)	Mean/median follow-up (mo)
Rassweiler JJ *et al.* (6)	2007	4/10	2.85	228	9.2	370	NA
Seideman CA *et al.* (19)	2009	18/45	3	NA	3	150	25.2
Simmons MN *et al.* (21)	2007	3/12	1.8	NA	2.6	86	23
Castillo OA *et al.* (22)	2013	30	7	161.16	4.86	123	32
Gözen AS. *et al.* (23)	2010	9/24	2.92	215	8.7	283	35
Ghosh B *et al.* (24)	2018	2/22	NA	170.2	6	115	25.4
Singh M *et al.* (25)	2018	7/20	NA	184.25	3.05	153.25	22.35

LBF, laparoscopic Boari flap; LUR, laparoscopic ureteral reimplantation; N/A, not available.

postoperative complications is reduced, especially for patients with borderline creatinine levels and slightly poor renal function (20).

As techniques have developed, minimally invasive methods have been widely used in ureteral reconstruction. Several teams have performed ureteral reimplantation involving the Boari flap in laparoscopic approaches, as shown in *Table 4* (6,19,21-25). In our research, the first laparoscopic Boari flap-psoas hitch procedure was performed in November 2015, and more patients have been treated using laparoscopic procedures in recent years. Based on the previous research, compared with open procedures, laparoscopic procedures offer a similar functional outcome with the advantages of being minimally invasive (6).

In our study, the most common etiology of distal ureteral strictures was iatrogenic ureteric injury. The surgical indications for laparoscopic and open surgeries differ. Laparoscopic surgery is suited for patients with iatrogenic ureteric injury, ureterovesical reimplantation failure and most benign diseases. However, indications for open surgery are broader. Open surgery can be used in patients with malignant diseases such as tumors, tuberculosis, and some complicated congenital and benign diseases such as a duplicated kidney and pelvic myofibroblastoma. Patients in the laparoscopic group were younger than patients in the open group, which may be associated with surgical indications. After comparing patients experiencing similar etiologies, we found that laparoscopic surgery showed the advantages of being minimally invasive, with less estimated blood loss and fewer surgical complications. From our initial experience, both laparoscopic and open surgeries can be performed successfully with a good prognosis. Laparoscopic surgeries are suited for selected patients and require the advanced laparoscopic surgical techniques of urologists.

The main limitations of our study were that it was a retrospective study. The laparoscopic Boari flap-psoas hitch for a broader etiology of ureteral stricture was lacking. Moreover, the sample size was small because of the relative low incidence, and the follow-up needs to be longer. For further study, prospective studies with larger sample sizes and longer follow-up durations are needed to evaluate the long-term outcomes of the technique.

In conclusion, Boari flap-psoas hitch is available for bridging complex distal ureteral defects in both open and laparoscopic approaches. This technique achieves a water-tight, tension-free anatomic reconstruction and preserves adequate vascular perfusion. Laparoscopic surgery shows the advantage of minimally invasive surgery with fewer surgical complications than open surgery. Larger series with longer follow-up periods need to be studied in the future.

Acknowledgments

The authors are grateful for Madam Xinying Ma, who is an outstanding medical illustrator, and the entire staff of the Department of Urology, Peking University First Hospital.
Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at http://dx.doi.org/10.21037/tau-20-789

Data Sharing Statement: Available at http://dx.doi.

org/10.21037/tau-20-789

Peer Review File: Available at http://dx.doi.org/10.21037/tau-20-789

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/tau-20-789). The 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. The present study was approved by the Institutional Ethics Committee of Peking University First Hospital (China) (NO.:2020-SR-283). Informed consent was obtained from all individual participants included in the study. All research procedures were conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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Cite this article as: Ding G, Cheng S, Li X, Fang D, Yang K, Tang Q, Zhang P, Hao H, Li X, Zhou L. Experience managing distal ureteral strictures with Boari flap-psoas hitch and comparison of open and laparoscopic procedures. Transl Androl Urol 2021;10(1):56-65. doi: 10.21037/tau-20-789

