

Robot-assisted laparoscopic repair of injuries to bladder and ureter following gynecological surgery and obstetric injury: A single-center experience

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Abstract

Introduction: The objective of the study is to evaluate the outcome of robot-assisted laparoscopic repair of injuries to urinary tract following gynecological surgery and obstetric injury.

Methods: This retrospective analysis from prospectively collected data of repair of injuries to bladder and ureter using da Vinci Si robotic platform was carried out. Between April 2014 and May 2019, 27 patients were operated on in a single surgical unit; 25 had hysterectomy and 2 were obstetric cases. Fifteen patients underwent vesicovaginal fistula (VVF) repair, ten underwent ureteral reimplant, with concomitant psoas hitch, and two underwent Boari flap repair following gynecological surgery and obstetric injury.

Results: Among 15 patients of VVF repair, 3 cases were previously attempted failed repair, 2 underwent concomitant ureteral reimplant, and 1 underwent concomitant ovarian cystectomy. The mean total operative time was 126 (75–206) min, and the mean hospital stay was 4.4 (3–6) days. Among 12 cases of ureteral injury, 5 were on the right side and 7 were on the left side; the mean total operative time was 150.16 (110–215) min, and the mean hospital stay was 4 (3–7) days. No case required conversion to open in this cohort. All cases were successfully cured without any recurrence of fistula or stricture during their mean follow-up period of 35.3 (9–66) months.

Conclusions: Robot-assisted laparoscopic repair for injuries to bladder and ureter is effective and highly successful even in previously failed cases.

Keywords: Gynecological surgery, obstetric injury, robot-assisted laparoscopy, ureterovaginal fistula, vesicovaginal fistula

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INTRODUCTION

The incidence of urinary tract injury in gynecologic laparoscopy for benign indications is reported to be 0.33%.^[1] The bladder is three times more commonly injured than the

ureter. In a systematic review of 37 studies, the reported incidence of bladder and ureter injuries is 0.1%–0.2% and 0.03%–0.05%, respectively, among total laparoscopic hysterectomy cases done for benign indications. Further,

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laparoscopic-assisted vaginal hysterectomy has more incidence of bladder and ureteral injuries of 0.9%–1.2% and 0.2%–0.3%, respectively. Moreover, the reported incidence of vesicovaginal fistula (VVF) and ureterovaginal fistula (UVF) is 0.02%, respectively. Historically, in countries with poor obstetric care, VVF arises mainly because of either prolonged obstructed labor or instrumentation during delivery. In countries with adequate obstetric care, 90% of VVF cases are caused by gynecological procedures. Hysterectomy, both with the transabdominal and transvaginal approaches, is the most common procedure that results in fistulae. Hysterectomy alone accounts for 75% of cases of VVF.^[2] Other causes comprise gynecological malignancies and pelvic radiation therapy. Approximately 10%–12% of individuals with VVF have associated ureteral injury, UVF. Instruments involved in electrocoagulation are associated with most ureteral injuries incurred during minimal invasive surgery. Laparoscopic reconstructive surgery in the pelvis is technically challenging and is associated with longer operative time. With the introduction of da Vinci Si robot, we had performed robotic surgery in 27 cases of bladder and ureteral injuries. The aim is to evaluate the outcome of robotic-assisted laparoscopic repair of injuries to bladder and ureter.

METHODS

After permission from the institutional review board and ethics committee approval, all patients who underwent robot-assisted laparoscopic repair of VVF and UVF/ureteral

stricture from April 2014 to May 2019 period were retrospectively analyzed. All surgeries were performed by a single surgeon who has extensive experience in robotic surgery. Our institute is a tertiary urology care center, and patients were referred from other hospitals. The extent of urinary tract injury was assessed by computed tomography (CT) urography, cystoscopy, and vaginal examination. In case of isolated ureteral injury, where endoscopic double-J (DJ) stenting failed, a percutaneous nephrostomy (PCN) tube was kept. Preoperative details of patients, total operative time, port placement and docking time, console time, estimated blood loss, length of postoperative hospitalization, duration of catheterization, complication, if any, and follow-up period were recorded [Table 1].

The outcome in terms of cure rate in case of VVF was defined by continence (patient perception of no leakage) on removal of catheter and findings of no leakage on voiding cystourethrogram, and in case of UVF, cure rate was defined as asymptomatic, no incontinence, along with no dilatation of upper urinary tract.

Operative procedure

Under general anesthesia, a Foley catheter was inserted and povidone-iodine-soaked pack was kept in the vagina to prevent loss of pneumoperitoneum.

All received third-generation cephalosporin at the time of induction and continued in the postoperative period. Closed technique was used for creating pneumoperitoneum

Table 1: Patients preoperative, intraoperative, and postoperative details

Preoperative details	VVF (n=15)	UVF/ureteral stricture (n=12)
Age (years)	37.27 (26-45)	44.3 (38-52)
BMI (kg/m ²)	24.30 (16.67-30.13)	26.08 (19.17-31.60)
Fistula size (mm) antecedent surgery	12.2 (5-35)	
Obstetric cause hysterectomy	2	Nil
AH	5	2
TLH	6	8
LAVH	1	1
VH	1	1
Time of presentation after index surgery (months) mean time to repair	2-36	0.5-4.2
After index surgery (months) (n=12)	4.1 (2.7-13.0)	3.0 (1.5-5.5)
After last failed repair (months) (n=3)	10.6 (6-19)	NA
Intraoperative		
Docking time (min)	23.33 (16-39)	19.5 (16-25)
Console time (min)	80.53 (45-150)	110 (65-175)
Total operative time (min)	126 (75-206)	150.16 (110-215)
Estimated blood loss (ml)	32 (5-85)	40 (20-60)
Interposition tissue, n		
Omentum	13	
Appendices epiploica of sigmoid colon	2	
Postoperative details		
Hospital stay (days)	4.4 (3-6)	4 (3-7)
Duration of catheterization (days)	18 (13-24)	2.6 (2-3)* 7**
Complication	Nil	Nil
Follow-up (months)	34.4 (9-66)	36.5 (24-66)

*Ureteral reimplant, **Boari flap. BMI: Body mass index, AH: Abdominal hysterectomy, TLH: Total laparoscopic hysterectomy, LAVH: Laparoscopic-assisted vaginal hysterectomy, VH: Vaginal hysterectomy, VVF: Vesicovaginal fistula, UVF: Ureterovaginal fistula

using a Veress needle, and port placement was done as per Figure 1A. A patient was given 30° Trendelenburg positioning, and docking of da Vinci Si robot was carried out. The bladder was bivalved by Mini-O’Conor vesicotomy technique^[3] up to fistula site by monopolar curved scissor. Fistula was identified, and its relation to bilateral ureteric orifices was confirmed. Fistula was circumscribed, dissecting bladder off the fistulous tract, creating a lateral margin of viable tissue to allow tension-free closure. The vaginal wall was further mobilized to allow tension-free closure. Vagina was closed in two layers, nonoverlapping fashion using 3-0 polyglactin suture: first layer in continuous manner and second layer in interrupted manner. Interposition tissue either omentum or appendices epiploica of sigmoid colon was advanced over vaginal closure and sutured distal to vaginal closure. The bladder was subsequently closed in a single layer using 2-0 polyglactin suture in a continuous manner [Figure 1B]. Bladder integrity was checked by inflating it with 250 cc saline, and no leakage from suture line was confirmed. No drain was kept except in one who underwent repair after the previous three failed attempts, and there were two defects, measuring 30 mm and 5 mm, and bilateral DJ stents were also kept. DJ stents were also kept in 2 more patients who underwent concomitant ureteral reimplantation. Port closure was done in a standard fashion.

For ureteral reconstruction, a modified Lich-Gregoir technique was used. After mobilizing the colon, a healthy ureter was identified at bifurcation of common iliac artery and dissected distally up to stricture segment. The ureter was clipped proximal to stricture and transected. A healthy ureter was spatulated at 6 o’clock position. The bladder was dropped sufficiently by incising medial umbilical ligaments laterally and caudally up to pubic symphysis. After moderately distending the bladder with saline, the bladder wall was hitched to ipsilateral psoas tendon using interrupted 2-0 polypropylene suture to have tension-free anastomosis. Subsequently, detrusor was incised on its anterior aspect and bladder mucosa was dissected. Mucosal rent was made. Mucosal-to-mucosal ureteroneocystostomy was created using 4-0 polyglactin in an interrupted fashion [Figure 1C]. Subsequently, detrusor muscle was closed over the ureter to create nonrefluxing anastomosis. No stent was kept.

Two patients underwent Boari flap repair because of long segment stricture. The procedure was done as described laparoscopic previously.^[4] Briefly, after moderately distending the bladder with normal saline, bladder flap of appropriate length, with its base width 4 cm at dome and apex width 2 cm, proximal to bladder neck were marked with curved monopolar scissor. Subsequently, after emptying the bladder, the flap was cut with cutting current. The bladder dome was

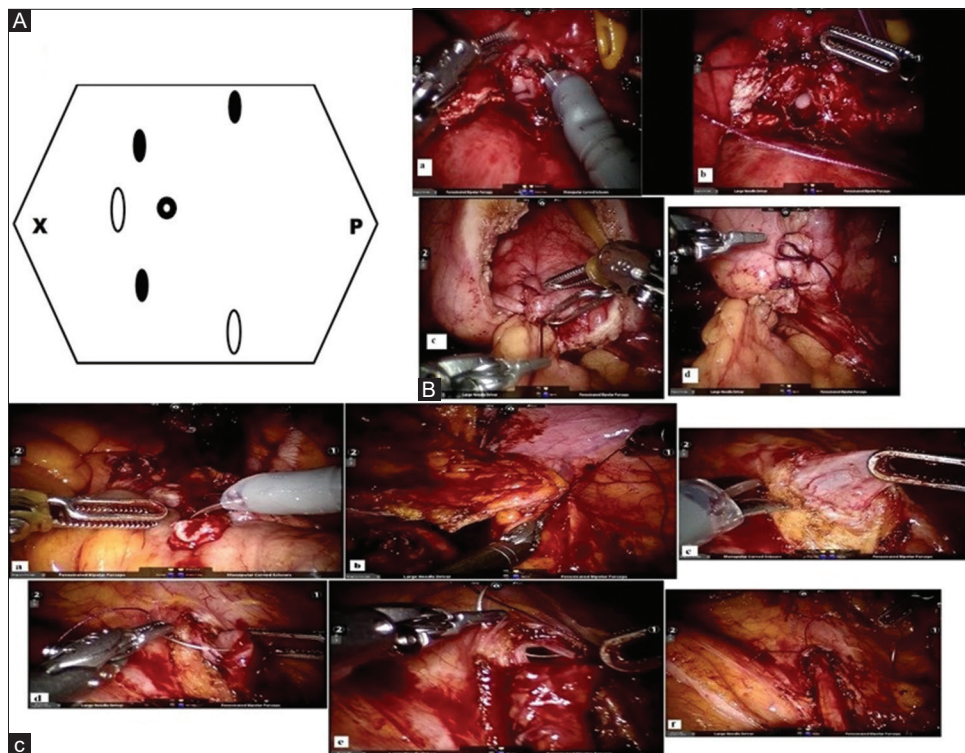


Figure 1: (A) Port placement: X: Xiphisternum; P: Pubic symphysis; Donut: Umbilicus; Oval solid: 12 mm port, Oval empty: 8 mm port; (B) Vesicovaginal fistula repair: a: Circumscribed fistula, b: Vagina closure, c: Omental interposition, d: Bladder closure; (C) Ureteral reimplant: a: Ureteral spatulation, b: Psoas hitch, c: Mucosal dissection, d-f: Ureterovesical anastomosis

fixed to ipsilateral psoas tendon. Proximal healthy ureter was spatulated at 6 o'clock position. Tunnel was made after making a small opening, 1 cm distal to apex of flap. End-to-side ureteral-tunneled flap anastomosis was performed with polyglactin 4-0 in an interrupted manner, followed by anterior ureteral flap anastomosis. Subsequently, the bladder was closed in a continuous manner with a 2-0 polyglactin suture. PCN tube, whenever present, was blocked intraoperatively and was removed before discharging the patient.

RESULTS

Patients' operative and postoperative details are shown in Table 1. Cause for VVF were hysterectomy (done for benign conditions :dysfunctional uterine bleeding, fibroids, prolapse and endometriosis) in 13 cases; vacuum suction application during vaginal delivery in one case; and cesarean section in another one case. In this cohort of VVF repair, three cases were previously attempted failed repair. One case was attempted twice transvaginally, and once laparoscopic, another case underwent previous transvaginal repair and the third one underwent previous failed open transabdominal repair. Two patients underwent concomitant ureteral reimplant and one concomitant left ovarian cystectomy. Location of fistula was supratrighonal in all the cases. Omentum was used as an interposition tissue in all patients except in two in whom appendices epiploica of sigmoid colon was used as an interposition tissue. All cases were successfully done without any need for open conversion. All tolerated liquid diet 6–8 h postsurgery. Analgesia was given in the form of oral tablet diclofenac for 24–48 h. All received tolterodine for 48 h. The postoperative hospital stay was 3–6 days. Micturating cystourethrogram was performed in all patients varying from 13 to 24 days' postoperative period to exclude any leak. All patients were continent during a mean follow-up period of 34.4 months.

Indications for surgical repair in ureteral injuries were persistence of fistula in two cases and development of ureteral stricture in one case (after initial successful DJ stenting); failed DJ stenting in two cases; and obliterative ureteral stricture and backpressure changes at 2–6 months in seven cases (where DJ stenting was not attempted). In this cohort, seven patients initially underwent PCN diversion to relieve the obstruction. Ten patients underwent robotic ureteral reimplantation by a modified Lich-Gregoir technique with concomitant psoas hitch. Two patients underwent Boari flap repair. All were successfully cured clinically and on radiological imaging during their mean follow-up period of 36.5 months.

DISCUSSION

Bladder injury mostly occurs during dissection of the bladder from the lower uterine segment and upper vagina. Bladder injuries are at least three times more common during abdominal hysterectomy compared with vaginal hysterectomy. Most commonly, it is unrecognized iatrogenic cystotomy near vaginal cuff, but potential risk factors which are prone to intraoperative bladder injury are pelvic inflammatory disease, diabetes, endometriosis, prior uterine surgery, prolonged and obstructed labor with distended bladder, emergency cesarean section, placenta previa and or accrete. Chances of bladder injury increase threefold in case of repeat cesarean versus primary cesarean. Bladder injuries, if not timely recognized and repaired, lead to VVF. In agreement with Agrawal *et al.*^[5] and Bora *et al.*,^[6] majority of the fistulae in the present series were result of hysterectomy, in contrast to historical literature in which obstetric complications are reported as the most common cause in developing countries. Urinary fistula can appear 1–6 weeks after gynecologic or obstetric surgery, and recurrent fistula can appear within 3 months of primary fistula repair.^[7]

To improve chances of successful repair, fistula should be approached either immediately (within 1–2 weeks of the insult) or delayed by 8–12 or more weeks after the causative surgery. However, Waaldijk defined immediate repair means <3 months from fistula formation.^[8] Timing of repair remains a matter of debate. The optimal time for repair of VVF has traditionally been 3 months after injury, while earlier intervention has been suggested for UVF.^[9] There is a paucity of data to support early repair. In this cohort, all patients underwent repair beyond 3 months since 92% of cases were referred from various nursing homes where primary surgery was carried out and presented to us after varying intervals. Various factors influence timing including etiology, nature of injury or fistula, and condition of the tissue and the patient. When the fistula site and surrounding tissue are pliable, epithelialized, and free of infection, inflammation, and granulation tissue, there is no point in waiting and the timing of repair should be individualized.

Several advantages to transabdominal approach to a VVF repair have been mentioned in the literature. Although advantages of laparoscopic approach over conventional open surgery have been mentioned in various series, still conventional laparoscopy has limitations of its steep learning curve, inherent difficulty in dissecting out the fistulous tract, and complex intracorporeal suturing. The best approach for the patient is with which surgeon

is comfortable. The da Vinci Si robotic platform is a master-slave system that provides a three-dimensional view that helps in identifying the proper tissue planes between vagina and bladder and further precise dissection preserves well-vascularized bladder and vaginal flaps for closure. Moreover, it gives 10 times magnification, articulated wristed instrumentation with 7° of movements, and ergonomic manipulation of the robotic instruments without fatigue and allows surgeons to perform complex laparoscopic procedures.

VVF repair using da Vinci robot-assisted laparoscopy was first reported by the University of California, Irvine, in 2005 by Melamud *et al.*^[10] In this report, dissection was performed with conventional laparoscopy, whereas suturing was done with robotic assistance and fibrin glue was injected to separate the suture lines. Subsequently, few case reports and case series have been reported^[5,6,11-14] [Table 2].

Classic abdominal transvesical approach was first described in the 19th century by Trendelenburg, made popular by O'Connor, and is hence commonly referred to as O'Connor technique. However, the current trend is toward a limited posterior cystotomy (Mini-O'Connor) approach that has the advantages of reducing the operative time and blood loss and decreases bladder spasm postoperatively. Moreover, robotic assistance allows excellent visualization with 30° lens up, even with limited cystotomy. Different ways to prevent loss of pneumoperitoneum and to identify the fistula have been described like tugging Foley catheter or Fogarty catheter transvaginally across the fistula into bladder,^[15] using end-to-end anastomotic sizer modified with an occlusion balloon for manipulating vaginal cuff,^[16] using petroleum jelly-soaked sponge in the vagina. However, through a small fistula, it is difficult to pass a Foley catheter; ureteric catheter over a guidewire can be negotiated. Fogarty catheter is more expensive than a ureteric catheter. Sotelo *et al.* have mentioned switching off robotic camera light while focusing light from cystoscope to locate the fistula, but their technique involves additional assistant from patient cart side and difficulty in performing cystoscopy using rigid cystoscope unless side docking is performed.^[15,17] In our study, we used only

povidone-iodine-soaked sponge in the vagina and did not find any loss of pneumoperitoneum.

Although closure of the bladder in double layer has been described in various series,^[16,17] Miklos *et al.* revealed a similar cure rate following single- or double-layer closure.^[18] Sokol *et al.* group in their animal study has shown the superiority of double-layer closure in comparison to single-layer closure.^[19] We routinely perform a single-layer bladder closure using 2-0 polyglactin suture.

Von Theobald *et al.* described omental flap interposition during laparoscopic VVF repair.^[20] Omentum may not always be available due to previous abdominal surgeries and associated adhesions. To separate bladder and vaginal suture lining, various other tissues such as adjacent peritoneal flap from iliac fossa or from pararectal space, adventitial layer of the bladder, and sigmoid fatty epiploica^[21] have been described. Biological fibrin sealant used in addition to native flaps or alone has also been described by Agrawal *et al.*,^[5] but the use of biological sealant may lead to VVF recurrence as reported by Sotelo *et al.*,^[15] who found fistula recurrence in 1 out of 2 patients after their use. In 2017, Matei *et al.* demonstrated the success of robotic-assisted VVF repair without omental interposition.^[22] It is still debatable the need for interposition tissue because there is no randomized study to document the success of repair with or without interposition tissue. In our opinion, interposition tissue, whenever available, should be used to avoid overlapping suture line of vagina and bladder closure; it should minimize the fistula recurrence.

UVF may be an unfortunate sequel of a ureteral injury, unrecognized at the time of surgery. Injury to ureter is a risk during vascular, colonic, gynecologic, and urological surgeries. Gynecological surgery accounts for majority of the cases where pelvic portion of ureter is most commonly injured. The incidence of ureteral injury in gynecological surgery is estimated to be 0.04% for abdominal hysterectomy, 0.02% for vaginal hysterectomy, and 0.8%–4.3% for laparoscopic hysterectomy.^[23] Laparoscopic-assisted vaginal hysterectomy is the most common cause of iatrogenic ureteral injury worldwide.

Table 2: Results of published series of robotic vesicovaginal fistula repair

Author	n	Total OT (min)	EBL (ml)	Hospital stay (days)	Duration of catheter (days)	Success rate
Sundaram <i>et al.</i> , 2006 ^[11]	5	233 (150-330)	70	5 (4-7)	10	5/5
Hemal <i>et al.</i> , 2008 ^[12]	7	141 (110-160)	90	3 (2-4)	14	7/7
Gupta <i>et al.</i> , 2010 ^[13]	12	140-console time	88 (50-200)	3.1	14-21	12/12
Gellhaus <i>et al.</i> , 2015 ^[14]	10	249.1 (117-416)	52.8 (25-100)	2.1 (1-5)	14	10/10
Agrawal <i>et al.</i> , 2015 ^[5]	10	214 (120-457)	43 (5-100)	1-5	13 (10-16)	10/10
Bora <i>et al.</i> , 2017 ^[6]	30	133 (53-250)	50	7.5	NA	28/30
Present series, 2020	15	126 (75-206)	32 (5-85)	4.4 (3-6)	18 (13-24)	15/15

OT: Operative time, EBL: Estimated blood loss, NA: Not available

Ureteral injuries may result from laceration, transection, or avulsion or from ischemic necrosis related to ligation, clamping, or cautery injury, resulting in UVF or ureteral stricture.

CT urography is the most commonly used diagnostic modality and remains the gold standard for the detection of ureteral injury, including fistula.^[24] However, intravenous urography and retrograde pyelography can also be considered to evaluate ureteral injuries.

Case series have shown a very lower success rate with endoscopic stenting.^[25] However, putting PCN tube temporarily has the advantages of salvaging renal function of that unit and nephrostogram, later on, gives us an idea of length and level of stricture. In this cohort, stenting was tried whenever feasible but with no success. PCN tube was put temporarily wherever indicated to prevent further deterioration of renal unit.

Laparoscopic ureteroneocystostomy with psoas hitch for posthysterectomy UVF is associated with lower incidence of vesicoureteral reflux and obviates the need for extensive mobilization of ureter.^[26] The bladder must be released sufficiently from its anterolateral attachments and fixed to psoas tendon for tension-free ureterovesical anastomosis.

Literature on robotic-assisted laparoscopic repair of ureteral injuries following gynecological surgery is sparse^[27-30] [Table 3]. Patil *et al.* in 2008 in their robotic series of 12 patients of ureteric reimplantation with psoas hitch had mentioned four patients due to previous gynecological surgery.^[29] Among four, two had ureteral stricture and two had UVF. All the four were managed by robotic-assisted ureteral reimplant with a 100% success rate. Baldie *et al.* in 2012 in their robotic series of 16 patients of ureteral stricture due to varied etiologies had 8 cases of ureteral stricture due to hysterectomy. Amongst 8 cases, secondary to post-hysterectomy stricture, two cases were needed conversion to open surgery because of extensive adhesions:

one case was managed with psoas hitch repair ; another one needed Boari flap procedure.^[30] Moreover, they used side docking over ipsilateral iliac spine and used an open-ended ureteral catheter to identify stricture length and location by flushing it with normal saline and later on for stenting.

Operative indices are variable among various surgeons. It depends not only upon surgeon expertise but other factors such as complexity of the case, re-do cases, or concomitant procedures. Moreover, few authors report only console time. Hospital stay in this cohort was comparable to available literature.

Complications in review of documented cases (<100) in the literature, including this series of robotic-assisted VVF repair, have been minimal. Gellhaus *et al.* mentioned Clavien Grade 3 complications in one patient with significant colonic dilatation, requiring colonoscopic decompression. In his report, 4.1% developed ureteric obstruction after robotic-assisted repair of ureteral injuries, requiring dilatation and stenting. Bora *et al.* in their series of 30 patients of robotic-assisted VVF repair reported a success rate of 93%, being recurrence in two patients, both being complex fistula.

Multi-institutional report of robotic management of genitourinary injuries had shown a 100% success rate of VVF repair and a 90.9% success rate of ureteroneocystostomy, without any open conversion. This cohort has also shown successful results even in previously attempted failed VVF repair and ureteral reconstruction with a 100% success rate. Our technique differs from the previously described technique (multi-institutional report from Gellhaus *et al.*) in the following ways: bladder defect was closed in a single layer using polyglactin 2-0, and leak-proof test was performed to check the integrity of closure. Ureteral reimplant technique involves interrupted suturing using polyglactin 4-0, in contrast to continuous suturing using poliglecaprone 3-0. DJ stent was not kept in this series, although 58.33% of patients had PCN tube *in situ*.

Table 3: Published series of robotic-assisted laparoscopic repair of ureteral injury

Author	Repair type (n)	Mean operative time (min)	EBL (ml)	Stent (%)	Hospital stay (days)	Mean follow-up (months)
Mufarrij <i>et al.</i> , 2007 ^[27]	UR-PH (3)	239.5	35 (20-50)	100	3.5	12.5
Laungani <i>et al.</i> , 2008 ^[28]	UR (3)	100.33	72.66 (52-102)	100	1.2	6
Patil <i>et al.</i> , 2008 ^[29]	UR-PH (4)	208 (80-360)	48 (45-100)	100	4.3 (2-8)	15.5
Baldie <i>et al.</i> , 2012 ^[30]	UR-PH (6) UR (1) Boari flap (1)	258.6 (146-450)	171 (30-500)	100	2.5 (1-8)	6.4 (2-18)
Gellhaus <i>et al.</i> , 2015 ^[14]	UU (15) UR (22)	227.5 214.4	89.7 88.1	100	2.2 (1-5) 2.4 (1-8)	16.6
Present series, 2020	UR-PH (10) Boari flap (2)	146.4 (110-215)	25-60	None	4 (3-7)	36.5 (24-66)

UR: Ureteral-reimplant, UR-PH: UR with psoas hitch, UU: Ureteroureterostomy, EBL: Estimated blood loss

CONCLUSIONS

In the hands of an experienced robotic surgery team, robot-assisted laparoscopic repair of injury to urinary tract is safe and effective, even in setting of challenging characteristics such as recurrent VVF repair, and requiring concomitant abdominal procedures such as ureteral reimplantation and other surgical procedures. However, the major limiting factor for robot-assisted laparoscopic surgery remains a high cost that includes installation, instrument cost, and maintenance cost.

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Conflicts of interest

There are no conflicts of interest.

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