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Postoperative bladder dysfunction and outcomes after minimally invasive extravesical ureteric reimplantation in children using a laparoscopic and a robot-assisted approach: results of a multicentre international survey

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Objectives

To assess and compare postoperative bladder dysfunction rates and outcomes after laparoscopic and robot-assisted extravesical ureteric reimplantation in children and to identify risk factors associated with bladder dysfunction.

Patients and Methods

A total of 151 children underwent minimally invasive extravesical ureteric reimplantation in five international centres of paediatric urology over a 5-year period (January 2013–January 2018). The children were divided in two groups according to surgical approach: group 1 underwent laporoscopic reimplantation and included 116 children (92 girls and 24 boys with a median age of 4.5 years), while group 2 underwent robot-assisted reimplantation and included 35 children (29 girls and six boys with a median age of 7.5 years). The two groups were compared with regard to: procedure length; success rate; postoperative complication rate; and postoperative bladder dysfunction rate (acute urinary retention [AUR] and voiding dysfunction). Univariate and multivariate logistic regression analyses were performed to assess predictors of postoperative bladder dysfunction. Factors assessed included age, gender, laterality, duration of procedure, pre-existing bladder and bowel dysfunction (BBD) and pain control.

Results

The mean operating time was significantly longer in group 2 compared with group 1, for both unilateral (159.5 vs 109.5 min) and bilateral procedures (202 vs 132 min; $P = 0.001$). The success rate was significantly higher in group 2 than in group 1 (100% vs 95.6%; $P = 0.001$). The overall postoperative bladder dysfunction rate was 8.6% and no significant difference was found between group 1 (6.9%) and group 2 (14.3%; $P = 0.17$). All AUR cases were managed with short-term bladder catheterization except for two cases (1.3%) in group 1 that required short-term suprapubic catheterization. Univariate and multivariate analyses showed that bilateral pathology, pre-existing BBD and duration of procedure were predictors of postoperative bladder dysfunction ($P = 0.001$).

Conclusion

Our results confirmed that short-term bladder dysfunction is a possible complication of extravesical ureteric reimplantation, with no significant difference between the laparoscopic and robot-assisted approaches. Bladder dysfunction occurred more often after bilateral repairs, but required suprapubic catheterization in only 1.3% of cases. Bilaterality, pre-existing BBD and duration of surgery were confirmed on univariate and multivariate analyses as predictors of postoperative bladder dysfunction in this series.

Keywords

robot, reimplantation, retention, dysfunction, children, complications, #PedUro

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Introduction

During the last 20 years, the Lich-Grégoire method of extravesical ureteric reimplantation using minimally invasive surgery has been described as a safe and effective technique for treatment of vesico-ureteric reflux (VUR) in children [1,2]. It has been associated with a success rate comparable to that of the open intravesical approach but has the advantages of decreased postoperative morbidity (e.g. haematuria and bladder spasms) and shorter hospitalization [3–5]. The extravesical ureteric reimplantation technique has been performed using both a laparoscopic and a robot-assisted approach, with reported success rates ranging from 77 to 100% [6–9]. Bladder dysfunction, including urinary retention, has been reported as a potential complication of extravesical ureteric reimplantation, especially in bilateral cases, caused by injury of the pelvic nerve plexus during ureteric dissection [10–12]. In recent studies performed on adult human cadavers, the pelvic plexus was identified dorsomedial to the ureter at a level distal to the uterine artery in women or the vas deferens in men and dorsocranial to the bladder trigone [13]. For this reason, nerve-sparing techniques have been applied in an effort to avoid injury to the pelvic plexus and the subsequent risk of urinary retention [14,15]. However, these studies lacked a description of the technique used for identifying or verifying the nerve plexus and were difficult to replicate by other surgeons. Key technical factors in preserving the neural plexus have been identified and include limiting dissection at the level of the distal ureter and the vesico-ureteric junction (VUJ), keeping the ureteric adventitia intact, dissection close to the ureteric adventitia, minimal cautery, and minimal dissection at the distal VUJ [16]. Apart from injury to the pelvic plexus, other factors including pre-existing bladder and bowel dysfunction (BBD), postoperative pain, bilateral procedures and anxiety could contribute to postoperative voiding dysfunction with urinary retention [17,18].

As postoperative bladder dysfunction has been mainly attributed to traction or injury of the pelvic nerve plexus during distal ureteric dissection, one could hypothesize that a robot-assisted approach that allows a more precise dissection of ureteric tissues should theoretically produce a lower risk of bladder dysfunction and urinary retention. Based on this premise, the aim of the present multi-institutional international study was to assess and compare postoperative bladder dysfunction rate and outcomes after laparoscopic extravesical ureteric reimplantation and robot-assisted extravesical ureteric reimplantation in children, and to assess risk factors that predict the occurrence of postoperative bladder dysfunction.

Patients and Methods

A questionnaire-based survey was sent to 10 international centres of paediatric urology via e-mail and the answers were collected and shared across the participating institutions through SurveyMonkey, an online survey development cloud-based software tool. A total of 151 children, who underwent minimally invasive extravesical ureteric reimplantation for primary VUR in one of five international centres of paediatric urology over a 5-year period (January 2013–January 2018), were included in the study. Exclusion criteria included: previous surgery for VUR; secondary VUR (posterior urethral valves, neurogenic bladder); and anomalies, such as duplex kidney and megaureters requiring ureteric tapering.

The children were divided into two groups according to surgical approach: group 1 included 116 children (92 girls and 24 boys), with a median (interquartile range [IQR]) age of 4.5 (2.3–6.5) years and a median (IQR) weight of 22.3 (11.6–32) kg, who underwent laparoscopic extravesical ureteric reimplantation, and group 2 included 35 children (29 girls and six boys), with a median age of 7.5 (5.4–10) years and a median (IQR) weight of 30.8 (27.3–35) kg, who underwent robot-assisted extravesical ureteric reimplantation.

Indications for intervention included breakthrough UTIs in 78/116 children (67.2%) and progressive renal scarring in 96/116 children (82.7%) in group 1 (laparoscopic approach), and breakthrough UTIs in 35/35 children (100%) and progressive renal scarring in 28/35 children (80%) in group 2 (robot-assisted approach). Preoperative VUR grade III was present in 23 children in group 1 (19.8%) and five children in group 2 (14.3%), grade IV was present in 59 children in group 1 (50.9%) and 19 children in group 2 (54.3%), and grade V was present in 34 children in group 1 (29.3%) and 11 children in group 2 (31.4%).

The choice of robot-assisted over laparoscopic approach was primarily determined by robot availability; however, the indications for a robot-assisted approach were restricted to age >2 years and weight >20 kg. All surgical procedures were performed by senior surgeons, with >20 years of experience in laparoscopy and >3 years of experience in robotics. The average volume of their minimally invasive surgery activity was ~500 laparoscopic procedures/year and 22 robot-assisted procedures/year. Two participating surgeons from two different institutions had moved from using a laparoscopic to using a robot-approach.

Bladder and bowel dysfunction was diagnosed preoperatively in 16/116 children in group 1 (13.8%) patients and in 2/35 children in group 2 (5.7%). With regard to evaluation and diagnosis of BBD, all participating physicians in each institution used a questionnaire to assess: daytime frequency; day or nighttime wetting; number of voids during day; holding manoeuvres; urgency; and straining. Any child with daytime enuresis, voiding fewer than three times per day, urinary frequency greater than 10 times per day, urge incontinence and any holding manoeuvres was considered to have 'voiding dysfunction'. Bowel regularity and stool

consistency were also assessed, using the Bristol Stool Scale. Eleven out of 18 children (61.1%) with preoperative BBD had a retentive bladder habit (infrequent voiding and urinary retention) that started a mean of 2.5 years prior to surgery. The remaining 7/18 children (38.9%) presented with voiding dysfunction with detrusor overactivity, urge incontinence and daytime enuresis that started a mean of 2 years prior to surgery and 8/18 children (44.4%) presented with associated constipation (Type I on the Bristol scale in four cases and Type II in the other four cases). All children were prescribed a treatment regimen preoperatively consisting of stool softeners, dietary advice, hydration, timed voiding and, in a few cases, anticholinergic medication (oxybutynin).

Patient demographics are shown in Table 1.

The two groups were assessed and compared with regard to: procedure length; success rate; postoperative complication rate; and postoperative bladder dysfunction rate (acute urinary retention [AUR], voiding dysfunction). Univariate and multivariate logistic regression analyses were performed to analyse predictors of postoperative bladder dysfunction. Factors assessed included age, gender, laterality, duration of procedure, pre-existing BBD, and pain control used.

Follow-up protocol included physical examination after 1 week, ultrasonography after 1 month and voiding cysto-urethrogram 6–9 months postoperatively. A successful outcome was defined as postoperative resolution of the patient's VUR according to voiding cysto-urethrogram. Postoperative complications were assessed according to the

Table 1 Patients demographics and outcome variables for laparoscopic (group 1) and robot-assisted extravesical ureteric reimplantation (group 2).

	Group 1 *n* = 116	Group 2 *n* = 35	Statistical analysis (*P* value)
Patients' demographics			
Boys, *n* (%)	24 (20.7)	6 (17.1)	0.001
Girls, *n* (%)	92 (79.3)	29 (82.9)	0.001
Median (IQR) age, years	4.5 (2.3–6.5)	7.5 (5.4–10)	0.001
Median (IQR) weight, kg	22.3 (11.6–32)	30.8 (27.3–35)	0.55
Preoperative VUR grade, *n* (%)			
I	0	0	
II	0	0	
III	23 (19.8)	5 (14.3)	0.66
IV	59 (50.9)	19 (54.3)	0.55
V	34 (29.3)	11 (31.4)	0.51
Indications for surgery, *n* (%)			
Progressive renal scarring	96 (82.7)	28 (80)	0.81
Breakthrough UTIs	78 (67.2)	35 (100)	0.75
Overall preoperative BBD	16 (13.8)	2 (5.7)	0.004
Infrequent voiding	8/16 (50)	1/2 (50)	
Urge incontinence	2/16 (12.5)	1/2 (50)	
Detrusor overactivity	2/16 (12.5)		
Daytime enuresis	2/16 (12.5)		
Urinary retention	2/16 (12.5)		
Constipation	7/16 (43.7)*	1/2 (50)†	
Operative outcomes			
Unilateral procedures, *n* (%)	81 (69.8)	19 (54.3)	0.66
Bilateral procedures, *n* (%)	35 (30.2)	16 (45.7)	0.57
Mean operating time unilateral procedures, min	109.5	159.5	0.001
Mean operating time bilateral procedures, min	132	202	0.001
Conversions to open surgery, *n* (%)	0	0	
Intra-operative complications, *n* (%)	0	0	
Mean analgesic requirement, h	32.2	31.5	0.55
Mean postoperative bladder catheterization, h	22.8	39	0.31
Mean length of hospital stay, days	1.8	2.6	0.33
Postoperative outcomes, *n* (%)			
Success rate – resolution of VUR on VCUG	111 (95.6)	35 (100)	0.001
Overall postoperative bladder dysfunction rate	8 (6.9)	5 (14.3)	0.17
AUR episodes	6/8 (75)	5/5 (100)	
High PVR	2/8 (25)	0	
Postoperative UTI/BBD persistence	2 (1.7)	0	0.55
Overall postoperative complications rate	6 (5.2)	2 (5.7)	0.55
Clavien I	0	0	
Clavien II	2/6 (33.3)	0	
Clavien IIIb	4/6 (66.7)	2/2 (100)	

*BBD, bladder and bowel dysfunction; IQR, interquartile range; PVR, post-void residual urine volume; VCUG, voiding cysto-urethrogram; VUR, vesico-ureteric reflux. *Three children had Type I on the Bristol Stool Scale and four children had Type II. †One child had Type 1 on the Bristol Stool Scale.*

Clavien–Dindo classification system [19]. Urinary retention was defined as the need for catheterization at any time in the postoperative period during hospital stay or during the follow-up period. This included AUR episodes as well as high post-void residual urine volume (PVR) 6 h after catheter removal. The urinary catheter was removed on postoperative day 1 in all cases. AUR was defined as inability to void, with suprapubic pain and palpable bladder on physical examination. PVR was measured using bedside ultrasonography. A PVR of >50% of the expected bladder capacity 6 h after catheter removal was considered significantly elevated and required catheterization. In children aged <1 year, the expected bladder capacity was calculated using the Fairhurst equation: [bladder capacity (mL): 7 × weight (kg)]. In children aged > 1 year, the expected bladder capacity was calculated using the Koff formula: [(age + 2) × 30].

The present study received the appropriate institutional review board approval. Statistical analysis was carried out using the Statistical Package for Social Sciences version 13.0 (SPSS Inc., Chicago, IL, USA). *P* values < 0.05 were taken to indicate statistical significance. Categorical variables were compared using chi-squared tests, while ordinal variables were compared using Student's *t*-test.

Surgical Technique

All the children underwent surgery under general anaesthesia in the classic supine position, with a Foley catheter positioned in the bladder using the sterile precautions required for bladder hydrodistention intraoperatively. For the laparoscopic approach, a 5- or 10-mm trocar was placed umbilically for 30° optics, and two 3-mm working trocars were placed in the right and left iliac fossa, respectively. For the robot-assisted approach, four trocars were placed. The first 8-mm trocar was always positioned in the umbilicus to produce a camera port, two 8-mm working ports were inserted 7–9 cm apart from the camera port along the mid-clavicular line, and one 5-mm assistant port was then placed to be used by the bedside surgeon to assist the main surgeon. Finally, the da Vinci robot was docked over the patient's feet.

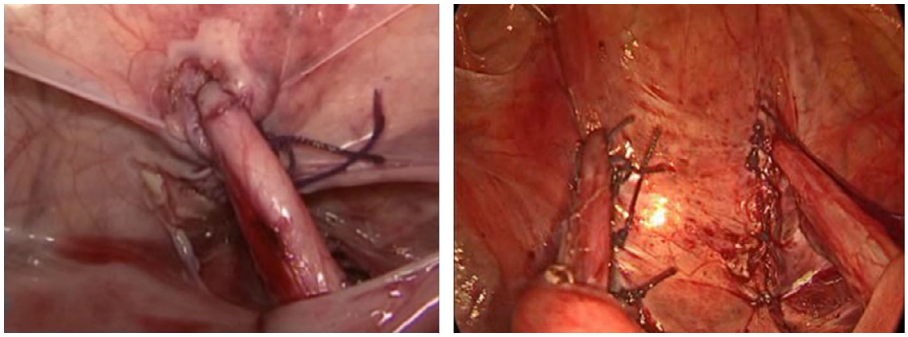
Apart from the trocars' size and position, both approaches followed the same surgical steps. An incision was made in the peritoneum just above the posterior bladder wall on the affected side and then the ureter was dissected. The ureter was mobilized by careful dissection to avoid injuring the vas deferens or uterine artery. A tape was passed around the ureter in order to avoid vascular injury from excessive direct manipulation. After completing the ureteric isolation down to the bladder base, the site and the length of the detrusor tunnel were identified and marked with a line created with the tips of monopolar scissors. After this step, the bladder was prepared for the detrusorotomy by filling it with saline and suspending it with a transabdominal stitch in order to better expose the site of the detrusor tunnel previously identified and ease the detrusorrhaphy. With regard to the length of the detrusor tunnel, we always followed Paquin's law and ensured that the detrusor tunnel had a length ~4–5 times the width of the ureter. A detrusor incision was made till the mucosa was seen pouting out. The detrusor muscle was then separated from the mucosa laterally, establishing the muscular flaps used to create the detrusor tunnel. The detrusor flaps were then wrapped around the ureter and reapproximated using 4/0 polyglactin suture. No ureteric advancement suture was placed and ureteric adventitia was incorporated within the detrusorrhaphy (Fig. 1). The trocar orifices were closed using separate stitches. A bladder catheter was left in place postoperatively in all cases. No other drains were placed after surgery.

All the surgical steps are reproduced in Video S1.

Results

Group 1 (laparoscopic approach) included 81 unilateral procedures (69.8%) and 35 bilateral repairs (30.2%) while group 2 (robot-assisted approach) included 19 unilateral procedures (54.3%) and 16 bilateral repairs (45.7%). No conversions to laparoscopic or open surgery, no major

Fig. 1 Final results after unilateral and bilateral robot-assisted extravesical ureteric reimplantation.



bleeding or other intra-operative complications were reported in either group. No significant differences were recorded between group 1 and group 2 with regard to mean analgesic requirement (32.2 vs 31.5 h; $P = 0.55$), mean postoperative bladder catheterization (22.8 vs 39 h; $P = 0.31$) or mean hospital stay (1.8 vs 2.6 days; $P = 0.33$). The mean operating time was significantly longer in group 2 than in group 1 for both unilateral (159.5 vs 109.5 min) and bilateral procedures (202 vs 132 min; $P = 0.001$). The success rate was significantly higher in group 2 compared to group 1 (100% vs 95.6%; $P = 0.001$). The overall postoperative bladder dysfunction rate was 8.6% and no significant difference was found between group 1 (six AUR episodes and two high PVRs, 6.9%) and group 2 (five AUR episodes, 14.3%; $P = 0.17$). All AUR episodes occurred early, at a mean (range) 1.8 (1–8) days after catheter removal. No tardive bladder paresis was reported in the present series. All episodes were managed with short-term bladder catheterization (mean duration 2.5 days) except for 2/151 children (1.3%), who developed AUR after laparoscopic extravesical ureteric reimplantation and required short-term suprapubic catheterization (mean duration 5 days) for failure of previous bladder catheterization. In particular, these two children had a preoperative history of severe urinary retention that started a mean of 2.5 years prior to the surgery. The suprapubic tube was removed when the child demonstrated the consistent ability to void >50% of bladder volume for 48 consecutive hours. No significant difference was reported between group 1 and group 2 with regard to other postoperative complications (6/116 [5.2%] vs 2/35 [5.7%]; $P = 0.55$). There was one case of transient haematuria (Clavien II) and one case of lower limb compartimental syndrome, attributable to incorrect patient positioning, lasting 3 weeks (Clavien II), and four cases of persistent symptomatic VUR with breakthrough febrile UTIs that were successfully managed with redo surgery (three open reimplantations and one endoscopic Dextranomer/hyaluronic acid copolymer injection) with no further recurrence (Clavien IIIb) were reported in group 1. Conversely, 2/35 children in group 2 (5.7%) who underwent bilateral repair developed a bilateral acute hydronephrosis postoperatively, which was managed with bilateral JJ stenting (Clavien IIIb). In these two children, the JJ stents were removed after 3 months with the spontaneous resolution of hydronephrosis and no need for redo surgery. Postoperative UTI/BBD persistence was reported in 2/116 children in group 1 (1.7%), but no correlation was found between surgical success rate and postoperative UTI/BBD persistence.

The outcome variables for both groups are reported in Table 1.

Univariate analysis revealed bilateral pathology ($P = 0.001$), pre-existing BBD ($P = 0.001$) and duration of procedure ($P = 0.001$) as predictors of postoperative bladder dysfunction. No association was found between age, gender or pain control used and incidence of postoperative bladder dysfunction (Table 2). On multivariate analysis controlling for age, bilaterality, duration of surgery and pre-existing BBD, only duration of surgery and bilaterality were confirmed significant factors associated with postoperative bladder dysfunction (Table 3).

Table 2 Univariate analysis of demographics and operating factors associated with postoperative bladder dysfunction in the children included in the study.

Variable	Bladder dysfunction events *n* = 13 (8.6%)	No bladder dysfunction *n* = 138 (91.4%)	*P* value
Median (IQR) age, years,	4 (2–5)	4 (2–6)	0.8
Boys, *n* (%)	6 (46.1)	24 (17.4)	0.9
Girls, *n* (%)	7 (53.9)	114 (82.6)	0.7
Bilateral procedures, *n* (%)	11 (84.6)	40 (28.9)	0.001
Unilateral procedures, *n* (%)	2 (15.4)	98 (71.1)	0.7
Median (IQR) duration of surgery, min	181.5 (158–210)	147.6 (131–180)	0.001
Pre-existing BBD, *n* (%)	8 (61.5)	10 (7.2)	0.001
Pain control, *n* (%)			
Paracetamol	4 (30.8)	49 (35.5)	0.8
Paracetamol + tramadol	5 (38.4)	49 (35.5)	0.8
Paracetamol + tramadol + ketorolac	4 (30.8)	40 (28.9)	0.7

BBD, bladder and bowel dysfunction; IQR, interquartile range.

Table 3 Multivariate logistic regression analysis of demographics and operating factors associated with postoperative bladder dysfunction in our series.

Variable	OR	95% CI	*P* value
Age (years)	0.934	0.557–1.566	0.795
Bilaterality	1.008	1.001–1.029	0.001
Duration of surgery (min)	1.015	1.005–1.036	0.001
Pre-existing BBD	0.985	0.648–1.498	0.943

BBD, bladder and bowel dysfunction; OR, odds ratio.

Discussion

In the last 20 years, Lich-Grégoire minimally invasive extravesical ureteric reimplantation has gained widespread acceptance as a means of minimizing the morbidity associated with formal open intravesical reimplantation, including lower frequencies of postoperative haematuria and bladder spasms and shorter hospital stay and bladder catheterization time compared to intravesical procedures [3–5]. This technique has been performed using both a laparoscopic and a robot-assisted approach, with reported success rates ranging from 77 to 100% [6–9].

Bladder dysfunction, including urinary retention, has been reported as a potential complication after any type of extravesical ureteric reimplantation, including open

reimplantation, with a reported incidence ranging from 4% to 26% [10,12,20–22]. It was mainly attributed to traction or injury of the pelvic nerve plexus during distal ureteric dissection [22]. In their study based on adult human cadavers, Leissner et al. [13] showed that the main portion of the pelvic plexus was located ~1.5 cm dorsally and at the medial portion of the VUJ; the bundles of the pelvic plexus ended at the distal ureter, trigone and rectum. After these anatomical mapping studies were conducted, different authors attempted to preserve the pelvic plexus by limiting the dissection at the level of the distal ureter and the VUJ, reporting postoperative voiding dysfunction rates ranging from 0% to 8% [15,16]. However, these studies lacked a description of the nerve-sparing technique used for identifying or verifying the nerve plexus and were difficult to replicate by other surgeons. Apart from injury to the pelvic plexus, other factors could potentially play a role in postoperative voiding dysfunction with urinary retention, including bladder overdistention, decreased bladder contractility and decreased micturition reflex activity [18,23,24]. Additionally, pre-existing BBD and other factors, such as postoperative pain, especially in bilateral cases, anxiety and hospital setting, could contribute to such complications [18].

Kawal et al. [25] reported that urinary retention after robot-assisted extravesical ureteric reimplantation was an infrequent complication in their recent series (8.59%) and they found that longer procedures and male gender were associated with a higher risk of urinary retention. In addition, they excluded other covariates such as laterality and prior BBD as additional risk factors for urinary retention [25]. They explained the findings of their study by the fact that technically demanding cases required greater levels of dissection and the significance of operating time as a predictor of postoperative risk was probably attributable to more complex variables such as narrow anatomy or poor visualization than merely the number of steps performed or ureters reimplanted [25].

We found no papers in the international literature that focus on an analysis of bladder dysfunction after laparoscopic and robot-assisted extravesical ureteric reimplantation. For this reason, we decided to organize a multi-institutional survey involving international centres with strong experience in this field in order to collect a large number of patients. In our series of 151 children, the overall postoperative short-term bladder dysfunction rate was 8.6% and was in accordance with the more recent studies [25,26]. We found no difference in bladder dysfunction rate according to the surgical approach adopted, laparoscopic or robot-assisted. In contrast to the data reported by Kawal et al. [25], the present study showed a positive correlation between bilateral procedures and duration of surgery and risk of postoperative bladder dysfunction. Despite the established and logical relationship between bilateral procedures and longer operating times, a longer operating time could be also associated with more technically demanding cases, that may require greater levels of dissection as a result of more complex anatomy or poor visualization, rather than as a result of the number of ureters reimplanted, as highlighted by Kawal et al. [25]. The present results confirmed that each variable was independently associated with the risk of postoperative bladder dysfunction. We also found that prior BBD was predictive of postoperative short-term bladder dysfunction, although an appropriate BBD management regimen including timed voiding and double voiding, was started preoperatively and continued after surgery. Additionally, the present study showed a positive correlation between the severity and type of preoperative BBD and the severity of postoperative bladder dysfunction. In this series of 151 children, two children (1.3%) who underwent laparoscopic extravesical ureteric reimplantation and developed postoperative bladder dysfunction, required positioning of a suprapubic catheter for failure of previous bladder catheterization. These two children had a history of severe urinary retention, starting 2.5 years prior to the surgery, that was probably correlated with the severity of their bladder dysfunction postoperatively. However, considering that all cases of postoperative bladder dysfunction that occurred in our series were temporary, we hypothesize that this was more likely to be related to dissection-related neuropraxia than to neurological damage to the bladder. The time of voiding return, which ranged from 2.5 to 5 days for the children who experienced postoperative bladder dysfunction, was more compatible with neuropraxia than with the time required for nerve regeneration after transection. Prolonged urinary retention, lasting until 8 weeks postoperatively, as reported with open extravesical ureteric reimplantation [11], is only exceptionally observed in cases of laparoscopic or robot-assisted extravesical ureteric reimplantation [12,22] because minimally invasive approaches do not require traction on the detrusor muscle with retractors, and the magnified view allows precise creation of a detrusor tunnel. No cases of prolonged bladder paresis occurred in the present series.

The present results confirmed that postoperative short-term bladder dysfunction after extravesical ureteric reimplantation has multi-factorial causes and families should be counselled with regard to this risk. Furthermore, the information provided by the present study on the average duration of voiding dysfunction may be used to inform patients preoperatively and to guide postoperative care. A history of preoperative BBD should not necessarily represent a contraindication for extravesical ureteric reimplantation, especially in cases with bilateral VUR [10]. Our results highlight the importance of correcting dysfunctional voiding

behaviours before surgery to optimize operative success and reduce postoperative bladder dysfunction rates.

From a technical point of view, in both laparoscopic and robot-assisted extravesical ureteric reimplantation techniques, we usually limit the direct manipulation of the ureter by placing a tape around it and grasping the end of the tape in order to obtain a better exposure of the ureter and ease the ureteric dissection (Video S1). Furthermore, before detrusorotomy, we prepare the bladder by suspending it with a transabdominal stitch and filling it with saline (Video S1); in this way, we are able to perform ureteric mobilization and detrusor dissection as distally as possible until a 5:1 ratio of tunnel length to ureteric diameter according to Paquin's law can be achieved.

We believe that the high success rate that we reported with both laparoscopic (95.6%) and robot-assisted repair (100%) was attributable to the fact that all the procedures were performed by senior surgeons, skilled in minimally invasive surgery, who had mastered the technique and had previously standardized it. In addition, the postoperative complication rate was acceptable, with only four Clavien IIIb complications in the laparoscopic group (3.4%) and two Clavien IIIb complications in the robot-assisted group (5.7%). In particular, the two children in the robot-assisted extravesical ureteric reimplantation group who underwent bilateral repair developed bilateral acute hydronephrosis postoperatively, which was managed with bilateral JJ stenting. The JJ stents were removed after 3 months with the spontaneous resolution of hydronephrosis and no need for redo surgery. We hypothesized that the acute hydronephrosis in these two children was more probably attributable to local postoperative oedema than to a narrow detrusor tunnel. Our hypothesis was confirmed by the bilateral localization of hydronephrosis and its spontaneous resolution.

In conclusion, the results of the present study confirm that short-term bladder dysfunction is a possible complication of extravesical ureteric reimplantation, with no significant difference between laparoscopic reimplantation and robot-assisted reimplantation. Bladder dysfunction occurred more often after bilateral repairs but required suprapubic catheterization in only 1.3% of cases. Bilaterality, pre-existing BBD and duration of surgery were confirmed on univariate and multivariate analyses as predictors of postoperative bladder dysfunction in the present series. We believe that, despite the statistical relevance of our results, further evidence is needed to confirm the clinical relevance of the study findings, and further research should be conducted to investigate the potential role of other factors including surgical learning curves in the development of such complications after minimally invasive extravesical ureteric reimplantation.

Conflict of Interest

None declared.

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Abbreviations: AUR, acute urinary retention; BBD, bladder and bowel dysfunction; IQR, interquartile range; PVR, post-void residual urine volume; VUJ, vesico-ureteric junction; VUR, vesico-ureteric reflux.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Video S1. Robot-assisted Extravesical Ureteral Reimplantation (REVUR): Surgical Technique.

