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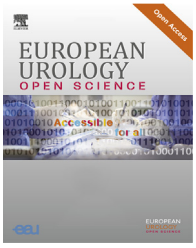

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The LUAA Gundeti Technique for Bilateral Robotic Ureteral Reimplantation: Lessons Learned over a Decade for Optimal (Resolution, Urinary Retention, and Perioperative Complications) Trifecta Outcomes

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Abstract

Background: Ureteral reimplantation is the gold standard treatment for high-grade vesicoureteral reflux (VUR) in pediatric patients. Robot-assisted laparoscopic extravesical ureteral reimplantation (RALUR-EV) using the LUAA technique has emerged as a viable alternative to traditional open and laparoscopic surgical correction.
Objective: To evaluate the outcomes, reflux resolution, urinary retention, and complications associated with bilateral RALUR-EV for primary VUR using the LUAA Gundeti technique in pediatric patients.
Design, setting, and participants: A retrospective study was conducted at a single academic center, involving 34 consecutive pediatric patients who underwent RALUR-EV for bilateral VUR management between December 2008 and December 2022. The study included only patients who were evaluated with postoperative voiding cystourethrogram (VCUG).
Surgical procedure: The LUAA extravesical ureteral reimplantation technique was performed, involving the identification and mobilization of the ureter, creation of a peritoneal window, dissection close to the neurovascular bundle, Y dissection at the ureterovesical junction, detrusorotomy, detrusorrhaphy with advential inclusion, and apical alignment suture.
Measurements: The primary outcome was radiographic resolution of VUR on VCUG. The secondary outcomes included urinary retention and Clavien-Dindo grade III complications.
Results and limitations: The overall radiographic resolution rate was 85.2%, with success rates of 76.7%, 75%, and 96.7% across the three distinct patient cohorts. The overall Clavien-Dindo grade III complication rate was 5.8%, and transient urinary retention was 8.8%. Resolution of urinary retention occurred within 7–28 d. The study's limitations include the small sample size, single-center design, and retrospective nature.

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Conclusions: The LUAA technique demonstrates sustainable outcomes for VUR resolution with a low incidence of transient urinary retention and complications. A thorough understanding of pelvic anatomy is essential for successful dissection and minimization of the risk of complications. Further studies are needed to evaluate the effectiveness of different approaches in reducing the incidence of transient urinary retention following bilateral extravesical reimplantation.

Patient summary: In this study, we examined the results of the Gundeti LUAA surgical technique for treating primary vesicoureteral reflux in children. We identified various essential modifications that increase the likelihood of achieving favorable outcomes.

1. Introduction

Ureteral reimplantation is the gold standard approach for treating high-grade vesicoureteral reflux (VUR) in pediatric patients and has a reported high success rate for reflux resolution. Robot-assisted laparoscopic extravesical ureteral reimplantation (RALUR-EV) was first described approximately two decades ago and has since gained popularity as an alternative to open and laparoscopic surgical correction in pediatric patients [1,2]. The technique was further refined by Gundeti et al [3] using the LUAA acronym, with standard steps described for optimal outcomes. Previous studies have raised concerns about the outcomes of bilateral extravesical reimplantation, whether performed via open, laparoscopic, or robotic-assisted techniques. Specifically, there is a risk of urinary retention, potentially caused by injury to the pelvic nerve plexus during ureteric dissection. Historically, performing one side at a time or possibly an endoscopic injection on the other side has been suggested, leading to additional anesthesia and surgical morbidity [4–6].

To further explore the potential risks associated with bilateral extravesical ureteral reimplantation, we performed a retrospective study to evaluate the outcomes for bilateral RALUR-EV using the LUAA technique. This study aims to determine the rates of radiographic resolution, urinary retention, and perioperative complications. Additionally, we examined potential nuances to the surgical technique that could help reduce the risk of complications.

The strengths of the study include being the largest single-center, single-surgeon analysis with no confounding factors, conducted at an academic institution with refinements at various stages of the technique. In addition, performing postoperative voiding cystourethrogram (VCUG) is a significant strength of our study, as it allows for a more comprehensive evaluation of reflux resolutions compared with previous published studies.

2. Patients and methods

In this retrospective study, we analyzed 34 consecutive patients who underwent robotic-assisted laparoscopic bilateral reimplantation for the management of bilateral VUR between December 2008 and December 2022. The study specifically included patients from all surgeries performed, who were evaluated with postoperative VCUG.

Patients undergoing surgery for ureterovesical junction (UVJ) obstruction (n = 1) and open conversions (n = 1) were excluded from this study. All duplex ureters (n = 4) were counted as a single system. Patients with complex anatomy, including bladder diverticula (n = 1), prior ureterocele incision (n = 1), and deflux (n = 2), were included in the study. The senior author performed the surgical procedure using the LUAA extravesical ureteral reimplantation technique. Patient demographics, perioperative data, and follow-up imaging were collected independently and analyzed from the electronic medical records. Following surgery, patients were observed in the hospital for 2 nights. Prior to discharge, the catheter was removed on postoperative day 2, and a bladder scan was performed to ensure adequate bladder emptying and voided volume. Renal and bladder ultrasounds were conducted at 1 mo and 1 yr postoperatively, with VCUG performed at 4–6 mo postoperatively.

The primary outcome of interest was the radiographic resolution of VUR on VCUG, defined as the absence of VUR on VCUG. The secondary outcomes were urinary retention and Clavien-Dindo grade III complications. Descriptive statistics were used to report patient characteristics, perioperative details, and follow-up data. Urinary retention in this study was defined as the requirement for recatheterization during the hospital stay after a catheter-free voiding trial or during the follow-up period after the operation. The institutional review board approved the study protocol.

To optimize the LUAA technique, it was performed in two phases, resulting in three distinct patient cohorts. The first cohort (group 1) included patients who underwent the procedure before adopting the LUAA technique from the literature, from November 2008 to June 2012. The second cohort (group 2) included patients who underwent the procedure during the implementation phase of the LUAA technique, from June 2012 to August 2013. The third cohort (group 3) included patients who underwent the procedure after the implementation phase of LUAA, where the technique had been further refined and surgical steps were standardized, from August 2013 until December 2022. These distinct cohorts allowed for comparing surgical outcomes at various technique optimization and refinement stages.

The video provides a detailed step-by-step demonstration of the LUAA technique. The technique involves several steps, including identification of the ureter, mobilization of the ureter up to the level of the uterine artery in girls, creation of a peritoneal window, and dissection of the ureter close to the adventia as to avoid neurovascular bundle injury. A Y dissection is then performed at the UVJ, and a detrusorotomy is created that aligns with the UVJ to prevent angulation. The (L) length of the detrusorotomy is standardized for all patients at approximately ~4 cm, and a (U) stitch is used to advance the ureter through the tunnel, followed by a permanent stay stitch at the apex of the detrusor tunnel (A) to align the ureter and prevent slippage. The detrusorrhaphy is performed using a running stitch that incorporates the ureteral adventitia (A), with care taken to ensure that the tunnel is not too tight.

3. Results

The study included 34 patients with VCUG being available for evaluation, who underwent robotic-assisted laparoscopic bilateral reimplantation using the LUAA technique. The mean age at surgery was 5.1 ± 2.4 yr. The median follow-up was 28.5 (5–114) mo. Preoperatively, five ureters had grade 2 reflux (7.3%), which were contralateral to those with three to five degrees of VUR. Twenty-five ureters had grade 3 reflux (36.8%), 30 had grade 4 reflux (44.1%), and eight had grade 5 reflux (11.8%). The mean reflux grades were 3.5, 3.7, and 3.9 in groups 1, 2, and 3, respectively. The overall radiographic resolution rate was 85.2%, with success rates of 76.7% in group 1, 75% in group 2, and 96.7% in group 3. The mean operative times were 210 ± 28, 196 ± 44, and 155 ± 25 min in groups 1, 2, and 3, respectively. The overall Clavien-Dindo grade III complication rate was 5.8% (two cases), all in group 3. The overall urinary retention was 8.8%, with 6.6% of patients in group 1, none in group 2, and 13.3% in group 3. Resolution of urinary retention occurred within 7–28 d. Preoperative demographic details and postoperative outcomes are presented in Table 1.

4. Discussion

In discussing our study of RALUR-EV using the LUAA technique, it is essential to consider the current management strategies for pediatric patients with VUR. Traditionally, conservative approaches such as antibiotic prophylaxis and management of bladder and bowel dysfunction (BBD) have been employed as first-line treatments for these patients. However, some patients with persistent high-grade VUR beyond the expected age of reflux resolution, or those displaying increasing kidney scars, often require surgical intervention. Each surgical technique for VUR correction, including extravesical reimplantation, intravesical reimplantation such as Cohen's procedure, and endoscopic treatment, has its own advantages and drawbacks. Given these complexities, it is crucial to focus on refining and optimizing surgical techniques to provide the best possible outcomes for this challenging subset of patients.

For more than a decade, we have been dedicated to refining and standardizing the LUAA technique for robotic ureteral reimplantation in the management of VUR. Since its introduction in 2011–2012 and our initial report published in 2016, our primary objective now has been to evaluate bilateral reimplantation outcomes, share the results, and highlight some of the nuances associated with the LUAA technique [3].

Since the Lich-Gregoir technique was described, in which detrusotomy is performed starting from the ventral aspect of the ureterovesical hiatus and ending at the top of the bladder, further modifications have been applied over time, including the advancement suture by Zaontz et al [7] and the inverted Y incision at UVJ for laparoscopic procedures by Lakshmanan and Fung [8,9]. We incorporated all these modifications into our technique and added two further additional steps: adventitial inclusion during detrusorrhaphy and apical alignment suture, which is now called the LUAA technique. The key elements of the LUAA technique, such as tunnel length of 3–4 cm (L), the U-advancement stitch, placement of the ureteral apical alignment suture (A), and inclusion of ureteral adventitia (A) in detrusorrhaphy, contributed to the high success rates of reflux resolution. By comparing our results with those of other studies, we can gain a deeper understanding of the advantages of the robotic approach and its potential benefits over alternative surgical methods.

Similar to the trifecta outcomes in robotic prostatectomy, our study focuses on three essential aspects: reflux resolution on VCUG, urinary retention, and Clavien grade 3 complications such as ureteral injury.

4.1. *Reflux resolution*

In our study, we divided the patients into three groups to investigate the effects of optimizing the LUAA technique on surgical outcomes over time. This allowed us to demonstrate the improvements in reflux resolution rates, which reached 96.7% in group 3, where the technique had been refined further and standardized. We observed complete resolution of VUR in 85.2% of ureters across all groups, including 23 of 30 ureters (76.7%), six of eight ureters

Table 1 – Preoperative demographic details and postoperative outcomes after robot-assisted laparoscopic bilateral extravesical ureteral reimplantation

	Group 1	Group 2	Group 3	Overall
No. of patients	15	4	15	34
Total ureters	30	8	30	68
Age (yr), mean (SD)	4.9 ± 1.1	7.3 ± 3.6	4.8 ± 2.9	5.1 ± 2.4
Sex (*n*)				
Male	4	1	5	10
Female	11	3	10	24
Preoperative VUR grade, ureters (*n*)				
2	3	1	1	5 (7.3%)
3	12	3	10	25 (36.8%)
4	14	3	13	30 (44.1%)
5	1	1	6	8 (11.8%)
Operative time (min)	210 ± 28	196 ± 44	155 ± 25	182 ± 39
Radiographic resolution rate (%)	23/30 (76.7%)	6/8 (75%)	29/30 (96.7%)	58/68 (85.2%)
30-d postoperative CDG III, *n* (%)			2 (13.3)	2 (5.8)
Postoperative retention, *n* (%)	1 (6.6)		2 (13.3)	3 (8.8)

CDG = Clavien-Dindo grade; SD = standard deviation; VUR = vesicoureteral reflux.

(75%), and 29 of 30 ureters (96.7%) for technique modification cohorts 1, 2, and 3, respectively.

Over the past decade, numerous surgeons have employed RALUR-EV, with reported surgical outcomes varying between 77% and 100% [2,6,10–15]. In addition, Boysen et al [16], in their prospective multicenter study, demonstrated a radiographic success rate of 93.8% following RALUR-EV for both bilateral and unilateral cases.

4.2. Urinary retention

Transient urinary retention is a known complication of bilateral extravesical reimplantation, with reported rates varying from 0% to 37.5% [17]. Numerous technical modifications have been proposed to reduce this incidence. Leissner et al [18] studied human cadavers and discovered that the main part of the pelvic plexus is approximately 1.5 cm dorsal and medial to the UVJ. Additionally, Yucel and Baskin [19] detailed the distal ureter and UVJ neuroanatomy with clinical implications. They revealed nerves on the medial aspect of the distal ureter and encircling the ureter at the UVJ. David et al [20] applied Leissner et al's [18] findings by limiting medial ureteral dissection and reported a significantly lower urinary retention rate of 2%. We have meticulously followed this principle, limiting distal dissection at the dorsomedial location of the UVJ.

In our study, three patients (8.8%) experienced transient urinary retention following bilateral RALUR-EV: one patient (6.6%) in group 1 and two patients (13.3%) in group 3. Urinary retention resolved spontaneously in all cases within 7–28 d. Notably, two of these patients had a prior history of BBD. Timed voiding charts and biofeedback therapies were beneficial, with one patient requiring alpha-blocker management.

A retrospective multi-institutional study by Song et al [21] found that urinary retention occurred in 7.0% of patients, with BBD being the only factor significantly associated with urinary retention after RALUR-EV. Kawal et al [22] reported postoperative urinary retention requiring catheterization in seven cases (13.5%), associated with male gender and longer operating room time. Esposito et al [23] reported on 57 pediatric VUR patients who underwent robot-assisted extravesical ureteral reimplantation across six institutions. Among the 16 bilateral repair cases, urinary retention was observed in five patients. They found preoperative BBD to be the primary risk factor associated with postoperative morbidity and surgical failure. Boysen et al [16], in their prospective multicenter study, reported transient urinary retention in 7.1% of 56 patients following bilateral RALUR-EV. A summary of selected published reports on bilateral RALUR-EV is presented in Table 2. Given the findings from these prior studies, it may be prudent to address these potential risk factors prior to surgery and adequately counsel families about this possible complication in high-risk patients. Additionally, considering intraoperative suprapubic catheter placement in these children may be an option to avoid potential repeated catheterizations and morbidity.

The rates of urinary retention in our study are significantly lower than those reported previously in the literature. This may be attributed to the enhanced visualization provided by the robotic-assisted approach and proper ureter mobilization within the adventitial planes to prevent damage to the neurovascular bundle and limiting dissection at UVJ toward the dorsomedial location. Additionally, the Y dissection at the UVJ contributes to preservation of neurovascular bundle and vascularity, and reduces the ureteral complications such as obstruction and stenosis. Our advice and essential tips are outlined in Table 3.

4.3. Complications

The overall Clavien-Dindo grade III complication rate was 5.8% (two cases). One patient in group 3 required 1-wk suprapubic catheter management due to suspected urinary leakage, while another patient from the same group underwent open reimplantation on the 5th postoperative day due to inadvertent ureteral injury. There was no ureteral stricture or stenosis in our group.

Grimsby et al [15] reported complications in 10% of their cohort of 61 patients (32 bilateral) who underwent RALUR-EV. The complications included ureteral obstruction in three cases and urine leak in two. Akhavan et al [14] observed a 10% complication rate in their study of 50 patients, for both

Table 2 – Summary of selected published studies on robot-assisted laparoscopic bilateral extravesical ureteral reimplantation

Study (date)	Number of patients (bilateral)	Postoperative VCUG in all patients	Reflux resolution rate (%)	Urinary retention (%)	Duration of urinary retention (d), (mean)	Clavien-Dindo grade III complications	Median operative time (min)
Boysen et al (2018) [16]	56 Multicenter Unilateral and bilateral	Yes	93.8%	7.1% (4/56)	3 (2–14)	5.6%	NA
Kawal et al (2018) [22]	52 Bilateral	No	NA	13.5% (7/52)	4	NA	190
Song et al (2021) [21]	57 Multicenter Unilateral and bilateral	Not clear	94.0% (VUR persistent on VCUG in 6%)	7% (4/57)	14	9.4% (Clavien grade 2)	NA
Esposito et al (2023) [23]	19 (57) Multicenter Unilateral and bilateral	Not clear	96.5%	8.7% (5/57)	13 (5–21)	8.7% (Clavien grade 2)	211
Current study	34	Yes	85.2% overall (96.7% current)	8.8% (3/34)	8 (7–28)	5.8%	182

NA = not available; VCUG = voiding cystourethrogram; VUR = vesicoureteral reflux.

Table 3 – Key tips to reduce the risk of urinary retention during bilateral RALUR-EV using the LUAA technique

Tips to reduce urinary retention risk	Description
Stay close to the ureteral adventitia	Limit dissection to the lateral side of the ureter and closely adhere to the ureteral adventitial plane
Limit dissection over the distal 1.5 cm of the ureter and preserve the dorsomedial area and fibers	Extreme caution in bilateral cases to minimize complications
Perform a Y dissection at the UVJ	This technique allows for a more precise dissection of the UVJ and minimizes the risk of injury
Avoid using cautery at the UVJ	This reduces the risk of injuring delicate neurovascular structures surrounding the ureterovesical junction

RALUR-EV = robot-assisted laparoscopic extravesical ureteral reimplantation; UVJ = ureterovesical junction.

bilateral and unilateral cases, including one case of ureteral injury. In a nationwide cohort of pediatric patients, Kurtz et al [24] reported that the incidence of any 90-d postoperative Clavien-Dindo complications (grades I–V) was 13.0% for RALUR compared with 4.5% for open reimplantation.

Adherence to meticulous surgical techniques is essential to minimize the risk of ureteral injury during ureteral reimplantation. Maintaining proper planes of dissection and atraumatic ureter handling, as described in Table 3, is crucial to avoid potential ureteral complications in addition to the Y dissection.

Hydronephrosis was detected in one patient (group 1) preoperatively, with grade 1; it was noted in 11.7% (eight) ureters postoperatively—grade 1 in 7.3%, grade 2 in 2.9%, and grade 3 in 7.3% . No patient has required reoperation for obstruction during follow-up.

We implemented stringent criteria for postoperative VCUG to demonstrate reflux resolution and to better understand and learn the technique. This, in turn, allowed us to share the nuances with the broader surgical community and ensure its reproducibility. Consequently, we included only those 34 patients. Owing to the traumatic experience of catheterization from preoperative VCUG, we acknowledged the parents' request. Although these patients are clinically doing well, we have not included them in the study as success cases. It is of utmost importance to adhere to these strict follow-up protocols for new techniques before these can be generalized.

The strengths of our study include being the largest single-center, single-surgeon study, eliminating confounding factors, and being conducted in an academic institution. Postoperative VCUG allowed for a comprehensive evaluation of reflux resolution. Our findings indicate that the key elements of the LUAA technique contributed to high success rates of reflux resolution. A comparison of our results with other studies helps understand the advantages of the robotic approach and its potential benefits over alternative surgical methods.

A potential limitation of the study is the small sample size of 34 patients, which may affect the generalizability of the findings. Additionally, being conducted at a single center may limit the ability to apply the results to other settings. Another limitation is the retrospective design of the study.

5. Conclusions

In conclusion, the LUAA technique demonstrates sustainable outcomes of VUR resolution, and the incidence of transient urinary retention can be minimized through various surgical techniques. A thorough understanding of pelvic anatomy is essential to minimize the risk of this complication. Further studies are needed to evaluate the effectiveness of different approaches in reducing the incidence of transient urinary retention following bilateral extravesical reimplantation.

***Author contributions*:** Parviz Hajiyev had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Hajiyev, Gundeti.
Acquisition of data: Hajiyev, Fialkoff.
Analysis and interpretation of data: Hajiyev, Fialkoff.
Drafting of the manuscript: Hajiyev, Sloan.
Critical revision of the manuscript for important intellectual content: Gundeti.
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Appendix A. Supplementary data

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