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Outcomes of complex robot-assisted extravesical ureteral reimplantation in the pediatric population

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Summary

Introduction and objective
While open ureteral reimplantation remains the gold standard for surgical treatment of vesicoureteral reflux (VUR), minimally invasive approaches offer potential benefits. This study evaluated the outcomes of children undergoing complex robot-assisted laparoscopic ureteral reimplantation (RALUR) for failed previous anti-reflux surgery, complex anatomy, or ureterovesical junction obstruction (UVJO), and compared them with patients undergoing open extravesical repair.

Study design
Children undergoing complex RALUR or open extravesical ureteral reimplantation (OUR) were identified. Reimplantation was classified as complex if ureters: 1) had previous anti-reflux surgery, 2) required tapering and/or dismembering, or 3) had associated duplication or diverticulum.

Results
Seventeen children underwent complex RALUR during a 24-month period, compared with 41 OUR. The mean follow-up was 16.6 ± 6.5 months. The RALUR children were significantly older (9.3 ± 3.7 years) than the OUR patients (3.1 ± 2.7 years; $P < 0.001$). All RALUR patients were discharged on postoperative day one, while 24.4% of children in the open group required longer hospitalization (mean 1.3 ± 0.7 days; $P = 0.03$). Adjusting for age, there was no significant difference in inpatient analgesic usage between the two cohorts. Three OUR patients (7.3%) developed postoperative febrile urinary tract infection compared with a single child (5.9%) undergoing RALUR ($P = 1.00$). There was no significant difference in complication rate between the two groups (12.2% OUR versus 11.8% RALUR; $P = 1.00$). A postoperative cystogram was performed in the majority of RALUR patients, with no persistent VUR detected, and one child (6.7%) was diagnosed with contralateral reflux.

Discussion
Reported VUR resolution rates following robot-assisted ureteral reimplantation are varied. In the present series, children undergoing RALUR following failed previous anti-reflux surgery, with complex anatomy, or UVJO experienced a shorter length of stay but had similar analgesic requirements to those undergoing open repair. Radiographic, clinical success rates and complication risk were comparable.

This study had several limitations, aside from lack of randomization. Analgesic use was limited to an inpatient setting, and pain scores were not assessed. Not all children underwent a postoperative VCUG, so the true radiographic success rate is unknown. A larger patient cohort with longer follow-up is necessary to determine predictors of radiographic and clinical failure.

Conclusion
Older children with a previous history of anti-reflux surgery were more likely to undergo RALUR. These children had success and complication rates comparable to younger patients following complex open extravesical reimplantation, which underscores the expanding role of robot-assisted lower urinary tract reconstructive surgery in the pediatric population.

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Introduction

Open surgery has long been the mainstay of ureteral reimplantation in the pediatric population, with durable and high success rates [1]. Robot-assisted laparoscopic ureteral reimplantation (RALUR) was first described over a decade ago, and has since become the preferred approach for minimally invasive reimplantation due to the technical challenges of pure laparoscopy and laparoscopic suturing [2,3,4]. Robot-assisted laparoscopic ureteral reimplantation is now routinely performed for primary vesicoureteral reflux (VUR) with wide-ranging success rates. In some series, radiographic cure rates were comparable to open reimplantation [4,5,6] but other authors have reported significantly lower success rates (77–80%) than those routinely achieved with open repair [7,8].

Complex lower urinary tract reconstructive surgery has expanded the role of robot-assisted surgery in the pediatric population. Previous studies have reported the feasibility of RALUR in increasingly challenging cases, including: previous anti-reflux surgery, duplication anomalies, periureteral diverticula, and megaureter [9]. In the present study, children undergoing complex RALUR were evaluated and compared with patients undergoing open extravesical repair for similar indications. It was hypothesized that children undergoing robot-assisted repair would have clinical and radiographic outcomes similar to those for open reimplantation. Length of stay and inpatient analgesic use were also assessed.

Materials and methods

Study population

Institutional review board approval was obtained. Children undergoing complex RALUR or open extravesical ureteral reimplantation (OUR) between January 1, 2013 and December 31, 2014 were identified. Patient demographics, length of stay, inpatient analgesic requirements, imaging, clinical outcomes, and complications were assessed and compared, based on surgical modality. Ureteral reimplantation was classified as complex if ureters: 1) had previous anti-reflux surgery (endoscopic injection or open reimplantation), 2) required tapering and/or dismembering, or 3) had associated duplication or periureteral diverticulum. Children undergoing ureteral reimplantation that did not meet criteria for 'complex' distal ureteral anatomy, and those undergoing intravesical ureteroneocystostomy were excluded from the study. All robotic surgeries were performed by a single surgeon (AJK).

Study design

The operative time was recorded from time of incision to skin closure in both groups. All children were routinely prescribed oral (acetaminophen and acetaminophen-hydrocodone) and intravenous (IV ketorolac and morphine) analgesia on an as-needed basis postoperatively. Medications were prescribed by standard weight-based dosing and, thus, postoperative pain medication requirements were recorded by number of doses, and adjusted for age and length of stay (LOS). Postoperative renal-bladder ultrasound (RBUS) was obtained in all children. Clinical success was defined as no postoperative febrile urinary tract infection (UTI). Radiographic success was defined as a negative postoperative cystogram in those with VUR and improved hydronephrosis/drainage in those with obstruction. Children undergoing reimplantation for obstruction with postoperative reflux on the ipsilateral side were classified as having *de novo* VUR. Patients undergoing ureteral reimplantation not classified as complex were excluded from the study, as were all children undergoing intravesical reimplantation.

Robot-assisted ureteral reimplantation technique

All children in the RALUR cohort underwent an extravesical ureteral reimplantation, as previously described [9]. All cases were performed with an 8.5-mm camera port and two 8-mm robotic working ports without the use of an assistant port; port placement was dependent upon body habitus with working ports placed below the level of the anterior superior iliac spine in older children. Bladder hitch stitch was not routinely employed, but utilized in cases with limited exposure during detrusorrhaphy. Cases of ureteral duplication were managed with a common sheath reimplantation. In children undergoing prior endoscopic injection, dextranomer/hyaluronic acid implants were seen within Waldeyer's sheath or at the ureteral hiatus. In these cases, visualization of the implant facilitated identification of the ureteral hiatus. The extravesical implants were fully encapsulated and permitted capsulotomy and drainage of product to afford a smaller-caliber ureter for reimplantation.

Statistical analysis

Statistical analysis was performed using SAS version 9.3 (SAS Institute, Cary, NC, USA), with $P < 0.05$ representing statistical significance. Descriptive statistics were calculated for all variables and included: means and standard deviations, medians and inter-quartile ranges, and counts/percentages, where appropriate. Statistical significance of categorical variables was determined by Fisher's exact test, whereas significance of continuous variables was determined by a two-sample *t*-test, Wilcoxon rank sum test, or Kolmogorovr-Smirnoff test. Significance of relationships between surgery type and outcomes of interest were adjusted for age and length of stay using multivariable models. Outcomes involving counts (length of stay, number of pain doses, number of pain doses per day) were tested using a Poisson model. In cases where over-dispersion was significant, negative-binomial models were used. A logistic model was used to model a length of stay >1 day.

Results

Demographics

Seventeen children (13 females, four males) underwent complex RALUR during a 24-month period, compared with