

Laparoscopic vs Open Extravesical Ureteral Reimplantation in Pediatric Population: A Single-Center Experience

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Purpose: To evaluate the safety and efficacy of conventional laparoscopic vs open Lich-Gregoir ureteral reimplantation in pediatric vesicoureteral reflux.

Material and Methods: A retrospective study was conducted in a tertiary care hospital. Patients with vesicoureteral reflux who underwent open or laparoscopic Lich-Gregoir ureteral reimplantation from 2013-2020 were included. The primary outcome was the resolution of reflux. Complications and perioperative characteristics were evaluated. The outcomes between open and laparoscopic surgery were analyzed.

Results: A total of 110 patients and 150 ureters were included. The mean age was 4.5 years \pm 3.4 and 73.6% were females. A total of 125 ureters (83.3%) underwent laparoscopic and 25 (16.6%) open Lich-Gregoir vesicoureteral reimplantation (5:1 Ratio). Resolution was reported in 112 (89.6%) for laparoscopy and 21 (84%) for open surgery ($P = .42$). Mean surgical time for laparoscopy and open surgery were 142.4 min \pm 64.4 and 153 min \pm 40, respectively ($P = .29$). Mean bleeding (9.5 mL \pm 11.2 vs 29.6 mL \pm 22.8) and length of hospital stay (2.4 days \pm 2.3 vs 5.05 \pm 3.1) were significantly higher with open surgery ($P < .001$). No significant difference in complications was reported between open surgery (32%) and laparoscopic approach (22.4%) ($P = .305$).

Conclusion: Conventional laparoscopic vesicoureteral reimplantation with the Lich-Gregoir technique has an acceptable success rate comparable with open surgery, with shorter hospital stay, less bleeding, and less need of transfusion.

Keywords: laparoscopy; Lich-Gregoir; minimally invasive surgery; pediatrics; vesicoureteral reflux; vesicoureteral reimplantation.

INTRODUCTION

Vesicoureteral reflux (VUR) is a frequent urologic anomaly that affects 1% of pediatric population.⁽¹⁾ This condition might be asymptomatic or being a cause of recurrent urinary tract infections (UTI), leading to renal scars and in long term, progression to chronic kidney disease.⁽²⁾ The importance of early treatment among these patients is to avoid febrile UTIs, and in long term, preserve the renal function.^(3,4) The current therapeutic options are pharmacological and surgical, the latter being reserved for high-grade cases above the age of one year, with refractory febrile UTIs, and abnormal renal parenchyma caused by VUR.^(5,6) Open vesicoureteral reimplantation is currently the reference surgical procedure for VUR among pediatric population. Success rates with this procedure have been reported up to 90% in some series, showing higher success rates compared to endoscopic procedures.^(5,6) Differentiating by VUR grades I to V, success rates are 99.1%, 99.0%, 98.3%, 98.5%, and 80.7%, respectively.⁽⁷⁾ Regarding intravesical approach, Ledbetter-Politano and the Cohen technique have been considered the most

popular techniques of ureteral reimplantation with successful rate in the range of 97–99%.⁽⁸⁾

In the last decade, several studies have shown comparable results with the conventional laparoscopic technique, with additional benefits such as low rates of VUR recurrence, even in cases with complex anatomy.^(9,10) Nevertheless, new techniques also come with new challenges, such as higher rates of complications compared to the reference procedure.⁽¹¹⁾

Minimally invasive techniques have acquired more popularity worldwide recently.⁽⁵⁾ However, the debate between open and laparoscopic ureteral reimplantation continues and the literature among pediatric population is limited. The objective of this manuscript is to evaluate the safety and efficacy of conventional laparoscopic vs open Lich-Gregoir ureteral reimplantation in pediatric patients with VUR.

MATERIALS AND METHODS

A retrospective study was conducted in a tertiary care hospital in Mexico City. Patients with VUR who underwent open or laparoscopic Lich-Gregoir vesicoure-

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Table 1. Study Population characteristics (n=150)

| Variables | Total (n=150) | Laparoscopy (n=125) | Open Surgery (n=25) | p-value |
|------------------------------------|---------------|---------------------|---------------------|--------------------|
| Demographics ^a | | | | |
| Females, n (%) | 81 (73.6) | 70 (76.9) | 11 (57.9) | 0.095 |
| Age Mean years ± SD | 4.5 ± 3.4 | 4.8 ± 3.6 | 4.1 ± 2.4 | 0.329 |
| Reimplant indication | | | | |
| Recurrent Urinary Tract Infections | 131 (87.3) | 116 (92.8) | 15 (60) | < 0.001 |
| Severe Hydronephrosis | 21 (14) | 17 (13.6) | 4 (16) | 0.752 ^b |
| Renal scars | 24 (16) | 19 (15.2) | 5 (20) | 0.555 |
| Previous Treatment | | | | |
| Antibiotic prophylaxis | 96 (64) | 79 (63.2) | 17 (68) | 0.82 |
| Bulking agents | 19 (12.7) | 14 (11.2) | 5 (20) | 0.318 |
| Additional procedures | | | | |
| Ureteroplasty | 16 (10.6) | 12 (9.6) | 4 (16) | 0.527 |
| Bladder diverticulum resection | 8 (5.3) | 6 (4.8) | 2 (8) | |
| Reflux Characteristics | | | | |
| Righta | 24 (21.8) | 21 (22.6) | 8 (28.6) | 0.852 |
| Lefta | 46 (41.8) | 37 (40.7) | 9 (47.4) | |
| Bilateral | 40 (36.4) | 34 (37.4) | 6 (31.6) | |
| Grade of reflux | | | | |
| Grade 3 | 38 (25.3) | 34 (27.2) | 4 (16) | 0.24 ^b |
| Grade 4 | 61 (40.7) | 46 (36.8) | 15 (60) | 0.044 |
| Grade 5 | 51 (34) | 45 (36) | 6 (24) | 0.355 |
| Anatomic abnormalities | | | | |
| Duplex collecting system | 17 (11.3) | 9 (7.2) | 8 (32) | < 0.001 |
| Megaureter | 9 (6) | 7 (5.6) | 2 (8) | 0.645 ^b |
| Diverticulum | 8 (5.3) | 6 (4.8) | 2 (8) | 0.166 ^b |
| Ureterocele | 4 (2.7) | 3 (2.4) | 1 (4) | 0.999 ^b |
| Vesicoureteral stenosis | 5 (3.3) | 1 (0.8) | 4 (16) | 0.003 ^b |
| Anorectal malformation | 1 (0.7) | 1 (0.8) | 0 (0) | 0.989 ^b |
| Ectopic ureter | 1 (0.7) | 0 (0) | 1 (4) | 0.167 ^b |

^a Considering 110 patients (100%); ^bFisher exact test; SD= Standard Deviation.

teral reimplantation from 2013 to 2020 were included. Data was obtained from clinical records, including demographic parameters, total of ureters treated, indications for surgery, previous therapy, and characteristics of VUR before and after surgery. Preoperative characteristics were laterality and grade of VUR, associated anatomical abnormalities such as duplex collecting system, megaureter, bladder diverticulum, ureterocele, vesicoureteral stenosis, anorectal malformations, and ectopic ureter. The peri- and postoperative characteristics evaluated were operation time, total bleeding, days of hospital stay, days of transurethral catheterization, days of percutaneous drainage, need of transfusion and use of opioids. The primary parameters measured were the frequency of complete resolution, decrease in the grade of reflux, and the persistence of reflux. Decrease in the grade of reflux was defined as an improvement to a low-grade reflux (grade 1 or 2). Persistence of reflux

was defined as persistence of high-grade reflux after the procedure (grade 3, 4 or 5). Complications associated with the procedure and reintervention rates were evaluated. Complications were classified using the Clavien-Dindo Classification of surgical complications.⁽¹²⁾ VUR nephropathy progression after surgery was defined as new renal scars documented in renal scintigraphy in patients with postoperative febrile UTI. Patients with a diagnosis of VUR secondary to infravesical obstruction, lower urinary tract dysfunction, and cases managed with conservative treatment were excluded. Indication for surgical management was a confirmed voiding cystourethrogram (VCUG) with VUR and recurrent UTI or renal scars in renal scintigraphy. Family members or tutors of patients who were candidates for surgery were informed about the treatment options, including an open or laparoscopic technique for ureteral reimplantation. The surgical approach (open or laparo-

Table 2. Comparison of perioperative findings and outcomes between laparoscopic and open surgery vesicoureteral reimplantation (n=150)

| Variables | Laparoscopy Group | Open Surgery Group | p Value |
|--------------------------------------|-------------------|--------------------|----------------------|
| Characteristics | | | |
| Operation Time, mean min ± SD | 142.4 ± 64.4 | 153 ± 40 | 0.29 |
| Bleeding mean mL ± SD | 9.5 ± 11.2 | 29.6 ± 22.8 | < 0.001 |
| Hospital stay mean days ± SD | 2.4 ± 2.3 | 5.05 ± 3.1 | < 0.001 |
| Transurethral catheter, median (IQR) | 1 (1-2) | 4 (3-5) | < 0.001 ^a |
| Percutaneous drainage, median (IQR) | 0.01 (0.01-0.02) | 3 (3-4) | < 0.001 ^a |
| Transfusion | 0 (0) | 3 (12) | 0.004 ^b |
| Opioid use | 19 (15.2) | 6 (24) | 0.281 |
| Outcomes | | | |
| VUR Resolution | 112 (89.6) | 21 (84) | 0.42 |
| Decrease in VUR grade | 12 (9.6) | 4 (16) | 0.344 |
| Persistence of VUR | 1 (0.8) | 0 (0) | 0.999 ^b |

VUR= Vesicoureteral reflux; ^a Mann-Whitney U test. ^bFisher Exact Test; SD= standard deviation; IQR= interquartile range.

Table 3. Complications of ureteral reimplantation surgery with a laparoscopic and open approach (n=150)

| Variables | Laparoscopic Group (n=125) | Open Surgery Group (n=25) | P value |
|------------------------------|----------------------------|---------------------------|--------------------|
| Total Complications | 28 (22.4) | 8 (32) | 0.305 |
| Clavien-Dindo Classification | | | |
| Grade ≤2 | 4 (3.2) | 2 (8) | 0.264 |
| Urinary Retention | 0 (0) | 2 (8) | 0.027 ^a |
| Urinary Tract Infection | 22 (17.6) | 5 (20) | 0.776 |
| Ileus | 0 (0) | 3 (12) | 0.004 ^a |
| Hematuria | 2 (1.6) | 0 (0) | 0.999 ^a |
| Surgical Wound infection | 0 (0) | 3 (12) | 0.004 ^a |
| Progression of nephropathy | 2 (1.6) | 4 (16) | 0.007 ^a |
| Grade >2a | 4 (3.1) | 4 (10.8) | 0.078 ^a |
| Ureteral Stenosis | 4 (3.2) | 2 (8) | 0.262 ^a |
| Need for reintervention | 1 (0.8) | 0 (0) | 0.999 ^a |

^aNo Clavien-Dindo Grade 5 complications were reported; ^aFishers' Exact Test.

scopic) was selected based on surgeons' criteria, taking into consideration history of previous abdominal procedures, and the availability of laparoscopic equipment at that time of the procedure. Informed consent was obtained in all recruited cases. In this study, no contraindication for laparoscopic surgery was found among the enrolled patients, such as multiple previous abdominal surgeries, marked obesity, large ventral hernia, or cardiorespiratory conditions.

Surgical technique

A laparoscopic extravesical transperitoneal approach was done following the Lich-Gregoir technique.^(9,13) The procedure was performed under general anesthesia and endotracheal intubation. Three ports from 3 to 5 millimeters were used. The camera port was placed subxiphoid or at the level of the umbilical scar with the conventional open Hasson technique. Subsequently, two para-rectal working ports were placed either subcostal or at the level of the umbilical scar under laparoscopic vision. A bladder traction suture was placed percutaneously. The bladder was filled with saline solution to facilitate its dissection; the ureter was dissected from

the lateral pelvic fascia for tension-free reimplantation. A detrusotomy was performed marking the cephalic end of the incision at the level where the full bladder rests without tension on the ureter, using a monopolar electrocautery hook together with blunt dissection, taking care not to perforate the bladder mucosa. Bladder distention with an intravesical irrigation solution through the transurethral catheter allows better dissection down to the submucosal plane, thus the mucosa protrudes over the detrusotomy area. A tunnel was created using Paquins' principle, with a length 4 to 5 times greater than the diameter of the ureter,⁽¹⁴⁻¹⁶⁾ as seen in Figure 1. Detrusorrhaphy was performed over the ureter with an absorbable 3-0 to 4-0 monofilament stitch suture (Figure 2). Bladder catheterization was performed, and the catheter was typically removed the next day. Open vesicoureteral reimplantation was performed using the Lich-Gregoir extravesical ureteroneocystostomy technique.⁽¹⁷⁾ The technique was selected based on the experience and preference of the surgeon.

Postoperative follow-up

Postoperative follow-up was performed by renal and

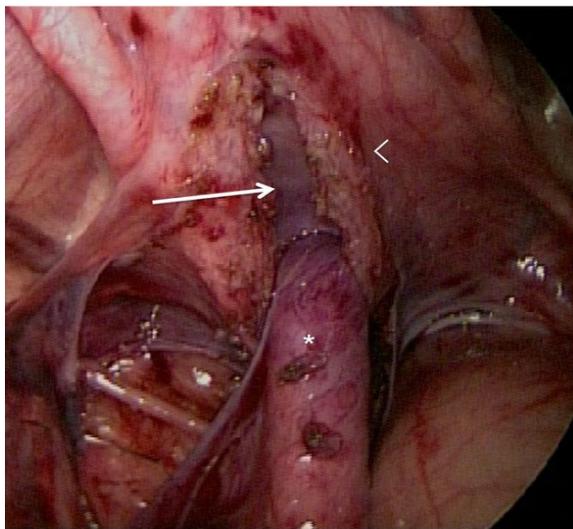


Figure 1. Right extravesical ureteral reimplant. A detrusotomy is performed until the mucosa is exposed without violation (Arrow). The mucosa protrudes over the detrusotomy, this being the area of the submucosal tunnel that follows Paquins' principle. The bladder is distended in order to facilitate dissection (arrowhead). A dilated ureter is observed in its distal section (asterisk).

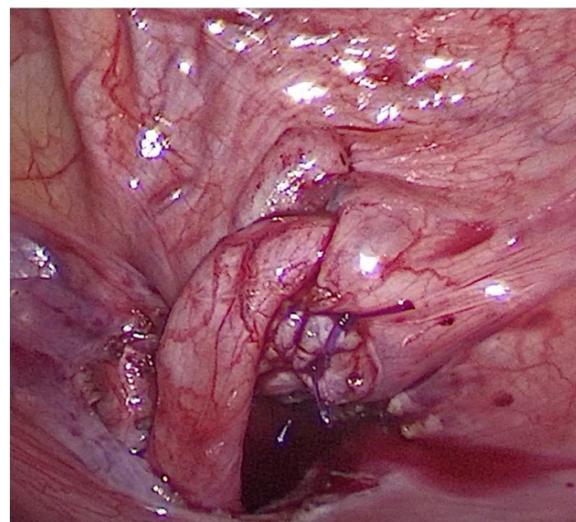


Figure 2. Detrusorrhaphy over the ureter with interrupted absorbable sutures developing a submucosal tunnel following Paquins' principle.

bladder ultrasound 1-3 months postoperatively and a VCUG at 6 to 8 weeks after surgery. Approval of the internal ethics committee with registration number R-2020-3603-065 was assigned.

Statistical analysis

Descriptive statistics were calculated for the variables included in the analysis. Categorical variables were represented by frequencies and percentages, and continuous variables by mean and standard deviation. The results of open versus laparoscopic surgery were also compared. Kolmogorov-Smirnov statistic was used to assess distribution of continuous variables. For categorical variables, the Pearson Chi Square test was used for binary outcomes with large expected cell counts and Fisher's exact test for small cell counts, and Student T test for independent continuous variables. For non-normally distributed variables, the Mann-Whitney U test was used. Statistical analysis was performed in SPSS v26 software.

RESULTS

Study Population

A total of 110 patients and 150 ureters were included in the study. The mean age was 4.5 years \pm 3.4 months and 81 patients (73.6%) were females. Bilateral VUR was reported in 36.4% (n=40). The most common indication for ureteral reimplantation was the presence of recurrent febrile UTIs (or pyelonephritis) in 87.3% (n=131) of ureters. In 64% (n=96) of treated ureters were refractory to a prophylactic antibiotic and 12.7% (n=19) to a bulking agent. The most frequent grade of reflux was grade 4 in 40.7% (n=61), followed by grade 5 in 34% (n=51). Anatomical abnormalities were reported in 30%, with a duplex collecting system being the most frequent abnormality in 11.3% (n=17).

One hundred and twenty five ureters underwent a laparoscopic approach and 25 an open surgery (5:1 ratio). All procedures were done with the Lich-Gregoir technique. An additional procedure was carried out during surgery in 12 cases (9.6%) in the laparoscopic group and 4 (16%) in open surgery ($P = .527$). The presence of recurrent febrile UTIs prior to surgery was more frequent in the laparoscopy group (92.8%) compared to the open surgery (60%) ($P < .001$). Grade 4 VUR was more frequent in the laparoscopic group ($P = .044$) and no significant difference was observed with grade 3 and grade 5 VUR between groups. Anatomical abnormalities were reported more frequently in the open surgery group ($P < 0.001$). The rest of population characteristics are described in **Table 1**.

Effectiveness

VUR was resolved in 112 of 125 ureters (89.6%) by laparoscopic approach and 21 of 25 patients (84%) by open surgery ($P = .42$). A decrease in the grade of reflux was reported in 12 cases (9.4%) with laparoscopy and 4 cases (16%) with open surgery ($P = .344$). The persistence of reflux was reported in only 1 case with laparoscopy and no cases with open surgery. The mean surgical time for laparoscopy and open surgery was 142.4 min \pm 64.4 and 153 min \pm 40, respectively ($P = .29$). The mean laparoscopic bleeding was 9.5 mL \pm 11.2 and for open surgery 29.6 mL \pm 22.8, showing a significant difference ($P < .001$). Hospital stay was lower in the laparoscopic approach ($P < .001$). The use of a transurethral catheter, ($P < .001$), percutaneous drainage time

($P < .001$), and the need of transfusion ($P = .004$) were lower in the laparoscopic group. The use of opioids for pain relief was not significant different between groups. **Table 2** describes the perioperative findings between groups.

Complications

Complications were reported in 36 cases (24%), 28 cases (22.4%) in the laparoscopic group and 8 (32%) in the open surgery group ($P = .305$). Urinary retention was reported in 2 cases (8%) only with open surgery. Ileus was significantly higher in the open surgery group (0% vs 12%, $P = .004$). Surgical wound infection (0% vs 12%) and progression of VUR nephropathy (1.6% vs 16%) were also higher between cases treated with open surgery ($P = .002$). All patients with progression of nephropathy had febrile UTI after surgery. According to Clavien-Dindo classification, 8 cases reported complications grade >2 , requiring additional procedures. No statistical significant differences were reported between groups for grade ≤ 2 and grade >2 ($P = .194$ and $P = .078$, respectively). However, there is a tendency to greater complications grade >2 in the open surgery group compared to laparoscopic approach (10.8 vs 3.1%, respectively) (See **Table 3** for complete description of complications).

DISCUSSION

Multiple studies published in recent years continue to consider open surgery as the reference surgical treatment for VUR with good long-term outcome and success rates up to 90%.⁽⁶⁾ This procedure has long been touted as the "gold standard" due to its high radiographic success rates reported.⁽¹⁸⁾ Recently, the use of minimally invasive techniques such as the conventional or robot-assisted laparoscopic approach have gained popularity and have been used more frequently.^(6,11) During the last decade, series of conventional laparoscopic ureterovesical reimplantation have shown good results and few complications, even in cases of complex anatomy.^(9,10) Bayne AP et al reported a retrospective study of 98 patients with VUR who underwent laparoscopic ureteral reimplantation with the extravesical Lich Gregoir technique. The success rate was 93.5%, with complications in 24% of the sample and requiring reoperation in 7% of cases.⁽⁹⁾ They concluded that laparoscopic technique is an effective and safe alternative for the surgical management of VUR.

Despite a decrease in the use of open ureteral reimplantation in recent years, it continues to be a valid option in younger patients and in those with previous abdominal surgeries.⁽¹⁸⁾ Some cases are not suitable for laparoscopic procedures, such as patients with severe cardiac diseases, pulmonary insufficiency, bleeding disorders, repeated abdominal procedures, patients with ileus, intestinal obstruction, and abdominal sepsis.⁽¹⁹⁾ In such patients, open surgery continues to be the most suitable option.

Recently, Bustangi N et al compared open versus laparoscopic Lich-Gregoir technique in a multicenter retrospective study. A total of 96 patients with VUR were included of which 50 were operated by open approach and 46 by laparoscopic approach. A higher operative time was reported in the laparoscopic group (127.9 vs 63.2 min, $p < 0.001$), shorter length of stay in laparoscopic approach (1.64 vs 5.4 days, $P < .001$), and shorter days of intravenous analgesia used (1.15 vs 3.9, P

< .001). There was no conversion in the laparoscopic group and only 1 case had to be reoperated for leakage. Success rate was 98% with open approach and 97.8% for laparoscopic approach with a mean follow-up of 3.6 and 1.5 years, respectively. The authors concluded that laparoscopic approach was as effective as the open approach, with reduction in analgesia medication, hospital stay, and faster recovery, with the disadvantage of requiring twice the operative time.⁽²⁰⁾

In our study, the success rate with the laparoscopic approach was 89.6% with improvement in the grade of VUR in 9.6% and persistence of high-grade VUR in only 1 case (0.8%), similar to the reported in most series.^(9,10) As compared with the results of Bustangi N et al⁽²⁰⁾, our success rate was lower (89.6 vs 97.8%) in the laparoscopic and open approach (84% vs 98%). One explanation for this discrepancy is the definition of therapeutic success. They defined success rate by the absence of documented febrile UTI or absence of recurrence of VUR objectivized by VCUg in both groups. Only 5 cases in open approach and 3 in laparoscopic group had a VCUg due to recurrent postoperative febrile UTIs. This could have influenced in subclinical VUR cases to be underestimated. In our study, all patients had a postoperative VCUg, and we differentiate between those patients with persistent VUR from those who had a decrease in the degree of VUR.

Complications were reported in 24% of the cases, most of them minor and requiring reintervention in a single case (0.8%).

In 2016, Farina et al conducted a systematic review evaluating ureteral reimplantation with laparoscopic technique. They concluded that this technique is safe and effective, comparable with open surgery.⁽²¹⁾ They reported a success rate of up to 96%, shorter hospital stay, less bleeding and less pain compared to open surgery, similar to our study. Riquelme M et al in 2013, reported a success rate of 95.8% in 81 patients, with few complications, requiring reintervention in 2 cases (2.4%).⁽²²⁾ Other authors such as Perez et al in 2014, reported success rates of 96.5% for laparoscopic reimplantation in 23 cases.⁽²³⁾

The laparoscopic technique has its drawbacks, for example, a greater learning curve and greater surgical dexterity to achieve success rates compared to the standard open surgery, but a remarkable set of benefits as well as shorter hospital stay. The authors consider that this technique should be the new reference procedure and the experience required for better outcomes must spread to as many centers around the globe as possible, with enough case volume and appropriate training.

This study has several limitations, starting with its retrospective nature and wide distribution of the study groups. This is because in the center where the study was carried out, the laparoscopic procedure has been considered the treatment of choice when there is no contraindication. Selection of surgical approach was decided by surgeons' criteria, and not randomly assigned. Further randomized prospective studies comparing open versus laparoscopic surgery using a specific reimplantation technique are needed to reinforce these findings.

CONCLUSIONS

Laparoscopic vesicoureteral reimplantation with the Lich-Gregoir technique is a procedure that has an acceptable success rate and a safe profile comparable to

open surgery. Shorter hospital stay, less bleeding, and less blood transfusion were reported using laparoscopic vesicoureteral reimplantation.

SUMMARY

Open and laparoscopic vesicoureteral reimplantation seem to have similar success rate and comparable complication rates. However, laparoscopic approach demonstrated shorter hospital stay and less bleeding compared to the open approach.

CONFLICTS OF INTEREST

The authors do not declare conflicts of interest.

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