Vesicoscopic Cross-Trigonal Ureteral Reimplantation: A Minimally Invasive Option for Repair of Vesicoureteral Reflux

Stephen J. Canon,* Venkata R. Jayanthi and Ashay S. Patel
From the Section of Urology, Columbus Children's Hospital, Ohio State University, Columbus, Ohio

Purpose: Cross-trigonal ureteral reimplantation is a commonly performed procedure for the correction of vesicoureteral reflux. Most previously described laparoscopic techniques have used an extravesical approach. A “vesicoscopic” technique is analogous to standard open cross-trigonal repair in principle, except that 3 ports with insufflation of the bladder are used to perform the ureteral reimplantation.

Materials and Methods: A retrospective review was performed of patients treated for primary vesicoureteral reflux with either vesicoscopic or open ureteral reimplantation. For patients with vesicoscopic reimplantation a 5 mm port is placed in the dome of the bladder and 2, 3 mm ports are placed laterally. The ureters are mobilized transvesically, cross-trigonal submucosal tunnels are made and the ureters are sutured in place with intracorporeal suturing. The bladder ports are closed under CO2 pneumovesicuim. That series demonstrated excellent results, with 96% of 16 patients having resolution of reflux. The aim of this study was to describe our initial experience with VR in a larger group of children, and to compare the outcomes to a control group undergoing OR.

Results: A total of 52 consecutive children underwent vesicoscopic ureteral reimplantation with 1 patient converted to open intravesical reimplantation, and 40 consecutive controls underwent open ureteral reimplantation. Postoperative vesicoureteral reflux resolution rates for the vesicoscopic and open groups were 91% (42 of 46 patients) and 97% (31 of 32 patients), respectively. Mean patient age and mean maximal grade of vesicoureteral reflux in the vesicoscopic and open groups were 5.7 and 4.0 years (p = 0.001), and 2.8 and 3.2 (p = 0.036), respectively. Mean operative times for vesicoscopic and open procedures were 199 and 92 minutes, respectively (p = 0.001). While the average length of hospital stay of 2 days was similar between the groups (p = 0.122), less oral and intravenous analgesia was needed postoperatively in the vesicoscopic group (p = 0.001 and p = 0.005, respectively). Complications of vesicoscopic ureteral reimplantation included urinary leakage in 1 child, bladder stones in 1 and bilateral ureteral obstruction in 1. There were no complications in the open group.

Conclusions: There is an ever increasing trend toward minimally invasive surgery. Our preliminary results indicate that vesicoscopic ureteral reimplantation is an effective procedure with minimal morbidity. Although success rates for vesicoureteral reflux resolution were slightly lower in the vesicoscopic group in this study, the favorable results of other series and the improvement in postoperative discomfort observed here suggest that this technique may be a reasonable option in the management of vesicoureteral reflux. Further refinement of the technique and critical analysis of the long-term outcomes are needed to understand fully its place in the treatment of vesicoureteral reflux.

Key Words: vesico-ureteral reflux, ureter, laparoscopy, reimplantation, cystostomy

The options for surgical management of VUR have expanded in recent years with the application of dextranomer/hyaluronic acid injection and the introduction of laparoscopic extravesical ureteral reimplantation. Recent studies aimed at determining parental preferences have shown that parents are more apt to choose minimally invasive techniques to treat VUR when intervention is necessary.1,2

Gill et al originally described a technique of vesicoscopic cross-trigonal ureteral reimplantation using glycine irrigation in a small series of patients, with 2 of 3 exhibiting resolution of VUR.3 Yeung et al subsequently developed a novel technique of vesicoscopic cross-trigonal ureteral reimplantation under CO2 pneumovesicuim.4 That series demonstrated excellent results, with 96% of 16 patients having resolution of reflux. The aim of this study was to describe our initial experience with VR in a larger group of children, and to compare the outcomes to a control group undergoing OR.

MATERIALS AND METHODS

We retrospectively reviewed the records of all children undergoing correction of reflux via a vesicoscopic approach at our institution. A control group of consecutive patients with a history of primary VUR and OR was reviewed for comparison. Indications for surgery for both groups included breakthrough urinary tract infections during antibiotic prophylaxis, persistent VUR after observation with medical treatment for 4 to 5 years, especially in association with...
significant renal scarring, and/or persistent VUR after injection therapy. Families were given the options of dextranom/hyaluronic acid injection, open reimplantation and vesicoscopic reimplantation. The VR technique is similar to that described by Yeung et al.,4 with minor variations.

**Positioning**
The VR procedure is performed with the patient in the standard dorsal lithotomy position, with the perineum and abdomen in the sterile field. This approach allows access to the urethra, as needed, throughout the operation. Careful positioning and padding are ensured to prevent nerve palsy.

**Bladder Wall Fixation and Port Placement**
Cystoscopy using CO₂ bladder distention filled to 10 to 15 mm Hg is performed to assess the anatomy and to allow for percutaneous fixation of the bladder to the anterior abdominal wall. Sequentially, at the dome and the lateral walls an 18 gauge spinal needle is passed into the bladder, through which a 2-zero polydioxanone suture is passed. A stone basket is then placed through an adjacent puncture to snare the suture and extract it. The sutures are then tied, fixing the anterior bladder wall to the abdomen. A 5 mm port is placed in the dome and 3 mm ports are placed laterally. A 30-degree lens is placed through the dome port and vesicoscopy is performed (fig. 1).

**Ureteral Dissection**
Feeding tubes (3.5Fr) are placed through the urethra into the bladder, passed up each orifice and fixed in place with 5-zero polydioxanone suture. The affected ureters are then mobilized with a hook electrode at a low power setting, or with a combination of blunt and sharp dissection using scissors or graspers (fig. 2, A). After sufficient ureteral mobilization the defect in the detrusor muscle is closed with interrupted 4-zero polydioxanone suture (fig. 2, B).

**Tunnel Creation**
Cross-trigonal tunneling is then performed with a combination of sharp and blunt dissection in the submucosal plane. Maryland graspers are used to elevate the mucosa, and fine scissors are used to initiate and develop the submucosal plane from either direction (fig. 3). The length of tunnel created spans from the initial hiatus across to the opposite hiatus. The feeding tubes are passed through the tunnels to aid in transposition of the ureters (fig. 2, C). The ureter is fixed into position with 5-zero polydioxanone interrupted sutures (fig. 2, D). The remaining mucosal defects are closed with absorbable suture, and the feeding tubes are removed.

**Bladder Port Closure**
To maintain the pathway through the incision into the bladder, a feeding tube is placed through each tract before removal of the port. By passing spinal needles through the incisions and avoiding the fascia, each bladder port is closed in a manner analogous to the abdominal wall fixation. After placing all bladder sutures a Foley catheter is inserted for decompression. The original bladder-anterior abdominal wall fixation sutures are removed, allowing the bladder to fall away from the abdominal wall. The bladder port closure sutures are then carefully tied, and the skin incisions are subsequently closed.

Postoperatively, all patients in both groups were given intravenous ketorolac for 24 hours unless contraindicated. Acetaminophen with codeine (1 mg/kg every 4 hours), intra-

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**Fig. 1.** Port placement in vesicoscopy

**Fig. 2.** Bilateral procedure. A, ureteral dissection is performed with hook electrode at low power setting. B, as in open repair, ureter is freed until enough length is gained to transpose to other side. C, left ureter has been placed in its submucosal tunnel with neomeatus to be placed near original location of right meatus. D, completed repair before removal of ureteral catheters.

**Fig. 3.** Tunnel creation. Lifting mucosa allows submucosal plane to be identified. Tunnel is then created using sharp and blunt dissection.
venous morphine (0.1 mg/kg every 4 hours) and oral oxybutynin were given as needed based on patient request in both groups. Bladder catheters were left indwelling until the morning of postoperative day 1 in the OR group and for 36 hours in the VR group. On discontinuation of the catheter and tolerance of a regular diet patients were discharged home. Renal ultrasound and voiding cystography were performed at 1 and 3 months postoperatively, respectively.

Statistics
SPSS® for Windows version 13 was used to perform statistical analysis of the VR and OR groups. Chi-square and logistic regression analysis were used to compare VUR outcomes. Student’s t test was used to compare results for maximum VUR grade, LOS, postoperative narcotic requirements, oxybutynin requirements, patient weight and age, and total operative time (see table).

RESULTS
The VR group was comprised of 45 girls and 7 boys, with an average age of 5.7 years (range 1 to 18) and an average followup of 11 months. These 52 patients underwent attempted VR between October 2004 and January 2006. Of these patients 13 underwent unilateral ureteral reimplantation and 38 underwent bilateral reimplantation. There was 1 open conversion due to equipment malfunction and poor port placement. A total of 10 patients had failed subureteral dextranomer/hyaluronic acid injection. At the time of the procedure 28 patients had bilateral VUR and 24 had unilateral VUR. Of the 24 patients with unilateral VUR 11 underwent bilateral ureteral reimplantation (8 had previous contralateral VUR, 2 had unfavorable anatomy and 1 had bilateral renal scarring on dimercapto-succinic acid scan). None of the patients had a ureteral stent left indwelling postoperatively.

The control group was comprised of 42 consecutive patients with a history of primary VUR who underwent OR between July 2003 and June 2004. Two patients were excluded from analysis because of insufficient records for adequate comparison. The group was comprised of 31 girls and 9 boys, with an average age of 4 years and an average followup of 28 months. Two patients underwent extravasals unilateral ureteral reimplantation, and the remainder underwent unilateral (6 patients) or bilateral (32) intravesical crosstrigonal ureteral reimplantation. A total of 17 patients had unilateral VUR and 23 had bilateral VUR. Of the 17 patients with unilateral VUR 9 underwent bilateral intravesical ureteral reimplantation due to a history of bilateral VUR or concerning contralateral anatomical findings.

The VR and OR groups were compared for VUR resolution, excluding the single patient with open conversion. Of the 51 patients in the VR group 46 underwent postoperative cystography, which showed VUR resolution in 42 (91%). Two of these 42 patients had transient VUR initially, which resolved spontaneously on subsequent cystography. Of the 40 patients in the OR group 32 underwent postoperative cystography, which demonstrated VUR resolution in 31 (97%). Chi-square and logistic regression analysis controlling for weight and age was used to compare treatment outcomes, and no significant differences in VUR resolution were found between the 2 groups.

Student’s t test was used to compare maximum VUR grade, LOS, postoperative narcotic dose requirements (oral codeine and intravenous morphine), postoperative anticholinergic dose requirements (oxybutynin), patient weight and age, and total operative time (see table). No significant differences in LOS or oxybutynin use were noted between the 2 groups. Average maximum reflux grade was higher in the control group, and weight and age were higher in the vesicoscop group. While the average operative time for VR (3.3 hours) was longer than for OR (1.5 hours, \( p = 0.001 \)), patients in the OR group required more postoperative oral and intravenous analgesics than those undergoing VR (\( p = 0.001 \) and \( p = 0.005 \), respectively).

Although no major intraoperative complications occurred in either group, minor intraoperative complications were encountered in the VR group. Pneumoperitoneum occurred on occasion, and was easily treated with transumbilical Veress needle placement. Also, proximal migration of the feeding tube occurred in 3 patients during VR, necessitating immediate flexible ureteroscopy for retrieval. This problem was attributed to inadequate fixation of the feeding tube to the ureteral orifice, and none of these 3 patients had persistent VUR or any other postoperative complications.

There were no major complications in the control group. Of 51 patients in the VR group 3 (6%) had postoperative complications. The initial patient in the series had extraperitoneal urinary leakage at 1 week postoperatively. This complication occurred before initiation of the port closure technique.

One child in the VR group had bladder stones, which passed spontaneously. Although stone analysis revealed no nidus, excessive suture tags may have contributed, and we have since made an effort to minimize suture tags.

Finally, 1 patient in the VR group was hospitalized elsewhere at 1 month postoperatively for bilateral ureteral obstruction with acute renal failure. After temporary dialysis and bilateral nephrostomy placement renal function returned to normal. We suspect that this child may have had leakage through the tunnels, with obstruction due to extrinsic compression from the retrovesical urinomas that had developed. Subsequent reconstruction was performed elsewhere.

Cystoscopy was performed in 3 patients with persistent VUR after VR. One patient had no evidence of intramural ureter crossing the trigone and 2 patients had ureterovesical fistulas.

DISCUSSION
Ureteral reimplantation has proved to be effective in the treatment of VUR, with few major complications. However,
minor complications following these procedures, such as hematuria and bladder irritability, can greatly affect the postoperative course. With the advent of laparoscopic urological surgery there exists the possibility of reproducing open ureteral reimplantation with less postoperative pain. Consequently, some urologists have applied laparoscopic techniques to ureteral reimplantation in an attempt to improve on the current options in the management of VUR.

Although there was no discernible statistical difference in VUR resolution between the VR and open groups in our study, the results were not as favorable in VR as in open surgery in this and other studies of open intravesical ureteral reimplantation.\(^5\)–\(^7\) However, after using a similar technique Yeung et al observed results equivalent to OR (96% VUR resolution) in a smaller series in children.\(^8\) Also, in a series of 50 patients with VR (6 months to 14 years old) Steyaert and Valla reported VUR resolution in 40 of 41 patients (98%) with followup.\(^8\) We believe that the technique of creating cross-trigonal tunnels is the same as that of OR but that the tools and exposure are slightly different. Errors with our execution of this technique likely caused decreased success compared to other series. With increasing experience we expect that VUR resolution rates will be identical to those of open ureteral reimplantation.

Although this study is retrospective and no validated postoperative pain questionnaire was used, there was a statistically significant difference in the amount of narcotic medications taken by the 2 groups. Significance was observed for the number of doses of oral and intravenous analgesics administered on an as needed basis (\(p = 0.001\) and \(p = 0.005\), respectively). However, there was no statistical difference between the 2 groups regarding the amount of anticholinergic medication (oxybutynin) taken postoperatively (see table). We believe that elimination of the anterior cystotomy and placement of an intravesical retractor through the VR decreases postoperative bladder irritability.

Operative times were clearly longer in the VR group in this study (\(p = 0.001\)). We analyzed the trend of operative times with increased experience. However, no substantial improvement was noted, which is likely due to inclusion of physicians in training during certain portions of the procedure in the latter half of the study. Factors unique to this procedure that make it challenging include a small working space, intracorporeal suturing, and dissection and tunneling of the ureters. Surgeon baseline laparoscopic skills and experience should influence the slope of the learning curve for this technique. Subjective improvement in ease of the procedure was noted after 15 to 20 cases, although certain aspects of the technique are constantly being modified and improved.

There was no statistically significant difference in hospital stay between the 2 groups studied (\(p = 0.122\)). Furthermore, LOS in the OR group was comparable to other studies of open ureteral reimplantation.\(^5\),\(^6\) We believe that this technique will eventually require only overnight observation, and we acknowledge our hesitancy to shorten the hospital stay due to the newness of the procedure and unknown expectations for the postoperative course. The main limiting factor for hospitalization involves removal of the Foley catheter, not pain control. There were 3 patients in the study who had the Foley removed on postoperative day 1, with no subsequent problems.

Cystoscopic examination of our treatment failures showed that persistent VUR was most likely due to electrical/ischemic injury of the ureter during mobilization. It is imperative that great care be taken during dissection and mobilization of the affected ureters. A low power setting on the hook electrode and liberal sharp scissors dissection of the periureteral tissue may help decrease the likelihood of cautery injury, as we have had no further cases of persistent VUR since instituting this change.

CONCLUSIONS

Our preliminary results indicate that VR is an effective procedure involving less pain compared to open transvesical repair. To our knowledge this series of vesicoscopic ureteral reimplantation is the first to compare results to a control group undergoing open ureteral reimplantation. The lower mean age and the higher preoperative VUR grade in the control group are likely reflective of our bias toward performing OR in small children and in children with high grade VUR. These differences may have an impact on the outcomes observed, and are certainly limitations to the study. Nevertheless, significant differences in narcotic requirements and total OR time were observed in this series.

While the rate of VUR resolution for VR in this series is not as high as that of OR, the favorable results of other series and the reduction in observed postoperative pain warrant consideration of this technique in the management of VUR. Further refinement of the technique and critical analysis of the long-term outcomes are needed to understand fully its place in the treatment of VUR. As with any new procedure, complications not typically encountered with standard techniques occurred. However, there is a steep learning curve, and we suspect that with greater experience the occurrence of such complications should be low.

**Abbreviations and Acronyms**

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<th>Abbreviation</th>
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<tr>
<td>LOS</td>
<td>length of stay</td>
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<td>OR</td>
<td>open ureteral reimplantation</td>
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<td>VR</td>
<td>vesicoscopic ureteral reimplantation</td>
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<td>VUR</td>
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**REFERENCES**

EDITORIAL COMMENT

As laparoscopic surgery in pediatric urology gains momentum, it is appropriate to pause periodically to review the results and compare them to those of well-established open procedures, as the authors of this study have done. The theoretical advantages of laparoscopic surgery include better cosmetic results, shorter hospitalization, decreased analgesic requirement, faster recovery, and in some cases more satisfactory operations resulting from better visualization and greater magnification. These theoretical advantages are not always easy to demonstrate in the pediatric population.

It is clear that at present laparoscopic surgery is superior to open surgery for orthiopexy of intra-abdominal or peeping testes, and for pyeloplasty in older children. I also use laparoscopy for primary or redo pyeloplasties in infants and toddlers, partial nephrectomy for duplication anomalies and ipsilateral ureteroureterostomy, and in cases when transureteroureterostomy, appendicovesicostomy or appendicocoeceostomy is required as an isolated procedure. In most of these cases laparoscopic surgery yields better cosmetic results with equal or better outcomes compared to open surgery. This outcome may justify the longer operating time. In our experience it has been difficult to determine a clear advantage as to the length of hospitalization and analgesic requirement.

With this background in mind the present report leaves me unconvinced of the wisdom of pursuing cross-trigonal ureteroneocystostomy in children. I have several concerns. Even in this series, the largest published to date, the results are inferior to those of open surgery. In my opinion 4 cases of persistent reflux and 1 bilateral ureteral obstruction are unacceptable in a series of fewer than 50 cases. I am skeptical about the statement that the results will improve with greater experience. The problem of creating a tunnel that extends beyond the original point of entrance of the ureter on the opposite side is intrinsic to the technique and one of the reasons why I have abandoned it. New instrumentation will have to be developed to solve this problem. It would have been useful if the authors had provided a chart outlining the surgical times in relation to increasing experience. In this type of procedure surgical time is a good indicator of technical ease.

Also, it is difficult to improve the cosmetic appearance of a well healed Pfannenstiel incision. Certainly, the scars of the 2 lower quadrant port sites are not necessarily better. The lower use of analgesics in this series is not convincing. No validated pain scale was used, the doses of ketorolac were not taken into account and in the absence of a strict protocol for analgesic administration that is not controlled by the surgeon results are likely to be biased.

Nonetheless, I would like to thank and congratulate the authors for this report. I admire the effort they have made to master this technically demanding procedure and the honesty of their reporting. However, for the reasons outlined herein, I doubt that this operation will become standard or even a valid option for treating vesicoureteral reflux in the near future.

Ricardo González
Department of Surgery, Division of Pediatric Urology
Alfred I. duPont Hospital for Children
Wilmington, Delaware

REPLY BY AUTHORS

The only way to know the extent to which laparoscopic techniques can be applied to pediatric reconstructive surgery is to push the limits and objectively review outcomes. As with any new technique or procedure one must objectively review outcomes to assess what good and what bad might have occurred. Evaluation of our cases with persistent reflux suggested that the technique of ureteral dissection might have been suboptimal. However, modifications to the dissection technique have improved outcome such that there have been no further cases of persistent reflux in the subsequent 30 patients tested. Presently we have a 94% rate of reflux resolution and can state that vesicoscopic reimplantation has a success rate nearly equivalent to open repair. The length of tunnel that can be created is a not a major issue, since even with open surgery there is no need to create a tunnel that extends past the contralateral hiatus. Indeed our present success rate would suggest that tunnel length creation is a nonissue.

Admittedly, no validated pain scale was used in this retrospective review. However, all patients had the same postoperative protocol with scheduled doses of ketorolac and with narcotics reserved for breakthrough pain. Thus, the documented decreased need for narcotics in the vesicoscopic group is suggestive of the procedure leading to less pain. Indeed the mother of a recent patient, who had undergone open unilateral repair 3 years previously and subsequent contralateral vesicoscopic repair for new onset reflux and recurrent pyelonephritis, noticed the marked decrease in pain and recovery time after the second procedure.

Every procedure has a learning curve during which there may be unexpected complications and problems. Indeed, laparoscopic cholecystectomy, early in its development, had an increased complication rate, such as bile duct injury, compared to open cholecystectomy. Recognition of this potential led to modifications to the procedure such that biliary injury is now rare and laparoscopic cholecystectomy is the standard of care.

Open surgery for reflux works well, especially after decades of refinement, and it is hard to improve something that has already been nearly perfected. Standard surgery has little risk, a low complication rate and a high success rate and can be performed through a relatively small incision. Why laparoscopy? As we demonstrated, a vesicoscopic approach leads to less pain. Parents are much more accepting of surgery, in general, when it can be done in a minimally invasive manner. Vesicoscopic reimplantation, although difficult to learn, can be a wonderful tool for resident or fellow education, forcing one to master complex dissection and suturing techniques.

What is best for the patient is not always best for the surgeon. The improved postoperative course in these children can be a strong motivating factor in learning an admittedly difficult technique. Our extended data suggest that vesicoscopic ureteral reimplantation is a valid and effective method for the correction of reflux.