LAPAROSCOPIC CORRECTION OF VESICOURETERAL REFLUX IN CHILDREN: REVIEW OF THE CURRENT LITERATURE

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Summary.- Vesicoureteral reflux is one of the most important pediatric urology topics. The correction of this pathology by means of open and endoscopic surgery has been well established. The laparoscopic approaches are evolved with the aim of combining the minimally invasive nature of endoscopic treatments with the high success rates of open surgeries. The first applications of laparoscopic ureteral reimplantation techniques started in mid 1990s. However, it did not gain wide acceptance as the latter endoscopic trigonoplasties could not. With 2000s, case series of transperitoneal extravesical and pneumovesicoscopic intravesical ureteral reimplantations showed the feasibility. Today, both conventional and robotic assisted laparoscopic approaches are shown to have comparable outcomes with open counterparts in terms of successful resolution of reflux, postoperative comfort and improved cosmesis. The only shortcoming of new techniques seem to be the longer operative period which stands as a barrier against the wide acceptance which probably will take some time to be improved.

Keywords: Vesicoureteral reflux. Surgery. Laparoscopy. Children. Review.

Resumen.- El refluo vesicoureteral es uno de los temas más importantes en urología pediátrica. La corrección de esta patología por medio de cirugía abierta y endoscópica está bien establecida. Los abordajes laparoscópicos han evolucionado con el objetivo de combinar la naturaleza mínimamente invasiva de los tratamientos endoscópicos con las altas tasas de éxito de las cirugías abiertas. Los primeros casos de reimplantes ureterales laparoscópicos empezaron a mediados de los 90. Sin embargo, no consiguieron una aceptación amplia como las más recientes trigonoplastias endoscópicas. Con los años 2000 aparecieron series que demostraron la viabilidad de reimplantes extravesicales transperitoneales e intravesicales con laparoscopia intravesical (neumovejiga). Hoy, se ha demostrado que tanto la laparoscopia convencional como la asistida por robot tienen resultados comparables con la cirugía abierta en resolución del refluo, confort postoperatorio y mejora de la estética. El único defecto de las nuevas técnicas parece ser el tiempo operatorio más largo, que se alza como una barrera contra la amplia aceptación, que probablemente necesite algún tiempo para mejorar.
INTRODUCTION

Vesicoureteral reflux (VUR) is one of the most important diseases in pediatric urology. In the long term, VUR related renal parenchymal lesions have several potential consequences such as hypertension, loss of renal function, end-stage renal failure, effects on somatic growth, risk for further infection and effects on pregnancy (1). Most of the patients with VUR initially undergo conservative treatment option however in patients with recurrent febrile infections despite antibiotic prophylaxis, medical non-compliance, development of new scars and in the presence of associated malformations surgical treatment should be warranted (2).

Interventional treatment modalities include endoscopic and open surgical correction techniques. Subureteric material injections have advantages of being minimally invasive and repeatable with reproducible results. However, the success rates with single injection are still far away from the open procedures which requisite the postoperative control voiding cystourethrogram (VCUG) though the results become better with repeated injections. Several open techniques have been described with universally high results which decreased the routine control VCUG requirement. However, these good results are obtained in consideration of an incision and retraction of the abdominal wall causing postoperative pain, bladder spasms, longer urinary diversion and prolonged hospital stay.

With the advances in laparoscopy in children, it has also been started to be performed in surgical correction of VUR with the aim of decreasing postoperative pain, shortening the postoperative hospitalization and better cosmesis. The present review aims to overview the current status of laparoscopic surgery in pediatric VUR treatment.

HISTORY

The idea of correcting VUR by means of laparoscopy has a history of about 20 years that Atala et al first showed the feasibility of laparoscopic Lich-Gregoir reimplantation in pigs with successful results (3). One year later, the first report of laparoscopic ureteroneocystostomy (UNC) in humans in 2 children was presented by Ehrlich et al (4). In 1995, Janetschek et al reported their experience on laparoscopic Lich-Gregoir UNC in 6 patients (1 extraperitoneal) (5). They concluded that the procedure was complex and had no advantage over the conventional procedure. Then the literature on laparoscopic Lich-Gregoir operation got a silence up to the new millennium.

TRIGONOPLASTY

During this silent period for laparoscopic Lich-Gregoir procedure, 2 authors presented their experiences on laparoendoscopic application of trigonooplasty with Gil-Vernet technique. Okamura published his first experience of endoscopic trigonooplasty in 5 (6 renal units) patients in a Japanese journal in 1994 (6). In 1995 he presented the results of 12 patients with a cure rate of 100% (7). However, in the longer follow-up period, the problems of trigonal splitting started to occur and the success rates from decreased 95% (3rd month) to 79% (12th month) (8). By the technique he utilized, the success rate was better in adults probably depending on the longer distance between ureteral orifices and the thicker detrusor backwall (9). Therefore they made major modifications in their technique and started to apply the principle of Orikasa antireflux operation and called it ‘Endoscopic Trigonoplasty 2 (ET2)’. They operated 8 female patients (14 renal units) and the success rate was 12/14 (86%) at the end of 12 months postoperatively (10). Their encouraging results let them perform this technique in 15 female patients (23 renal units) with a 12th month success rate of 86% which is less than the open or laparoscopic surgeries and they did not recommend ET2 for treatment of vesicoureteral reflux operation. Cartwright was the other author attempting to popularize the percutaneous endoscopic trigonooplasty (PET). In his first publication, he reported a success rate of 62.5% (20/32 renal units) (11) which they stated that could be improved with technical modifications. They reported 3 complications (1 vesico-vaginal fistula, 1 extravasation from the port site, 1 dilutional hyponatremia). However, in the longer follow-up period this rate decreased substantially to 53% (12) that was considered unacceptable also by the authors. After these disappointing results, Simforoosh (13) et al described a novel laparoscopic correction of reflux. They made Gil-Vernet trigonooplasty via extraperitoneal approach. However, they opened the bladder with a 3-4 cm incision and performed trigonooplasty through this cystotomy incision. The technique was applied in 27 (41 RU) patients and the success rate 89% (in 24 patients). They reported no complication (13). Except from opening the bladder, it seems a practical way of creating an anti-reflux mechanism.
Extravesical Technique

After the initial experiences in 1990’s, Lakshmanan et al was the first who presented their experiences on transperitoneal extravesical Lich-Gregoir technique in a significantly high volume of patients with the description of the method in details. The similar technique has been used in the following papers on laparoscopic extravesical UNC.

Surgical Technique (14)

Cystoscopy is performed to assess the ureteral orifices and possible additional abnormalities. A ureteral catheter is placed to the relevant ureter to ease the procedure during laparoscopy. The authors recommend ureteral catheterization for the beginners and need for ureteral catheterization may decrease with the gained experience. Then, a urethral catheter is placed for hydrodistention and drainage of the bladder during the laparoscopic procedure. Patient is given supine position. The first trocar for the camera is placed by the open technique at the inferior umbilical fold. The working trocars are placed under direct vision. A pfannenstiel incision is drawn by a marker and two lateral trocars are placed at the lateral edges of this imaginary line on the midclavicular line. An additional trocar for traction is placed in the middle of this line. The peritoneum is incised transversely between the broad ligament and bladder in females and at a caudal level to vas deferens in males. After incision of the peritoneum, the connective tissue is bluntly dissected to find the ureter which can be recognized with the catheter in. As the ureter is found, it can be elevated by a Babcock, vessel loop or Diamond Flex retractor. However, the authors do not recommend the use of Babcock for elevation of ureters larger than 5 mm because of the risk of grasping the ureteral wall. The optimal position of detrusor tunnel is determined by several filling levels of bladder to avoid kinking. The tunnel is marked with cautery at the posterior wall and a prolene traction suture is placed at the most caudal point of this mark to elevate the bladder during tunnel creation. The detrusosmyotomy is performed until the mucosa bulges and the tunnel is created. At the distal part of myotomy, dissection is directed to medial and lateral aspects forming an ‘inverted Y’ shape. The mucosal perforations can be closed with sutures. The detrusor is then approximated to each other with interrupted sutures 5 mm apart (Figures 1.1-1.5). The first suture should be placed at a few millimeters away from the detrusor border to prevent buckling. The inverted-Y dissection technique eliminates the need for the anchoring suture which is used in the open technique. Because the pressure in the peritoneum can push the bladder anteriorly, the filling of bladder at different levels for the assessment of ureteral position should be done under partially desufflated abdomen. Then, the hemostasis is completed, the working trocars are removed under direct vision and the umbilical fascial opening is closed. The urethral catheter is held in place for 12-24 hours.

Authors performed this technique in 71 refluxing ureters (23 unilateral and 24 bilateral) with no persistent reflux or obstruction. Although not given in details, they reported that patients generally had markedly decreased postoperative morbidity, returned to full physical activities in about 7 days. There are some other series with significant number of patients. Riquelme et al reported a success rate of 94.7% (18/19 renal units) in 15 patients having VUR less than grade IV (15). They interestingly made cystoscopy and intraoperative cystogram to confirm the resolution of reflux. In series of Lopez et al 100% of success rate was reported in 30 patients (43 renal units) with all having VUR grade III or higher (16). The mean operative time was varying between 70 and 110 minutes for unilateral and between 2 and 3 hours for bilateral cases. The mean postoperative hospital stay was about 2 days. The complications included mucosal perforation, ureteral leakage and urinary retention which mostly treated conservatively. The only extraperitoneal Lich-Gregoir series in 2000s belongs to Sakomoto et al including 4 patients with reflux of grade III or lower (17). The mean operative time was 230 minutes with resolution of reflux in all patients.

Figure 1.1. The trocar for the camera is placed at the level of umbilicus. The working trocars are placed inferior to the camera port at the lateral border of the rectus muscles.
Baldwin et al. (18) described a simple laparoscopic transperitoneal technique which was utilized in pigs. They made a full-thickness cystotomy (including transection of the urothelium) from the point of ureteral insertion, extending cephalad and lateral, along the lateral bladder wall for a distance of 3 to 4 cm. The distal ureter was then placed inside the bladder, and the full thickness of the bladder wall was reaproximated in a single layer. They did not try to close the urothelium over the ureter and leave for self-epithelization. They reported that all operated units became free of reflux and self-epithelization was achieved in all cases. However, this technique couldn’t find application in human beings.

**Intravesical Technique**

In 2001, Gill (19) et al reported transvesical cross-trigonal UNC to avoid the potential side effects of transperitoneal extravesical ureteral reimplantation...
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(risks of transabdominal surgery, risks of voiding problems in bilateral cases) and failure of subureteric injection technique. However, in their first 3 cases, 2 of them were obtained to be free of VUR. They used Collin’s knife to incise the mucosa transurethrally and they made the Cohen type reimplantation through two suprapubic intravesical ports. They limited their dissection of ureter within a 2-3 cm length to minimize the irrigation fluid. However, they didn’t suture the hiatal defect in the detrusor which should be improved technically which the authors claimed to be the cause of decreased reflux resolution. This technique did never gained wide acceptance.

Following the initial animal studies in pigs which confirmed the feasibility of intravesical procedure with CO₂ insufflation of the bladder (20), Yeung et al presented the first clinical series of pneumovesicoscopic cross-trigonal Cohen procedure (21).

Surgical Technique (21)

The surgical technique has been described in details by Yeung (21). The patient is placed in supine position with the legs separated that surgeon can get access to the urethra for intraoperative cystoscopy and catheterization. Following the cystoscopy, a traction suture was passed percutaneously at the bladder dome under cystoscopic vision through both the abdominal and bladder walls to keep the bladder wall from falling away when the first camera port site incision is made and during insertion of the cannula. Although, some authors state that gas leakage through the urethra, even in girls, is uncommon and urethral occlusion is generally not necessary (22), the urethral catheter was mostly used to occlude the internal urethral meatus to secure CO₂ pneumovesicum, and also serve as an additional suction irrigation device during subsequent dissection and ureteral reimplantation. Two more 3- to 5-mm working ports were then inserted along the interspinous skin crease on either side of the lower lateral wall of the distended bladder under vesicoscopic guidance. In small children less than 3 years old, the bladder is in a high position and the trocars are closer to the umbilicus and more medial. In older children, the bladder is deeper and lower in the pelvis and the trocars are closer to the pubis and more lateral (22). A 3- to 4- cm-long segment of 4F or 6F catheter was inserted into the respective ureter as a stent to facilitate subsequent ureteral mobilization and dissection and secured with a 4-0 monofilament suture. Intravesical mobilization of the ureter, dissection of the submucosal tunnel, and a Cohen’s type of ureteral reimplantation was performed under endoscopic guidance in a manner similar to the open procedure (Figures 2.1-2.5). Use of ureteral catheters at the end of the procedure is not routine. In their original description, Yeung et al did not close the place of the working trocars, however Jayanthi et al advocated the closure of these port sites and developed an internal ring suturing technique for that purpose in order to decrease the risk of extravasation postoperatively (23). Canon et al used sutures passed through a spinal needle for this aim (24).

Following these modifications, intravesical approach found more proponents and reflecting this trend, several reports have been published (22-27). Mean operative time for unilateral cases was 80-160 minutes and for bilateral cases was 130-180 minutes. Hospital stay was reported to be around 2 days. The success rate was varying between 91 to 97.6%. Conversion to open surgery was mostly due to port displacement and proximal migration of ureteral catheter. Ureteral stricture or obstruction may occur due to inappropriate handling and dissection of the distal ureter. Extraperitoneal extravasation or the urine leak was reported to be occurred due to inadequate closure of the bladder and improper ureterovesical anastomosis. Scrotal and suprapubic emphysema was related to the gas leakage to the subcutaneous tissue which always resolved spontaneously. In some occasions, inadvertent pneumoperitoneum treated by intraoperative intraumbilical Veress needle placement.

Figure 2.1: Following the traction suture which was passed percutaneously at the bladder dome under cystoscopic the first camera port site incision is made. Two more working ports were then inserted along the interspinous skin crease on either side of the lower lateral wall of the distended bladder under vesicoscopic guidance.
Robotic Assisted Technique

In 2003, the feasibility of pneumovesicoscopic Cohen procedure has been shown by the use of robotic instruments in pigs (20). After the first robotic assisted intravesical Cohen procedure in 6 children aged between 5 and 15 years, a limited number of publications were present (28). In one of them, Casale et al described a robotic assisted nerve sparing technique for extravesical UNC (29). They performed the operation in 41 patients with all having bilateral reflux of grades 3 or higher. The success rate was 97.6% with no conversion to open surgery and no postoperative urinary retention. They concluded that besides being time consuming, robotic assistance eases the fine nerve sparing maneuvers and provides better visualization of pelvic plexus. Sorensen et al made a comparison between 13 robotic assisted laparoscopic (RAL) extravesical UNC and open counterparts (30). They found that operative time was longer in RAL group, blood loss and hospitalization (only for unilateral cases) were less in RAL group. Within these series authors did not recognize a learning curve. With the collection of experience, 2 comparative studies have been published. In one of them, Smith et al published a comparative study between RAL transperitoneal extravesical and open intravesical ureteral reimplantations. Comparison

![Image of a catheter and ureter]

**Figure 2.2:** The ureter with a stent in it is dissected and freed with the help of a traction suture.

![Image of a traction suture, laparoscopic scissors, and ureter]

**Figure 2.3:** The dissection is completed by sharp and blunt dissection.

![Image of a catheter, ureter, and bladder neck]

**Figure 2.4:** The cross-trigonal tunnel is created with the help of laparoscopic dissector.

![Image of right and left ureters and bladder neck]

**Figure 2.5:** The ureter is passed through the submucosal tunnel and ureter orifice is anastomosed to bladder mucosa with 4 or 5 interrupted sutures.
revealed longer operative time, shorter hospital stay and lesser analgesic requirement in RAL group. Although being different techniques, the success rate was similar (RAL: 97% vs open: 100%) (31). The latest publication belongs to Marchiani et al. Although the number of cases are limited and having a retrospective nature, it is the only study up to date which makes a detailed comparison (32). The study made the comparison of 39 robotic (19 intravesical and 20 extravesical) and 39 open (22 intravesical and 17 extravesical) anti-reflux surgeries in many aspects. The results confirmed that robotic approach in both extra and intravesical approaches have longer operative time than their open counterparts. However, the robotic intravesical approach had fewer bladder spasms, less hematuria, shorter bladder drainage and shorter postoperative hospital stay. In extravesical group, robotic cases were not significantly different from their open counterparts in any of the parameters. The success rates were similar in all groups.

DISCUSSION

The role of open and endoscopic surgery has been well established for the treatment of VUR. The intravesical cross-trigonal Cohen procedure is one of the most popular techniques which permits the correction of bilateral cases, ability to correct the accompanying abnormalities (ureteroceles, diverticula) with a success rate up to 99% (33). It has its disadvantages that postoperative bladder spasms due to the cystotomy incision and the difficulty on ureteral catheterization for the future interventions such as ureteroscopy though can be solved by flexible instruments. Moreover, it was shown that operation can even be done without a bladder catheter which shortens the postoperative hospital stay (34). The extravesical Lich-Gregoir method has the advantages of being simpler, short hospital stay, no requirement for bladder drainage and not opening the bladder and has a success rate of 92-98% (35), however it is not usually preferred for bilateral cases because of the risk of urinary retention in 8-15% of cases and ureteral obstruction in 2-4% of cases (36). Subureteric injection techniques besides being minimally invasive, having possibility to be performed as an outpatient procedure and repeatable, it has lower success rates than the open procedures. Routh et al in their systematic review on use of Dextranomer/Hyaluronic Acid for VUR treatment, they reported an overall ureteral unit success rate of 77% varying from 81% for grade I to 62% for grade V (37).

The laparoscopic approaches arose from the idea of combining minimal invasiveness of endoscopic treatments with the successful outcomes of open procedures. After the initial papers reporting the complexity and having no advantage of the procedure in children, new publications on this issue started to appear in the literature after 2000s. The percutaneous endoscopic application of Gil-Vernet which seems less complex couldn’t get wide acceptance because of its low success rates even by their inventors (10). However, Simforoosh et al’s report on extraperitoneoscopic application of Gil-Vernet is the only series which have acceptable results. The attempts of Gill et al who performed Cohen procedure endoscopically did also have poor results (19). After 2000, Lakshmanan showed the feasibility of transperitoneal extravesical application of Lich-Gregoir procedure in a considerably high volume of patients and this study became the re-birth of the laparoscopic applications (14). Lich-Gregoir technique has the advantages of minimal bladder spasm, less morbidity because the bladder remains intact, no hematuria, and no anastomosis. In addition, decreased hospital stay with faster recovery makes it a potential 1-day surgery (16). Transperitoneal approach had the advantages of having a larger operative field in the relatively small body of a child and with the advantages of not opening the bladder. The transperitoneal approach may have the potential risks of injury of the intraperitoneal organs and the metabolic consequences. Placement of the first camera port by open technique, the placement of the working ports under direct vision, having the patient in a Trendelenburg position and meticulous working style dissipates these potential risks. Moreover, pediatric urologists perform these kinds of operations after getting experience in other laparoscopic procedures such as orchiopexy, nephrectomy, pyeloplasty and therefore no organ injury related complications have been reported in the transperitoneoscopic Lich-Gregoir operations. There is a concern on the application of Lich-Gregoir technique bilateral VUR because of the postoperative urinary retention. Although being transient, it is reported to occur in upto 15% of cases in the open surgeries. Interestingly, when we gather the data on bilateral laparoscopic Lich-Gregoir operations (also including the robotic ones), urinary retention was reported in only 7 of 100 cases (Table). A small but an original study in 9 patients made the comparison of preoperative and postoperative voiding parameters in details and confirmed that no postoperative urinary retention was present (38). This finding may be attributed to the limited dissection and preservation of vascular structures around the posterior bladder by magnifications of the laparoscopic optical system. The metabolic consequences of laparoscopic surgery in children have been reviewed by McHoney et al. They concluded that minimally invasive surgery may maintain preoperative metabolic processes by altering the postoperative processes on a physiological level.
**Table.**

<table>
<thead>
<tr>
<th>Author, year, ref.</th>
<th>Mean age (range)</th>
<th>Number of patients</th>
<th>Gender (M/F)</th>
<th>Number of renal units</th>
<th>Technique</th>
<th>Grade of VUR, number</th>
<th>Unilateral / bilateral (patients)</th>
<th>Mean operative time (range)</th>
<th>Mean hospital stay (range)</th>
<th>Success</th>
<th>Complication (n)</th>
<th>Mean follow-up (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakshmanan, 2000, (14)</td>
<td>4.1 y (10 mo -13 y)</td>
<td>47</td>
<td>NA</td>
<td>71</td>
<td>TpEv (L-G)</td>
<td>NA</td>
<td>23 / 24</td>
<td>NA</td>
<td>NA</td>
<td>100%</td>
<td>Ureteral injury (3)</td>
<td>NA</td>
</tr>
<tr>
<td>Yeung, 2005, (21)</td>
<td>5 y (14 mo -11 y)</td>
<td>16</td>
<td>10 / 6</td>
<td>23</td>
<td>PV (Cohen)</td>
<td>t: 0</td>
<td>It: 1 RU</td>
<td>II: 4 RU</td>
<td>IV: 10 RU</td>
<td>V: 8 RU</td>
<td>9 / 7</td>
<td>13.6 (80-230)</td>
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<tr>
<td>Kutikov, 2006, (26)</td>
<td>5.7 (1-18)</td>
<td>52</td>
<td>7 / 45</td>
<td>89</td>
<td>PV (Cohen for VUR, G-A for POM)</td>
<td>t: 0</td>
<td>II: 1 pt</td>
<td>III: 4 pts</td>
<td>IV: 6 pts</td>
<td>V: 3 pts</td>
<td>III-V: 18 pts</td>
<td>0 / 32</td>
</tr>
<tr>
<td>Canon, 2007, (24)</td>
<td>8.2 (2-16)</td>
<td>27</td>
<td>3 / 24</td>
<td>41</td>
<td>EpTRI (G-V)</td>
<td>t: 2 pts</td>
<td>II: 3 pts</td>
<td>III: 17 pts</td>
<td>IV: 9 pts</td>
<td>13 / 14</td>
<td>147 min (60-240)</td>
<td>2.7 days (1-6)</td>
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<tr>
<td>Jayanthi, 2008, (23)</td>
<td>13 mo – 18 yrs</td>
<td>103</td>
<td>12 / 91</td>
<td>175</td>
<td>PV (Cohen)</td>
<td>NA</td>
<td>25 / 78</td>
<td>NA</td>
<td>NA</td>
<td>94% (72/77 pts)</td>
<td>Conversion to open surgery (3)</td>
<td>Proximal migration of feeding tube (4)</td>
</tr>
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<td>Casade, 2008, (29)</td>
<td>38 mo (18-81)</td>
<td>41</td>
<td>NA</td>
<td>82</td>
<td>TpEv (Robotic nerve sparing)</td>
<td>III: 8 pts</td>
<td>IV: 5 pts</td>
<td>V: 5 pts</td>
<td>III-V: 23 pts</td>
<td>0 / 41</td>
<td>2.3 (1.4-3.2) hrs</td>
<td>26.1 hrs (18.34)</td>
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<tr>
<td>Valla, 2009, (28)</td>
<td>4.2 yrs (0.5-14)</td>
<td>72</td>
<td>NA</td>
<td>113</td>
<td>PV (Cohen)</td>
<td>t: 7 pts</td>
<td>III: 42 pts</td>
<td>IV-V: 23</td>
<td>31 / 41</td>
<td>82 min (uni)</td>
<td>130 (bi)</td>
<td>2.8 days</td>
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<td>Author, year, ref.</td>
<td>Mean age (range)</td>
<td>Number of patients</td>
<td>Gender (M/F)</td>
<td>Number of renal units</td>
<td>Technique</td>
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<td>Unilateral / bilateral (patients)</td>
<td>Mean operative time (range)</td>
<td>Mean hospital stay (range)</td>
<td>Success</td>
<td>Complication (n)</td>
<td>Mean follow-up (range)</td>
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<tr>
<td>Lopez, 2010, (16)</td>
<td>52 mo (15-183)</td>
<td>30</td>
<td>7 / 23</td>
<td>43</td>
<td>TpEV (L-G)</td>
<td>III: 31 RU IV: 11 RU V: 1 RU</td>
<td>17 / 13</td>
<td>70 (38-120) min (uni)</td>
<td>24 (20-26) hours</td>
<td>100%</td>
<td>Ureteral leakage (1) Urinary retention (1)</td>
<td>11 (2-24) mo</td>
</tr>
<tr>
<td>Marchini, 2011, (32)</td>
<td>9.9±5.2 yrs</td>
<td>19 (intra vesical)</td>
<td>7 / 12</td>
<td>38</td>
<td>PV (Cohen, robotic)</td>
<td>III: 11 RU IV: 8 RU II: 4 RU</td>
<td>2 / 17</td>
<td>232.6± 37.4 min (bil)</td>
<td>1.8±1.2</td>
<td>92.2%</td>
<td>Urinary retention (1) Bladder leak (4)</td>
<td>19.4±18.2</td>
</tr>
<tr>
<td>Smith, 2011, (31)</td>
<td>69±39 (3-144)</td>
<td>25</td>
<td>9 / 16</td>
<td>33</td>
<td>TpEV (L-G, robotic)</td>
<td>IV: 13 RU</td>
<td>17 / 8</td>
<td>185±41.6 (117-286) min</td>
<td>33±12.5 (14-57) hours</td>
<td>97%</td>
<td>Urinary retention (1) Bladder leak (2)</td>
<td>16 (2-44)</td>
</tr>
<tr>
<td>Hong, 2011, (27)</td>
<td>6 yrs</td>
<td>28</td>
<td>NA</td>
<td>46</td>
<td>PV (Cohen)</td>
<td>II: 5 RU III: 14 RU IV: 15 RU V: 12 RU</td>
<td>10 / 18</td>
<td>166.1± 46.8 min (uni)</td>
<td>1.38 (1-4) days</td>
<td>94.6%</td>
<td>Conversion to open (2, port displacement) Proximal migration of feeding tube (1)</td>
<td>8.6 (6-14) months</td>
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<td>Bayne, 2012, (43)</td>
<td>6.7</td>
<td>98</td>
<td>15 / 83</td>
<td>144</td>
<td>TpEV (L-G)</td>
<td>NA</td>
<td>NA</td>
<td>1.4 days</td>
<td>93.5% (patients)</td>
<td></td>
<td>UTI (16.7%) Urinary retention (6.5% of bilateral cases) Ureteral obstruction (3.4%)</td>
<td>8 months</td>
</tr>
<tr>
<td>Riquelme, 2013, (42)</td>
<td>4.5 (3.5-9) yrs</td>
<td>81</td>
<td>20 / 61</td>
<td>95</td>
<td>TpEV (L-G)</td>
<td>II: 32% III: 55% IV: 8%</td>
<td>67/14</td>
<td>105 min (left side)</td>
<td>1.6 days</td>
<td>95.2% (RU) 95.8%</td>
<td>Urinoma (2)</td>
<td>&gt;12 months</td>
</tr>
</tbody>
</table>

decreased operative time with increasing experience and complication rates (47). One study showed a difference including the operative times, success and complication rates of 15 young patients and revealed no significant difference. Kawauchi et al also did. Kutikov et al compared 15 adults and showed the feasibility of the technique also in double collecting systems (40). In the case-report of Sakamoto et al, extravesical laparoscopic Lich-Gregoir was performed by extraperitoneal approach in 4 patients. All the cases were unilateral and completed within a mean period of 230 minutes which may be considered exceedingly long and no more cases was reported after this experience (41). Two recent large series reports a success rate more than 95% with a hospitalization period less than 2 days (42,43).

The experience on pneumovesicoscopic cross-trigonal UNC is larger than the extraperitoneal technique. The allowance for bilateral reimplantation, reduced bladder trauma, absence of wide cystotomy and retraction of bladder wall may be counted as the benefits of this approach (22). Besides these facts, it also allows to intravesical repair of diverticula (44). However, the operative field is smaller and intracorporeal knot-tying is more demanding. In a study of Kutikov et al, they noticed that complications mostly occurred in children who had small (<130 cc) bladder capacity and were younger than 2 years age (26). Their observations showed that increasing intravesical pressures (>10 mmHg) were causing contractions therefore they recommend to work under pressures between 6-8 mmHg. The effect of CO₂ on upper urinary tract was studied in sows and pneumovesicum at a pressure of 10 mm Hg for 2 hours did not result in any demonstrable deleterious effect (45). Canon et al made one of the few comparative studies (24). They showed in their retrospective study that the mean age was higher, the reflux grade was lesser, operative time was longer and narcotic analgesic need was lesser in vesicoscopic reimplantation group than the open group. Another smaller study also showed that financial cost-effectivity and hospital stay were favouring the laparoscopic technique (46). Jayanthi with the largest experience in the literature recommended the low power cautery use, correct placement of ports, closure of port sites as Kutikov et al also did. Kawachii et al compared 15 adults and 15 young patients and revealed no significant difference including the operative times, success and complication rates (47). One study showed a decreased operative time with increasing experience (27).

There are 3 clinical studies on the robotic assisted laparoscopic UNC with considerable size of patient groups. The techniques in both intravesical and extravesical approaches are same as in the conventional laparoscopy. These studies reported very successful VUR resolution rates (29,31,32). The comparisons with open surgeries revealed longer operative time, shorter hospital stay and lesser analgesic requirement in RAL group (31,32).

Other than pediatric cases, the laparoscopic approach for ureteral reimplantation was also used for treatment of secondary cases such as ureteral strictures (48) or ureterovaginal fistula (49) in adults with successful outcomes. The use of laparoscopy in terms of cosmesis seems more significant than pediatric cases. The open surgery has well established outcomes and performed for decades. Although, laparoscopy promises a better cosmesis, the incision for open surgery mostly covered beneath the underwears or swimsuits. Therefore, it does not seem to cause a social problem. The retraction and handling of the bladder wall and mucosa are the causes of postoperative complaints after open surgery. Laparoscopy minimizes the tissue trauma and yields a better postoperative course which recently confirmed by comparative studies (31,32). The reflux resolution rates are satisfactory for both intravesical and extravesical techniques when compared to their open counterparts. The main concern on the laparoscopic approach for VUR is the longer operative time. Although, operative times are decreasing with increased experience, it is still far away from open approaches. The reasons for this fact can be counted as follows: the small number of institutions performing these cases (both for conventional and robotic assisted laparoscopy), requirement for a very high level of laparoscopic skill, small number of patients suitable for this approach, the idea of mentors on this approach in educational and practical purposes and the parental decisions. Another difficulty particularly against spreading of robotic surgery in developing regions of the world is the financial burden it costs.

In 2008, Callaghan presented the factor involved in parental decision making for surgical correction of VUR and considered that the parents selecting open surgery consider the success of the procedure most important, and the majorities are satisfied with their choice of treatment. Parents choosing endoscopic correction consider the minimally invasive nature of the procedure and the success rate most important, but the outcome may alter their satisfaction (50). These trends may be changed with the results of laparoscopic approaches.
CONCLUSION

The conventional and robotic assisted laparoscopy for treatment of VUR seems to be finishing its infancy and walking with straight steps. Collected experiences helped to define the indications, advantages and disadvantages of laparoscopic approaches. For the present time, laparoscopy can be said to be reaching its goal about the high successful results with a minimal invasive nature. The only barrier on the way of widespread acceptance is the long operative times which will take some more times to be improved.

REFERENCES AND RECOMMENDED READINGS
(*of special interest, **of outstanding interest)


