Minimally Invasive Ureteral Reimplantation in Children with Vesicoureteral Reflux: History and Current Status

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Abstract

Ureteral reimplant being one of the most complex operative procedures performed in children, it is a rational challenge to incorporate minimally invasive approach of laparoscopy with or without robotic assistance to provide the equivalent clinical advantage seen with complex procedures in adult population. It is important to comprehend the history and current status of this technological application in children and recognizes the clinical factors affecting optimal surgical outcome. Furthermore, it is necessary to grasp the essential technical and technological advancement from current literature to promote better surgical outcome of this challenging yet rewarding procedure among children.

Keywords

Pediatric vesicoureteral reflux · Robot-assisted laparoscopy ureteral reimplantation · Extravesical ureteral reimplantation · Intravesical ureteral reimplantation

Abbreviations

2D	2-Dimension
CAKUT	Congenital anomalies of the kidney and urinary tract
UTI	Urinary tract infection
UVJ	Ureterovesical junction
VCUG	Voiding cystourethrogram
VUR	Vesicoureteral reflux

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17.1 Introduction

17.1.1 Background

Vesicoureteral reflux (VUR) is a condition with anatomic and/or functional etiology that causes backflow of urine into the upper urinary tract. It is one of the most commonly diagnosed congenital anomalies of the kidney and urinary tract (CAKUT) among children presented with first febrile urinary tract infection (UTI) (Vachvanichsanong et al. 2017). The actual prevalence of the condition is unknown (Tekgul et al. 2017); however, estimated to be affecting 1–3% of infants and children.

Severe form of this condition causes recurrent pyelonephritis and renal scarring, which eventually lead to long term sequale of renal failure. Depending on the severity of VUR, management is catered according to individual patient condition (Arlen and Cooper 2015). Management options include, conservative close monitoring and continuous antibiotics prophylaxis, endoscopic bulking agent injection, minimally invasive procedures of ureteral reimplant using laparoscopic with or without robotic assistance to invasive open surgical approaches (Tekgul et al. 2017; Kim et al. 2017; Peters et al. 2010).

17.1.2 Scope

The scope of this chapter is confined to present the literature on minimally invasive approach of ureteral reimplant in children with VUR. Specifically to discuss the history, current status, consideration on the approach and future direction with highlights on Asian setting. For procedural description and technical details, recent publications and video bank are recommended as citations but not illustrated in this chapter (Patel and Ramalingam 2017; Dangle et al. 2014; Diaz et al. 2014; Schober and Jayanthi 2015; Weiss and Shukla 2015; Gundeti et al. 2016). Source of literature reference for this chapter was acquired from Pubmed on November 2017 with

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restriction only for human studies. (Search term strategy in Appendix A.)

17.2 History of Minimally Invasive Ureteral Reimplant in Management of Vesicoureteral Reflux Among Children

The conventional open approach of ureteral reimplantation of various techniques has shown high success rate ranging 92–98.3% in the treatment of VUR among children (Kennelly et al. 1995; Heidenreich et al. 2004; Austin and Cooper 2004). With the introduction of minimally invasive approach, laparoscopy was utilized in the early 1990s reported initially on animal model with extravesical technique (Atala et al. 1993; Schimberg et al. 1994; McDougall et al. 1995). Subsequent reports on human series, initially on adult patient, later on pediatric series were then published within the same decade (Reddy and Evans 1994; Ehrlich et al. 1994; Janetschek et al. 1995). The feasibility of the laparoscopic extravesical ureteral reimplant procedure was then established; however, due to the initial experience of technical challenges and time demanding, the approach was not immediately adopted by many (Smaldone et al. 2007). With learning curve being traversed, availability of better laparoscopic equipments and technical modifications, better successful clinical outcomes of the minimally invasive approach had been reported; yet careful selection of suitable patient was strongly recommended to achieve good outcome (Lakshmanan and Fung 2000; Carswell et al. 2003; Shu et al. 2004). Within the parallel timeframe, the adaptation and modification of laparoscopic extravesical ureteral reimplant were being reported in Asian countries with later showing comparable clinical outcomes (Kawauchi et al. 2003; Sakamoto et al. 2003; Ansari et al. 2006; Simforoosh et al. 2007).

In the initial exploration of minimally invasive approach ureteral reimplant, the endovesical approach utilizing both endoscope and laparoscopic instruments, was also reported in Asia (Okamura et al. 1993, 1996, 1999); however, due to limitation of visibility and mobility in using the urethral endoscope, technical difficulty of transvesical port placement and lower success rate (62.5–86%) compared to open approach; this approach was not favoured and became unpopular (Cartwright et al. 1996; Gatti et al. 1999; Gill et al. 2001; Tsuji et al. 2003; El-Ghoneimi 2003). Further animal studies were then performed to explore the feasibility of carbon dioxide insufflations of the bladder modifying the intravesical approach to improve visibility and technical mobility (Lakshmanan et al. 1999; Olsen et al. 2003). Subsequent reports in human series were published from Asian countries as well as north American experience with comparable success rate (91–96%) to open approaches (Yeung et al. 2005; Kutikov et al. 2006; Canon et al. 2007; Schober and Jayanthi 2015; Soulier et al. 2017). To overcome the limited dexterity, 2D spatial image and steep learning curve of pure laparoscopy, robotic system was introduced in 2000 to assist laparoscopic procedure, which gained high popularity for pelvic surgery procedures (Finkelstein et al. 2010). Robotic assisted laparoscopic was then being adapted for ureteral reimplants in children with initial experience reported in the early 2000 (Peters 2004; Peters and Woo 2005; Hayn et al. 2008).

17.3 Current Status of Minimally Invasive Approach of Ureteral Reimplant in Children

17.3.1 Current Status of Laparoscopic Ureteral Reimplants in Asian Countries

In the past decade, numerous successful intermediate to long term outcome were being reported from the Asian countries for pure laparoscopic ureteral reimplant of both extravesical and intravesical approach with some modifications (Tsai et al. 2008; Chung et al. 2008; Kawauchi et al. 2009; Chan et al. 2010; Hong et al. 2011; Chung et al. 2012; Emir et al. 2012; Moritoki et al. 2012; Bi and Sun 2012; Hayashi et al. 2014; Kim et al. 2015; Javali et al. 2015; Soh et al. 2015; Lau et al. 2017) The reported success rate ranges from 90% to 100% with low number of complications (Table 17.1). Some Asian studies also showed an improving perioperative and long term outcome with the learning curve being traversed (Chung et al. 2012; Choi et al. 2016; Lau et al. 2017).

17.3.2 Current Status of Robotic Assisted Laparoscopic Ureteral Reimplants Worldwide and Asian Countries

In the recent years, robot assisted laparoscopic ureteral reimplant is becoming a more prevalent approach for children with VUR (Weiss and Shukla 2015; Bowen et al. 2016). Two reports from Asian country have also demonstrated their early experience and feasibility of robotic assisted laparoscopic ureteral reimplant in children with acceptable outcome (Table 17.1) (Chan et al. 2010; Hayashi et al. 2014). Several literatures from USA are now available to demonstrate the short term to intermediate outcome of this new approach (Casale et al. 2008; Sorensen 2010; Marchini et al. 2011; Smith et al. 2011; Callewaert et al. 2012; Kasturi et al. 2012; Chalmers et al. 2012; Dangle et al. 2013; Gundeti et al. 2013; Schomburg et al. 2014; Akhavan et al. 2014; Dangle et al. 2014; Faasse et al. 2014; Diaz et al. 2014; Silay et al. 2015; Grimsby et al. 2015; Arlen et al. 2016; Herz et al. 2016; Kurtz et al. 2016; Gundeti et al. 2016; Boysen et al. 2017). Although still at its infancy stage, the clinical outcome reported are mostly for extravesical approach and the rate of success varies from 72% to 100% with some factors need to be considered as discussed by some of the authors (Table 17.2).

Table 17.1 Summary of current literature from Asian countries on Laparoscopic ureteral reimplant in Children since 2008

	Source	# Children/# ureters	Age (years) mean/ median (SD/ranges)	VUR grade	Approach (techniques)/ modifications	Mean/median OR time (min) Unilateral/bilateral/ overall	Hospital stay (days)	Follow-up time (months)	Success (%)	Complications (%)	Remarks
Tsai et al. (2008)	Taiwan	9/14	3.4 years mean (7 months–5 year)	I–V	Nerve sparing extravesical approach (Lich-Gregoir)	170/218/–	1.4 days	3–4 months VCUG	13 (92.9%)[a]	1 ureterovesical stenosis	
Chung et al. (2008)	Hong Kong	9/14	7.2 years mean (±4.5)	Not mentioned	Pneumovesical approach (Cohen)	–/–/214.8 ± 34.2	9.3 ± 2.4	3 months VCUG	? (>95%) 100% according to 2008 ffup	2 conversion to open (failure to maintain pneumovesicum and working port dislodgement). No post-op complications	Included VUJO and VUR with prior bulking agent injection therapy. Data compared to open approach showed longer operative time in pneumovesicum
Kawauchi (2009)	Japan	15/27	5 years median (1–12 year old)	I–V	Pneumovesical approach (Cohen)	–/–/225 (median)	0–1 day	3–6 months VCUG	26 (96%)	1 failure—UVJ stenosis	Included adult patients for comparison
Chan (2010)[b]	Hong Kong	3/3	5.2 years mean (18 months–10 years)	IV	Extravesical (Lich-Gregoir)	350/–/–	3–10 days	Overall mean 38 months (17–46)	3 (100%)[a]	1 postop urinary retention	Included 5 PUJO cases in the report
Hong et al. (2011)	South Korea	28/46	6 years	II–V	Pneumovesical approach (Cohen)	166 ± 46.8/188.8 ± 54.2/180 ± 51.7	1.38 (1–4)	8.6 (6–14 months)	94.6%[c] 35 of 37	2 conversion to open due to port dislodgement, 1 intraop complication of ureteral stent migration	Assessment of learning curve showed improvement
Kojima et al. (2012)	Japan	30/51	60.8 years mean ± 48.6	I–V	Extravesical (Lich-Gregoir)	118 ± 34/209/46	6.2 (2–12)	16.4 ± 7.5	47 (92%)[a]	1 postop urine leak	Included additional analysis on modified technique with ureteral advancement, better success rate with ureteral advancement technique
Chung et al. (2012)	South Korea	48/90	3.7 (7 months–13 years)	I–V	Pneumovesical approach (Cohen)	–/–/155.6 ± 42.77	1.6 ± 0.91	16.3 median	96.4%[c] 81 of 84	3 open conversion (2 port dislodgement, one posterior bladder injury	Assessment of learning curve improvement (Updated data of Hong et al. (2011))
Emir et al. (2012)	Turkey	11/17	6.9 years (2–15)	II–IV	Pneumovesical approach (Cohen)	217/306/–	3.8 (3–5)	4.5 years (3–7)	94% (16 of 17)	2 cases had pneumoperitoneum, 1 had recurrent uti	
Moritoki et al. (2012)	Japan	1/2	11 months	V	Extravesical (Lich-Gregoir) with diverticulectomy	–/311/–	Not mentioned	6 months VCUG	100%	None	Letter to editor, minimal invasive laparoscopic bilateral antireflux surgery with diverticulectomy

(continued)

Table 17.1 (continued)

	Source	# Children/# ureters	Age (years) mean/ median (SD/ranges)	VUR grade	Approach (techniques)/ modifications	Mean/median OR time (min) Unilateral/bilateral/ overall	Hospital stay (days)	Follow-up time (months)	Success (%)	Complications (%)	Remarks
Bi and Sun (2012)	China	45/61	40.16 months (3 months to 10 years)	VUJO	Pneumovesical approach (Cohen) with ureteral tapering	3.5 h/5.4 h (2–9 h)	8.3 (4–15)	19.3 months (1–67 months)	32 of 48[c]	2 conversion to open due to difficult dissection and bleeding. 1 stenosis developed at neoureteral opening	Mega-ureter tapering, decrease dilatation in postop ultrasound as definition of success
Hayashi et al. (2014)[b]	Japan	7/10	7.6 (2–11)	I–V	Extravesical (Lich-Gregoir)	159/293/241.1	7.3 (7–8)	3–4 months VCUG	9 (90%)	None major	Included 2 adults in the report, only peds cases were extracted for this table
Choi et al. (2016)	South Korea	10/18	6.9 (4–10)	II–V	Pneumovesical approach (Politano-Leadbetter)	92.5/133.3/125.1	6 (3–9)	8.9 (3.4–15.7)	All (100%)	1 intraop ureteral injury, I recurrent UTI	Assessed learning curve
Kim et al. (2015)	South Korea	11/11	9.18 (1–24 year old)	Primary megaureter (2 refluxing)	Pneumovesical approach (intravesical detrusorrhaphy)	214/–/–	7.3	12.6 (5–24 months)	10 of 11 (91%)	1 persistent grade 2 hydronephrosis	Mega-ureter tapering, decrease dilatation in postop ultrasound as definition of success (Different timeframe cases from Hong et al. (2011) and Chung et al. (2012))
Javali et al. (2015)	India	76/98	9.5 ± 3.75 (3–16)	I–IV	Extravesical approach (Lich-Gregoir)/ vascular sling modification	102 ± 26.5/165 ± 18/–	1.5 ± 1.7	3 months VCUG	96 of 98 (97.9%)	3 significant bladder mucosal perforation, 1 port infection, I urinary retention	One case with concomitant diverticulectomy
Soh et al. (2015)	Japan	18/28	9.1 (4–17)	I–IV	Pneumovesical approach (Politano-leadbetter & Cohen)	250.4/301.1/–	3.6 mean (2–8)	45.1 mean (2–81 months)	27 of 28 (96.4%)	1 urine leakage	Included 6 adults in the report, only peds cases were extracted for this table. Compared Politano-Leadbetter versus Cohen. Concluded PL, with better physiologic advantage
Lau et al. (2017)	Hong Kong	31/42	6.1 ± 0.6	IV–V and VUJO	Pneumovesical approach (Cohen)	–/–/221 ± 7 (169–318 min)	7.4 ± 0.8 (3–22)	3 months VCUG	42 (100%)[a]	4 conversion to open (3 due to diff dissection, 1 port leakage)	Updated data of Chung et al. (2008) Hong Kong
Khan et al. (2017)	India	8/8	18.5	VUJO	Extravesical approach (Lich-Gregoir/ intracorporal tailoring over a dilator)	95 (115–80)/–/–	2.5 (2–5)	3–6 months VCUG	100%	None major	Mega-ureter tapering, decrease dilatation in postop ultrasound as definition of success

[a]Success—considers complete resolution and downgrade
[b]Robotic Assisted
[c]Only22 patients had postop vcug

Table 17.2 Current literature on Robotic Assisted Laparoscopic ureteral reimplants in Children

	Source	# Children/# ureters	Age (years) mean/median (SD/ranges)	VUR grade	Approach (techniques)/ modifications	Mean/median OR time (min) Unilateral/bilateral/overall	Hospital stay (days)	Follow-up time (months)	Success (%)	Complications (%)	Remarks
Casale et al. (2008)	USA	41/82	38 months (16–81)	III–V	Extravesical approach	–/2.33 h (1.4–3.19)/–	26.1 h (18–34)	3 months VCUG	40 of 41 (97.6%)	1 with recurrent pyelonephritis	Mentioned visualization and avoidance of pelvic plexus to avoid post-op bladder dysfunction
Lendvay (2008)	USA	16/–	Not discussed	Not discussed	Extravesical approach	Not discussed	Not discussed	Not discussed	13 of 16 (81.2%)	No intraoperative complication, 1 postop urinary retention, 1 ureteral leak, 1 transient ureteral obstruction, 1 denovo contralateral reflux development	
Sorensen (2010)	USA	13/18	8.4 ± 4.1	3.2 (0.9)	Extravesical approach	309 ± 36/443 ± 57/361 ± 80	2.5 (1.5)	14 month	11 of 13 (85%)	1 ureteral obstruction, 1 had urinoma	Compared with open procedure with general recommendation for RAL program initiation
Marchini et al. (2011)	USA	39/76	9.9 ± 5.2 (intravesical) 8.6 ± 9.1 (extravesical)	I–V	Intravesical and extravesical approaches	–/–/232.6 ± 37.4 (intravesical); 233.5 ± 60.2 (extravesical)	1.8 ± 1.2 (intravesical); 1.7 ± 1 (extravesical)	19.4 ± 18.2 (intravesical); 12 ± 14.3 (extravesical)	Intravesical (92.2%) Extravesical (100%)	Intravesical—2 significant bladder spasm, 1 urinary retention, 4 bladder leaks Extravesical—2 significant bladder spasm, 2 urinary retention, 2 ureteral leaks, 1 UTI	Compared two approaches with open reimplants
Smith et al. (2011)	USA	25/33	69 ± 39.1 (3–144)	II–V	Extravesical approach	177/203/185 ± 41.6 (117–286)	33 h ± 12.5 (14–57)	3–4 months VCUG 16 (2–44)	31 of 33 (97%)	3 had difficulty voiding postop, no intraop complications	Compared to open approach
Callewaert et al. (2012)	Netherland	5/10	6.8 (4–11 year old)	IV	Extravesical approach	–/2.7 h (2.5–3.5)	24–72 h	28 months	9 of 10 (90%)	1 bladder perforation, 1 marked hydronephrosis on lower pole	
Kasturi et al. (2012)	USA	150/300	42.6 (27–111)	III–V	Extravesical approach	–/1.8 h (1.1–3.2)/–	22.1 h (18–34)	3 months VCUG 2 years	149 of 150px (99.3)	1 pyelonephritis, no intraop complication	Nerve sparing modification

(continued)

Table 17.2 (continued)

	Source	# Children/# ureters	Age (years) mean/median (SD/ranges)	VUR grade	Approach (techniques)/ modifications	Mean/median OR time (min) Unilateral/bilateral/overall	Hospital stay (days)	Follow-up time (months)	Success (%)	Complications (%)	Remarks
Chalmers et al. (2012)	USA	16/22	6.23 ± 3.4	I–IV	Extravesical approach	127 min (105–155)/177 min (160–200)	1.3 ± 0.48	11.5 months	20 of 22 (90.0%)	No intraop complications	
Srougi et al. (2013)	USA	17/–	1.9 (1.2–2.9)	Not discussed	Extravesical approach	–/–/153.3 ± 57	Not discussed	13.6 months	14 of 17 (82.3%)	No intraop complications, 1 unilateral ureteral stenosis	Operative time and follow-up duration were not stratified only for reimplant. Data report include other pediatric robotic surgery. Complication extracted for reimplant only
Bansal et al. (2013)	USA	14/–	83 months median (3.6–316.4)	Not discussed	Extravesical approach	225 median (103–591)	2 (0–16)	Not discussed	Not discussed	No intraoperative complications, 1 UTI, 1 port site infection	All data were not stratified only for reimplant. Data report include other pediatric robotic surgery. Complication extracted for reimplant only
Dangle et al. (2013)	USA	7/10	5.5 (2.8–9.9)	IV	Extravesical approach	190 (127–297)/215 (194–257)	2 (2–4)	–	–	No inraop complications	Plexus nerve inconsistently identified intraop
Gundeti et al. (2013)	USA	24/37	5.5 (2.8–9.9)	II–V	Extravesical approach	173.72 (103–297)/217 (194–265)/–	2.2 (1–4)	337 days (range 98–889 days)	30 of 37 (81%)	9 ureters (28%) developed transient hydronephrosis	Discussed technique development in improvement of clinical outcomes (data from abstract adopted)[a]
Schomburg et al. (2014)	USA	20/25	74 months	2.84	Extravesical approach	165/227/–	1.05	13 months	25 of 25 (100%)[a]	2 febrile UTI, 1 urine leak and 1 ureteral stenosis	Compared to Open
Akhavan et al. (2014)	USA	50/78	6.2 (1.9–18)	(3) 0–V	Extravesical approach	–/–/–	2 (1–6)	286 (27–2238)	72 of 78 (92.3%)	5 febrile UTI, 2 ileus, 2 ureteral obstruction, 1 ureteral injury, 1 perinephric fluid, 1 transient retention	5 of 22 unilateral repair had contralateral de novo vur[a]
Dangle et al. (2014)	USA	29/40	5.38 (3–10)	III–V	Extravesical approach	–/–/–	1.8 (1–3)	4 months VCUG	32 of 40 (80%)	None discussed	39 of 40 (97.5%) if downgrade is considered success

Faasse et al. (2014) and Diaz et al. (2014)	USA	23/40	Not discussed	Not discussed	Extravesical approach	Not discussed	Not discussed	Not discussed	20 of 23 (86.9%)	1 ileus, 1 transient bilateral obstruction	Compared cautery vs. CO_2 laser for detrussor tunnel creation (Faasse et al. 2014 as single report included in Diaz et al. 2014)
Silay et al. (2015)	USA	89/114	5.4 ± 1.9	Not discussed	Extravesical approach	Not discussed	Not discussed	Not discussed	89 of 91 (97.9%)	2 temporary urinary retention	Modified top down approach suture without stent placement facilitates suturing
Grimsby et al. (2015)	USA	61/93	6.7 (0.6–18)	3.3 (I–V)	Extravesical approach	Not discussed	Not discussed	3 months vcug/RNC, 11.7 months (1.2–32.3)	44 of 61 (72%)	1 intraop mucosal perforation, 3 ureteral obstruction, 2 urine leak, 1 nausea vomiting	Advised robotic only for bilateral and older children
Harel et al. (2015)	USA	23/33	7.5 ± 2.9	Not discussed	Extravesical approach	–/–/204 ± 34	Majority after 1 day (87%)	Not discussed	84% with 3% downgrade	1 febrile UTI	Assessed objective post-op pain diff between open and robotic
Arlen et al. (2016)	USA	17/20	9.3 ± 3.7 year old	3.4 (1.1)	Extravesical approach	–/–/169.3 ± 45.5	1	4–12 weeks VCUG	15 of 17 (88%) radiographic, 94.1% for clinical success	No intraop complication, 1 ileus, 1 uti	Included VUJO into the data. Compared to open. 1 contralateral vur
Herz et al. (2016)	USA	54/72	5.2	3.43 (I–IV)	Extravesical approach	206.5 (145–256)/306.2 (229–444)/273.3	1.64 days	4–12 weeks	61 of 72 (85.2%)	5 reop for VUR, 4 ureteral obstruction, 2 urine leak, 4 urinary retention, 4 UTI at 4 weeks, 12 worsening BBD	Multivariate analysis to assess variables related to poor outcome
Kurtz et al. (2016)	USA	108/–	5 median	Not discussed	All approach as revealed from database	–/–/232 (median) IQR 188–270	2 median IQR 1–2	90 days complication rate	Not discussed	14 (13%) complications. 2 urinary retention, 4 postop hydronephrosis, 2 UTI, 2 cardiovascular issues, 2 urinary issues and 2 GI issues	Assessed the cost, showing high cost related to robot assisted procedures compared to open. Also assessed factors related to 90 day complications

(continued)

Table 17.2 (continued)

	Source	# Children/# ureters	Age (years) mean/median (SD/ranges)	VUR grade	Approach (techniques)/ modifications	Mean/median OR time (min) Unilateral/bilateral/overall	Hospital stay (days)	Follow-up time (months)	Success (%)	Complications (%)	Remarks
Gundeti et al. (2016)	USA	58/83	5.3 ± 2.2	III–V	Extravesical approach	Not discussed	2 (1–6)	30 (4–69)	68 of 83 (82%)	No intraop complications reported, 1 transient retention	Modified techniques LUAA (detrusor tunnel length, U stitch, permanent ureterak alignment suture, inclusion of ureteral adventisia)
Boysen et al. (2017)	USA	260/363	6.4 ± 3.9	0–V	Extravesical approach	152 ± 56.1/198 ± 57.6/177 ± 61.4	1.6 ± 1.1	3 months postop ultrasound-VCUG or RNC	246 in 280 (87.6%) radiographic, 239/260 clinical	1 conversion excluded from analysis. 21 postop UTI, 25 overall complications (9.6%) 4 transient retention, 4 ureteral obstruction 2 port site hernia, 1 urine leak	267 of 280 (95.4%) if downgrade considered success. Multivariate variable assessed factor associated with outcomes

±Reported operative time is overall total
[a]None have persistent VUR

17.4 Considerations in Minimally Invasive Approach for Ureteral Reimplants in Children

17.4.1 Advantage and Disadvantage of Minimally Invasive Approach in General

Minimally invasive approach using laparoscopic ureteral reimplant for children with VUR has shown to have comparable result with the open counterpart procedure, while sustaining the clinical benefit of less postoperative pain, lower postoperative morbidity of endoscopic procedures (Esposito et al. 2016). Additionally, recent survey reported that urological surgery scars in children seem to influence the decision of parents and patients on the approach of the surgical procedure and favours minimally invasive ureteral reimplant over the open approach (Barbosa et al. 2013). However, some authors contradicts this opinion by describing that small scar may not always be the preference of the family and patient, special consideration must also focused on the scar location for concealment (Gargollo 2011; Garcia-Roig et al. 2017).

Pure laparoscopic approach was said to have limitation on the manipulation of the instrument intracorporally, whereas the robotic assistance improve the dexterity, motion scale, magnification of vision with spatial depth perception and enhance fine movement which could offset the disadvantage of lack of haptic feedback (Schomburg et al. 2014; Phillips and Wang 2012). While still in its infancy stage, laparoscopic with robotic assistance seems to incur higher cost, longer operative time and some related morbidity (Kurtz et al. 2016; Arlen et al. 2016). Recent literature argued that the shorter hospital stay and lesser need for post-operative analgesia may indeed offset the related cost (Smith et al. 2011; Hayashi et al. 2014; Schomburg et al. 2014; Harel et al. 2015).

17.4.2 Advantage and Disadvantage of Laparoscopic Extravesical and Intravesical Approach with or Without Robotic Assistance

Majority of the recent minimally invasive approach on ureteral reimplants in children were reported to be robotic assisted laparoscopy (Tables 17.1 and 17.2) and specifically applying the extravesical approach. The extravesical approach of Lich-Gregoir was previously described to have the advantage of its technical simplicity, with avoidance of bladder intrusion and or vesicoureteral anastomosis, which then rendered less post-operative pain, shorter recovery period and some bladder related postoperative morbidities such as hematuria and bladder spasm (Schwentner et al. 2006; Hayashi et al. 2014; Silay et al. 2017). Similar advantage of this approach holds true for minimally invasive ureteral reimplant (Casale et al. 2008; Lopez et al. 2011). Although open extravesical bilateral ureteral reimplant was once reported to have increased incidence of post-operative bladder dysfunction, which was thought to be due to injury of pelvic plexus (Fung et al. 1995; David et al. 2004). However, with the improved visualization of minimally invasive approach, this concern was addressed by precise dissection of the ureter and bladder that avoids the pelvic plexus, which is described to be 1.5 cm dorsal and medial to ureterovesical junction (UVJ) (Chan et al. 2010; Dangle et al. 2014; Marchini et al. 2011; Kasturi et al. 2012; Riquelme et al. 2013). This being said, yet the potential disadvantage of extravesical approach includes the risk of bowel injury (Tsai et al. 2008), ureteral injury (Marchini et al. 2011), unsuitable for ureters that need tailoring (Javali et al. 2015), challenge in creating detrusor channel (Javali et al. 2015; Kojima et al. 2012). As such, it is recommended to incorporate technical modifications and preventive measures to avoid these complications.

Minimally invasive intravesical/pneumovesical approach of ureteral reimplant was described to have the advantage of replicating the gold standard open procedures (such as Cohen, Politano-anderson, Anderson-Leadbetter) with complete extraperitoneal access and reducing the chance of visceral perforation as well as performing concomitant intravesical procedures (Valla et al. 2009; Emir et al. 2012; Bayne et al. 2012). Furthermore, it allows ability to create longer submucosal tunnel and addressing bilateral VURs (Soh et al. 2015). However, the disadvantage lies on the limited intravesical space with short distance and acute angle between the trocars leading to difficult navigation and manipulation of the surgical field (Soh et al. 2015; Hong et al. 2011) The presence of risk for port dislodgement and water tight closure of these ports needs to be assured to prevent complications (Valla et al. 2009; Hong et al. 2011). Likewise, it was described that this approach has steep learning curve, although once traversed good surgical outcome can be achieved (Schober and Jayanthi 2015; Valla et al. 2009).

17.4.3 Considerations on Patient Selection and Factors for Good Surgical Outcomes

Several studies have analyzed clinical factors affecting the surgical outcome. Most of the reported initial experiences in laparoscopic ureteral reimplant with or without robotic assistance have recommended careful selection of patient that would be suitable for the procedure. Younger patient (<3 year old) tend to have poor surgical outcome, due to smaller working space; this issue hold true for both intravesical and extravesical approach with or without robostic assistance (Gundeti et al. 2013; Herz et al. 2016). Furthermore, through the intravesical approach, a small bladder volume, specifically less than 130 cc, with narrow pelvic space limits the positioning of the trocar causing issue on clashing instrument and mobility (Kutikov et al. 2006; Hong et al. 2011; Chung et al. 2012; Finkelstein et al. 2015). It may not be ideal to perform minimally invasive approach among patients with prior abdominal surgery with severe intraperitoneal adhesion, which could impede trocar placement and potentially adds excessive operative time for lysis (Sávio and Nguyen 2013; Phillips and Wang 2012). Although some authors suggest that positional modification and appropriate minimally invasive instruments may overcome these limitations and considered them as relative contraindications (Lendvay 2008; Casale and Kojima 2009; Bayne et al. 2012; Sávio and Nguyen 2013) Megaureter or concomitant ureterocoele that needs tailoring is another consideration for their suitability, which needs the surgeons' expertise or further modification of the technique to improve the surgical outcome (Ansari et al. 2006; Bi and Sun 2012; Khan et al. 2017). Patients with co-morbidities such as severe bladder bowel dysfunction or other medical conditions have been shown to be associated with poor surgical outcome, which should need adequate preoperative counselling to make informed decision making. (Herz et al. 2016; Lendvay 2008; Kurtz et al. 2016).

17.4.4 Considerations on Potential Complications and Respective Management

Although reported with low occurrence of complication associated with laparoscopic ureteral reimplant with or without robotic assistance, these complications should be adequately managed or even prevented. Table 17.3 summarizes the approximate occurrence of complications base on the current literature with study series of 20 or more cases and their proposed management (Marchini et al. 2011; Hong et al. 2011; Chung et al. 2012; Weiss and Shukla 2015).

Table 17.3 Perioperative complications of minimally invasive ureteral reimplant for VUR in Children

Intraoperative complications	Estimated incidence[a] (%)	Recommended management	Remarks
Bleeding	4	Careful dissection with coagulation and pressure control.	
Ureteral injury/bladder mucosal injury	2–10	Early identification and intraoperative management. Field visualization and surveillance, avoid aggressive dissection and vascular compromise of ureter. Low coagulation setting on dissection.	Most reported in extravesical approach
Port dislodgement	3–7	Anchoring sutures on the ports. Proper suspension of the bladder wall.	Reported among intravesical approach
Bowel Injury	<1	Early identification and intraoperative management. Field visualization and surveillance.	In extravesical approach
Postoperative complications			
Transient ureteral edema	4–28	Atraumatic intrap handling of ureter. Ureteral stent placement to avoid azotemia in solitary kidney.	
Bladder spasm or urinary retention	1–12	Preoperative diagnosis and assessment of bladder bowel dysfunction or constipation and manage accordingly. Suprapubic tube placement for severe BBD patients. Pelvic plexus avoidance on dissection to prevent possible neuropraxia.	Intraop bladder spasm may due to increased intravesical pressure. Post op spasm due to ureteral stents and or catheters. More reports from bilateral extravesical approach
Recurrent UTI	2–10	Treat BBD, or prophylaxis as appropriate.	Pre-op UTI increased risk
Urine leak/urinoma	1–10	Prolong indwelling catheter, stent placement or drain.	
Ureteral stenosis	1.5–7	Avoid aggressive dissection of ureter and preserve vascular supply.	
Ileus	2–4	Decrease narcotic use and early ambulation.	Mostly reported in extravesical approach
Port hernia or infection	<1	Port site fascial closure.	

[a]Estimated incidence based on studies with ≥20 patient series

17.5 Advancement of Technology and Techniques in Minimally Invasive Ureteral Reimplant in Children

In addressing some inherent limitation of minimally invasive approach of ureteral reimplant in children, technique modifications and new technique application have been proposed by several recent studies to improve surgical outcome. A good amount of Asian literatures are available in describing new techniques to improve perioperative outcomes (Okamura et al. 1996; Ansari et al. 2006; Tsai et al. 2008; Chan et al. 2010; Kojima et al. 2012; Hong et al. 2011; Chung et al. 2012; Soh et al. 2015; Javali et al. 2015). The following bullet points summarize the available literatures on innovative techniques and application of new technologies to improve surgical outcomes:

- Application of balloon or rocking trocar ports to prevent inadvertent port dislodgement (Okamura et al. 1996; Dangle et al. 2014)
- Diamond flex retractor or vessel loop over the ureter thru an extraport to ensure atraumatic handling of ureter (Lakshmanan 2000)
- Intravesical pressure limited within 6–8 mmHg not over 10 mmHg to prevent intraoperative bladder spasm and optimise intravesical suturing and manipulation (Kutikov et al. 2006)
- Extracorporeal ureteral tailoring thru an instrument port (Ansari et al. 2006)
- Lower coagulation setting on dissection at UVJ to avoid ureteral compromise and prevent post-operative ureteral edema, stenosis and urine leak (Canon et al. 2007)
- Pelvic nerve sparing ureteral dissection for extravesical approach to prevent post-operative bladder dysfunction (Casale et al. 2008; Tsai et al. 2008; Chan et al. 2010; Dangle et al. 2014)
- Urethral route on instrument placement (Kawauchi et al. 2009)
- Intracorporeal ureteral tailoring to maintain rotational orientation or dislodge of the ureter (Faasse et al. 2014)
- Anterior bladder hitch stitch to improve exposure (Chalmers et al. 2012)
- To lengthen the mucosal tunnel by performing ureteral advancement suture with empty bladder to ensure good visualization of UVJ (Kojima et al. 2012)
- Bladder wall anchoring suture to prevent port dislodgement; lateral placement of trocar to achieve wide angle for mucosal tunnel procedure, vessel loop tagging on the lower ureteral segment for bidirectional tunnelling thru the neohiatus (Hong et al. 2011; Chung et al. 2012)
- Carbon dioxide laser detrussoraphy (Faasse et al. 2014; Diaz et al. 2014)
- Endoscopic/cystoscopic assisted procedure (Soh et al. 2015)
- Detrusor top down anchoring suture without stent placement (Silay et al. 2015)
- Intravesical detrusorraphy with Politano-Leadbetter technique to create long submucosal tunnel and being more effective for higher grade VUR and rendering orthotopic location of orifice (Soh et al. 2015)
- Maintaining bladder volume at one-third full for easy visualization of UVJ while preventing tense bladder predisposing to bladder mucosal perforation (Javali et al. 2015)
- Recently described surgical points to ensure good surgical outcome, in particular for extravesical approach is called LUAA to represent adequate length of detrusor tunnel of 5 cm (L), use of a U stitch (U), placement of permanent ureteral alignment suture (A), and inclusion of ureteral adventitia (A) in detrusorraphy to prevent ureter slipping off the tunnel while not inducing obstruction (Gundeti et al. 2016)

17.6 Training in Asia

Aside from careful selection of suitable patient to achieve successful surgical outcome with minimally invasive approach ureteral reimplant in children, the literature has enumerated other key factors. Such as (1) Incurring high volume cases to traversing the steep learning curve. (2) Availability of minimally invasive program (Casale et al. 2008; Sorensen 2010; Hong et al. 2011; Chung et al. 2012; Choi 2016; Schober and Jayanthi 2015; Weiss and Shukla 2015; Gundeti et al. 2016; Boysen et al. 2017). Although there are several publications reported from Asian countries; however these were confined to only few centers (Table 17.1). The reason for this could be due to lack of minimally instruments and robotic facility secondary to limited resources, and availability of minimally invasive experts in the region. To address these constraints, initiation of training centers for minimally invasive procedures in Asia is recommended. Sorensen et al. (2010) has shared their experience and proposed guidelines to initiate robotic minimally invasive surgery program (Sorensen 2010). The general recommendations includes: dedicated surgical team, dedicated operative days, committed administration, robotic/minimally invasive surgeon subspecialization, innovation to expand minimally invasive approach application and recognize technical differences in individual pediatric patients (Sorensen 2010).

17.7 Controversies and Future Directions

Being critical on appraising the current literature, several factors need to be considered. Most of the available studies are retrospective in nature, with inherent limitation of uncontrolled confounding factors, selection bias as well as reporting bias. Presence of publication bias with favourable results is likely being published may give an overestimation of clinical success or underestimation of complication rate with minimally invasive approach ureteral reimplant in children (Grimsby et al. 2015). Likewise, with the decrease trend of post-operative voiding cystourethrogram (VCUG) in assessing surgical success, where the recent studies comparing efficacy with open procedure might not be able to give an actual picture of VUR resolution (Herz et al. 2016). Future prospective studies with multi-institutional collaboration to assess patient characteristics and technical difference that render long term optimal clinical outcome are therefore recommended.

To date, even with the application of robotic system to address the ergonomic aspect of the approach, or traversing the steep learning and technical modification; the perioperative outcome of minimally invasive ureteral reimplant compared to open procedure still showed longer operative time (Arlen et al. 2016; Kurtz et al. 2016; Gundeti et al. 2016). Hence, promoting the development and application of new technology and or further technical modification to improve procedural efficiency and safety are still imperative.

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Appendix

Literature search date: November 9, 2017

Medical database source: Pubmed

Search term strategy: ((“laparoscopy”[MeSH Terms] OR “laparoscopy”[All Fields] OR “laparoscopic”[All Fields]) OR (“laparoscopy”[MeSH Terms] OR “laparoscopy”[All Fields])) AND (reimplant[All Fields] OR VUR[All Fields] OR (“vesico-ureteral reflux”[MeSH Terms] OR (“vesico-ureteral”[All Fields] AND “reflux”[All Fields]) OR “vesico-ureteral reflux”[All Fields] OR (“vesicoureteral”[All Fields] AND “reflux”[All Fields]) OR “vesicoureteral reflux”[All Fields])) OR “laparoscopic ureteral reimplantation”

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