Ureteral Stents Do Not Cause Bacterial Infections in Children After Ureteral Reimplantation

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OBJECTIVES	To determine, in a prospective study, the incidence of bacterial colonization and the risk of bacterial infection of indwelling double-J stents in children undergoing ureteral reimplantation. In a balance between the safety and comfort of the child, the need for postoperative stenting of the reimplanted ureters has been discussed. It is unknown whether an indwelling double-J stent after ureteral reimplantation would be a risk factor for postoperative urinary tract infection.
METHODS	From 2005 to 2010, 209 children (138 girls and 71 boys; median age 3.8 years) with vesicoureteral reflux underwent unilateral or bilateral cross-trigonal ureteral reimplantation (352 ureters). All children received a single dose of gentamicin (2 mg/kg body weight) and a preoperative bladder rinse with 10% polividone-saline solution. A transurethral catheter was also left postoperatively for 2 (unilateral) or 3 (bilateral) days. The ureter was stented with a 8-22 cm multilength catheter. At 3 weeks postoperatively, the ureteral catheters were removed and investigated for bacterial colonization.
RESULTS	Of the 209 children, 10 (4.8%) developed a urinary tract infection within the first 6 weeks after ureteral reimplantation. Of the remaining 199 children without any symptoms, 13 (6.5%) had a positive urine culture at removal of the catheters. Of the 199 children without any symptoms, 90 (45.2%) had a positive culture of one or more segments of the double-J catheter.
CONCLUSIONS	Although the colonization rate of ureteral stents in our study was 42.9%, the rate of urinary tract infection during the first 6 weeks after ureteral reimplantation using indwelling ureteral stents was only 4.6%. We have concluded that the clinical significance of bacterial colonization of an indwelling ureteral stent is low, and therefore, ureteral stents can be used safely. UROLOGY xx: xxx, xxxx. © 2011 Elsevier Inc.

Vesicoureteral reflux has been defined as the abnormal, retrograde flow of urine from the urinary bladder into the upper urinary tract. It is the most common urologic anomaly, accounting for a prevalence rate of 1%-2% in children.¹ Theoretically, the retrograde flow of urine could facilitate bacteria to the upper urinary tract, possibly predisposing these children to febrile urinary tract infections (UTIs), which can result in permanent renal parenchymal damage. The main goal of the management of vesicoureteral reflux should be the prevention of febrile UTIs and renal parenchymal damage.² Spontaneous resolution of vesicoureteral reflux owing to the natural elongation of the vesicoureteral junction is possible.³ The treatment options for vesicoureteral reflux have included a conservative approach with targeted antibiotic therapy at episodes of a UTI, long-term

antiseptic or antibiotic prophylaxis, subureteral or intraureteral injection therapy, or surgical therapy. In 1997, the Pediatric Vesicoureteral Reflux Guidelines Panel of the American Urological Association recommended continuous antibiotic prophylaxis as the initial therapy for children with reflux of grades I-IV.⁴ The indications for active treatment, such as injection or surgery, have included breakthrough UTI, renal parenchymal damage, or the decision of the parents or doctor. In a balance between the safety and comfort of the child, it has been debated whether postoperative stenting of the reimplanted ureters is necessary. Initially, externalized ureteral catheters were left in place for ≤ 10 -14 days. More recently, surgeons have decided to use no catheters, with the resultant risk of ureteral obstruction, externalized stents for a short period, or indwelling double-J catheters, which must be removed at a separate procedure.^{5,6} It is unknown how long externalized stents should remain in place to completely ensure free drainage of the urine by way of the ureters; therefore, we have adopted the use of indwelling ureteral stents. Any kind of stent, whether indwelling or externalized, poses, from a microbiologic

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Submitted: September 17, 2010, accepted (with revisions): November 14, 2010

viewpoint, an ideal surface for bacterial colonization. Bacteria from urine that adhere to free biomaterial surfaces produce biofilm polysaccharides, an important virulence factor.⁷

The present prospective study was designed to determine the incidence of bacterial colonization and the risk of bacterial infection of indwelling double-J stents in children who had undergone ureteral reimplantation.

MATERIAL AND METHODS

From January 2005 to March 2010, 209 children with unilateral or bilateral vesicoureteral reflux underwent cross-trigonal ureteral reimplantation and were prospectively enrolled in the present study. The median age at surgery was 3.8 years (range 0.4-15). The female/male ratio was approximately 2:1 (138 girls and 71 boys). Of the 209 children, 143 (68.4%) had undergone a bilateral procedure, for a total of 352 reimplanted ureters.

The diagnosis of vesicoureteral reflux was confirmed by voiding cystourethrography according to the grading scales defined by the International Reflux Study Committee.⁸ The distribution of reflux grades was grade I in 8.5%, grade II in 21.2%, grade III in 38.7%, grade IV in 24.8%, and grade V in 6.8%. All patients were receiving antibiotic prophylaxis before surgery. The type of antibiotic prophylaxis was dependent on their treating and referring physician. The indication for surgery was persistence of reflux, breakthrough UTIs, reduction of renal function, and parental preference. In our pediatric urology clinic, all parents were informed about the detailed pathologic condition of their child, the possibility of spontaneous resolution was calculated, and the options for follow-up with and without prophylactic antibiotics, subureteral and intraureteral injections, and surgery were discussed.

At surgery, a preoperative urine culture was taken, and the bladder was filled with a povidone iodine solution (10%) until the maximal bladder capacity was reached to induce vesicoureteral reflux with the diluted iodine solution. In addition, all patients received intravenous gentamicin (2 mg/kg body weight) at anesthesia induction.⁹

Before bladder closure, a Sof-Flex multilength ureteral double-J stent (4.7F, 8-20 cm, Cook Urological, Spencer, IN) was placed in each corrected ureter. A transurethral catheter (8, 10, or 12 Ch, depending on the child's age) was also placed postoperatively to allow for continuous bladder drainage for 2 (unilateral procedure) or 3 (bilateral procedure) days. The placement of a transurethral catheter allowed for continuous drainage of the bladder and obviated the need for placement of a drain. Immediately after removal of the transurethral catheter, the patient was discharged, and their preoperative antibiotic prophylaxis (nitrofurantoin 2 mg/kg, trimethoprim 2 mg/kg, or cefaclor 15 mg/kg once daily before bedtime), was reinstalled. At 3 or 4 weeks postoperatively, the double-J ureteral stents were removed with the patient under sedation in the outpatient surgery clinic. For the purposes of the present study, a urine culture and three 1-cm fragments of each catheter (top, middle, and bottom) were sent separately for microbiologic examination (species identification and susceptibility testing of the relevant isolated bacteria). After cystoscopy, all patients received 1 oral dose of fosfomycin, and all antibiotic treatment was ceased.

To exclude the chance of bacterial contamination from passage of the stents through the distal urethra or meatus, we

Table 1. Demographics of patients with postoperative urinary tract infections

Pt. No.	Age (y)	Sex	UTI Before or After Stent Removal	Unilateral or Bilateral Stents	Febrile	Urine Culture at UTI	Urine culture at Stent Removal	Stent Culture	Antibiotic Prophylaxis Before Infection
1	2	Female	After	Bilateral	No	<i>Escherichia coli</i>	No	<i>Escherichia coli</i>	SXT
2	2	Male	After	Bilateral	No	<i>Enterobacter cloacae</i>	No	Coagulase-negative staphylococci	SXT
3	1	Female	Before	Unilateral	Yes	<i>Pseudomonas aeruginosa</i>	No	<i>Escherichia coli</i>	CFC
4	0	Female	Before	Bilateral	No	<i>Escherichia coli</i>	No	<i>Enterococcus</i>	TEM
5	0	Male	After	Unilateral	Yes	<i>Pseudomonas aeruginosa</i>	No	No	TMP
6	2	Female	Before	Bilateral	Yes	<i>Escherichia coli</i>	No	<i>Escherichia coli</i>	CTX
7	1	Male	After	Bilateral	Yes	<i>Pseudomonas aeruginosa</i>	<i>Pseudomonas aeruginosa</i>	<i>Staphylococcus aureus</i>	CFC
8	1	Male	Before	Unilateral	Yes	<i>Escherichia coli</i>	No	No	CFC
9	2	Male	Before	Unilateral	Yes	No	No	No	SXT
10	8	Male	Before	Unilateral	No	<i>Pseudomonas aeruginosa</i>	No	No	NRF
	Median 1.5	60%	Before 60%	Bilateral 50%	Febrile 60%	Positive 90%	Positive 10%	Positive 60%	

SXT, trimethoprim sulfamethoxazole; CFC, cefaclor; TEM, temocillin; TMP, trimethoprim; CTX, cefotaxime; NRF, nitrofurantoin.

Table 2. Colonization rates of stents after ureteral reimplantation

Variable	Total	Stent Segment		
		Bottom	Middle	Top
All patients (n = 352 stents)	151 (42.9)	118 (33.5)	113 (32.1)	111 (31.5)
Patients without infection (n = 337 stents)	143 (42.4)	112 (33.2)	107 (31.8)	108 (32.0)
Patients with infection (n = 15 stents)	8 (53.3)	6 (40)	6 (40)	3 (20)

Data are presented as number of stents with colonization, with percentages in parentheses.

performed an additional urethral swab in a control group of 18 patients.

Also, 22 children who had undergone pyeloplasty from January 2005 to March 2010 were prospectively enrolled in our study. The median age at surgery (Anderson-Hynes pyeloplasty¹⁰) was 4.1 years (range 0.2-11). The female/male ratio was 0.37 (6 girls and 16 boys).

A lower UTI or cystitis was considered present if the urine culture showed bacteriuria with pyuria. A UTI was defined as febrile when a positive urine culture was associated with fever >38.5°C.

Urinalysis was performed on all urine samples using an Aution Max AX-4280 analyzer (A. Menarini Diagnostics, Florence, Italy), an automated urine test strip, and an automated flow cytometer (Sysmex UF-100i, TOA Medical Electronics, Kobe, Japan). The strips of the Aution Max enabled measurement of the pH, glucose, protein, blood, leukocytes, ketones, bilirubin, urobilinogen, and nitrite. The specific gravity was determined by the refractive index method. Furthermore, the UF-100i counts the erythrocytes, leukocytes, squamous epithelial cells, casts, and bacteria.

The urine samples were cultured on chromogenic agar Uriselect 4 (Bio-Rad Laboratories, Hemel Hempstead, UK) and blood agar (tryptic soy agar with horse blood). The stents were removed under sterile conditions and were rolled on the surface of the blood agar. The plates were then incubated in air at 37°C for 24 hours. The representative colonies were identified using the Vitek 2 Card System (bioMérieux, Hazelwood, MO), and the susceptibility of all clinically significant bacterial isolates was determined by measuring their minimal inhibitory concentrations using the automated Vitek Card System. Significant bacteriuria was defined as a bacterial count of >10⁵ colony-forming units/mL of urine with 1 or 2 bacteria isolated from the midstream urine.

RESULTS

Of the 209 children who underwent ureteral reimplantation, 10 developed a UTI within a 6-week postoperative period. Of these 10 children, 6 were febrile (Table 1). Six UTIs (4 of 6 were febrile) were recorded with the double-J stents still in place and during oral antibiotic prophylaxis. Four UTIs (2 of 4 were febrile) were recorded during the first 2 weeks after stent removal, after antibiotic prophylaxis had been stopped (Table 1). One urine culture was sterile, probably because empirical antibiotic treatment was started before the urine sample for culture had been taken. All other UTIs were treated with oral antibiotics at the therapeutic dosage guided by the antibiogram after a positive urine culture.

Cultures of the removed ureteral stents after ureteral reimplantation were sterile in 113 (54.1%) of 209 chil-

Table 3. Number of isolated microorganisms after ureteral reimplantation

	Stents (n = 352)	Urine Cultures (n = 209)	Urethral Cultures (n = 18)
Coagulase-negative staphylococci	53 (15.1)	1 (0.48)	1 (5.6)
<i>Enterococcus</i> spp.	44 (12.5)	3 (1.4)	1 (5.6)
<i>Corynebacterium</i>	20 (5.6)		
<i>Escherichia coli</i>	18 (5.1)	4 (1.9)	1 (5.6)
<i>Pseudomonas aeruginosa</i>	14 (4.0)	4 (1.9)	
<i>Morganella morganii</i>	8 (2.3)	1 (0.48)	1 (5.6)
<i>Streptococcus viridans</i>	9 (2.6)		
<i>Proteus mirabilis</i>	7 (2.0)		1 (5.6)
<i>Streptococcus anginosus</i>	7 (2.0)		
<i>Staphylococcus aureus</i>	3 (0.85)		
<i>Streptococcus mitis</i>	3 (0.85)		
<i>Staphylococcus epidermidis</i>	3 (0.85)		
<i>Candida albicans</i>	2 (0.57)		
<i>Bacillus</i>	2 (0.57)		
<i>Enterobacter cloacae</i>	2 (0.57)		
<i>Proteus vulgaris</i>	2 (0.57)		
<i>Staphylococcus haemolyticus</i>	2 (0.57)		
<i>Klebsiella pneumoniae</i>	1 (0.28)	1 (0.48)	
<i>Staphylococcus hominis</i>			1 (5.6)
Other species	5 (1.42)		
Commensal flora			8 (44.4)

Data in parentheses are percentages.

dren but were positive in 96 (45.9%) of 209 cases. Only small differences were noted between the colonization rates of the top, middle, and bottom segments of the ureteral catheter (Table 2). The main microorganisms cultured were coagulase-negative *Staphylococci*, which grew on 53 (15.1%) of 352 stents; 44 (12.5%) of 352 stents grew *Enterococcus* (Table 3).

In Table 4, the urine culture results at stent removal are listed. They were sterile in 195 (93.3%) of 209 children and a positive urine culture was found in 14 (6.7%) of 209 cases. The main microorganism isolated from urine cultures was *Escherichia coli*, which was found in 4 (1.9%) of 209 urine samples (Table 3).

We performed an additional urethral swab test in a control group of 18 patients. In 5 (31.3%) of 18 cases, the combination of a positive urethral swab culture and a positive ureteral stent culture was noted (Table 5). In 8 (44.4%) of the 18 urethral cultures, commensal flora was detected (Table 3).

Table 4. Colonization rates of urine cultures at stent removal after ureteral reimplantation

Variable	Total (>1000 /mL)	$<10 \times 10^3$ /mL	$10-100 \times 10^3$ /mL	$>100 \times 10^3$ /mL
All patients (n = 209)	14 (6.7)	1 (0.48)	6 (2.9)	7 (3.3)
Patients without infection (n = 199)	13 (6.5)	1 (5.0)	6 (3.0)	6 (3.0)
Patients with infection (n = 10)	1 (10)	0	0	1 (10)

Data in parentheses are percentages.

Table 5. Comparison of urethral and double-J stent cultures after ureteral reimplantation (n = 18)

Variable	Total (n)	Urethral Culture (n)	Double-J Stents (n)
Sterile urethral culture and double-J stents	4	4	4
Sterile urethral culture or double-J stents	9	3	6
Positive urethral and double-J stent culture	5	5	5

Table 6. Number of isolated microorganisms after pyeloplasty

	Stents (n = 22)	Urine Cultures (n = 22)
<i>Escherichia coli</i>	4 (18.2)	
Coagulase-negative staphylococci	2 (9.1)	
<i>Corynebacterium</i>	2 (9.1)	
<i>Staphylococcus aureus</i>	2 (9.1)	
<i>Gemella haemolysans</i>	1 (4.5)	1 (4.5)
<i>Streptococcus viridans</i>	1 (4.5)	

Data in parentheses are percentages.

The children who had undergone pyeloplasty developed no UTIs during their 6-week postoperative period. Cultures of the removed ureteral stents were sterile in 13 (59.1%) of 22 children but were positive in 9 (40.9%; Table 6). The main microorganism cultured was *E. coli*, which grew on 4 (18.2%) of 22 stents. In this group, 1 (4.5%) of the 22 urine cultures were positive (Table 6).

COMMENT

The results of the present study have shown that leaving an indwelling ureteral stent after ureteral reimplantation does not cause clinical UTIs. Therefore, it is safe to use indwelling catheters to maintain postoperative ureteral urine drainage and anastomotic healing and leave the ureteral catheters in place for ≥ 3 -4 weeks.

Bacterial colonization of double-J ureteral stents occurs; however, the relationship between this colonization and the development of UTIs is not clinically clear. In adults, a stent colonization rate of 44%-68% and an incidence of bacteriuria of 21%-30% have been reported.^{11,12} In children, bacterial stent colonization has only been studied after pyeloplasty, after which the colonization rate was

70.7%. Also, 10% of children after stented pyeloplasty developed a febrile UTI postoperatively. No statistically significant association was found between a positive stent culture and the development of a postoperative febrile UTI.¹³ No studies are available on the stent colonization and UTI rates after ureteral reimplantation using an indwelling ureteral stent.

It could be argued whether it is necessary to leave indwelling ureteral stents in place after ureteral reimplantation, because most pediatric urologists will use either externalized stents or no stents at all. However, as originally described by Cohen,¹⁴ externalized stents were used for 10-14 days, but it is not known nor has been studied clinically how long the stents should remain in the ureter to ensure continuous urine drainage by the reimplanted ureters. Leaving no stents will cause temporary and partial ureteral obstruction.¹⁴

We have observed that children who have undergone pyeloplasty and had an identical type of double-J stent in place for an identical period of 3 weeks had a lower risk of developing a UTI (0 [0%] of 22 children) than those undergoing ureteral reimplantation (9 [4.6%] of 196 children). However, the stent colonization rate was comparable, with 9 (40.9%) of 22 stents showing microorganisms in the culture and 187 (42.9%) of 317 stents positive in the ureteral reimplantation group (Tables 3 and 6).

Theoretically, we hypothesized that the high ureteral catheter colonization rate could be explained by bacterial contamination from passage of the stents through the distal urethra or meatus at stent removal, because we saw the combination of a positive urethral swab culture and a positive ureteral catheter culture in only 5 (27.8%) of 18 cases from a control group (Table 5). Similarly, the exact same pathogen colonizing the ureteral stent and causing the UTI was only found in 2 cases (20%). The ureteral catheter colonization rate in the patients with a clinical UTI was 53.3%, comparable to the ureteral catheter colonization rate of the asymptomatic patients (42.4%; Table 2). The clinical significance of bacterial colonization of an indwelling ureteral stent should therefore be considered low. One limitation of the present study was that we did not study the influence of the transurethral catheter on the risk of stent colonization.

In our present study, we observed an incidence of 4.6% (9 of 196) clinical febrile and nonfebrile UTIs within the first 6 weeks after ureteral reimplantation. The UTI rate after unstented ureteral reimplantation within 6 weeks after surgery is unknown; thus, it was not possible to compare our data with data from unstented patients. The

only available data of febrile UTIs after ureteral reimplantation have reported an overall incidence of 4.6% (18 of 395 patients) at an average follow-up of 15 months.¹⁵

CONCLUSIONS

Although the colonization rate of ureteral stents in our study was 42.9%, the rate of UTIs during the first 6 weeks after ureteral reimplantation using indwelling ureteral stents was only 4.6%. Therefore, we have concluded that the clinical significance of bacterial colonization of an indwelling ureteral stent is low. We believe that indwelling ureteral catheters after ureteral reimplantation can be used safely.

References

1. Cheng CH, Tsai MH, Huang YC, et al. Antibiotic resistance patterns of community-acquired urinary tract infections in children with vesicoureteral reflux receiving prophylactic antibiotic therapy. *Pediatrics*. 2008;122:1212-1217.
2. Gargollo PC, Diamond DA. Therapy insight: what nephrologists need to know about primary vesicoureteral reflux. *Nat Clin Pract Nephrol*. 2007;3:551-563.
3. Schwab CW Jr, Wu HY, Selman H, et al. Spontaneous resolution of vesicoureteral reflux: a 15-year perspective. *J Urol*. 2002;168:2594-2599.
4. Elder JS, Peters CA, Arant BS Jr, et al. Pediatric vesicoureteral reflux guidelines panel summary report on the management of primary vesicoureteral reflux in children. *J Urol*. 1997;157:1846-1851.
5. Barbour KW, Arunachalam P, King PA, et al. The use of ureteral stents and suprapubic catheter in vesicoureteric reflux surgery. *Pediatr Surg Int*. 2004;20:387-388.
6. Steffens J, Stark E, Haben B, et al. Politano-Leadbetter ureteric reimplantation. *BJU Int*. 2006;98:695-712.
7. Riedl CR, Plas E, Hubner WA, et al. Bacterial colonization of ureteral stents. *Eur Urol*. 1999;36:53-59.
8. Medical versus surgical treatment of primary vesicoureteral reflux: report of the International Reflux Study Committee. *Pediatrics*. 1981;67:392-400.
9. Cohen SJ. The Cohen reimplantation technique. *Birth Defects Orig Artic Ser*. 1977;13:391-395.
10. Anderson JC, Hynes W. Retrocaval ureter: a case diagnosed pre-operatively and treated successfully by a plastic operation. *Br J Urol*. 1949;21:209-214.
11. Paick SH, Park HK, Oh SJ, et al. Characteristics of bacterial colonization and urinary tract infection after indwelling of double-J ureteral stent. *Urology*. 2003;62:214-217.
12. Farsy BA, Mosli HA, Al-Zamaity W, et al. Bacteriuria and colonization of double-pigtail ureteral stents: long-term experience with 237 patients. *J Endourol*. 1995;9:469-472.
13. Ben-Meir D, Golan S, Ehrlich Y, et al. Characteristics and clinical significance of bacterial colonization of ureteral double-J stents in children. *J Pediatr Urol*. 2009;5:355-358.
14. Cohen SJ. Ureteric reimplantation for vesico-ureteric reflux. In: Frank JD, Gearhart JP, Snyder HM, eds. *Operative Pediatric Urology*, 2nd ed. London: Churchill Livingstone; 2002:13-18.
15. Whittam BM, Thomasch JR, Makari JH, et al. Febrile urinary tract infection after ureteroneocystostomy: a contemporary assessment at a single institution. *J Urol*. 2010;183:688-693.