NON-REFLUXING ILEAL URETER REPLACEMENT USING INTUSSUSCEPTED NIPPLE VALVE

—AN EXPERIMENTAL STUDY IN DOGS—

Takuji TSUKAMOTO

From the Departments of Urology and Pathology, New York Medical College, Valhalla, NY

Although the vast accumulation of data from the continent urinary reservoir clearly proves that intussusception of the ileum is a reliable procedure for preventing urine reflux, few reports have appeared on the application of this technique to ileal replacement of the ureter. In an effort to determine if the nipple valve created by the intussuscepted ileum can prevent urine reflux in the ileal ureter, an experimental study was done using five dogs.

I performed ureteral replacement using a newly developed procedure to secure the nipple valve in place. All dogs were followed for 6 months and evaluated by blood urea nitrogen (BUN), creatinine (Cr), serum electrolyte, urine culture, intravenous urogram (IVU), cystogram, and urodynamic studies.

No significant differences were notable between the preoperative and 6-month postoperative values of BUN, Cr, and serum electrolytes in all dogs. Only one of the dogs, which showed extussusception of the nipple valve, demonstrated the reflux. IVUs and Whitaker flow studies did not confirm any urinary outflow obstruction. Furthermore, during the pressure studies, the nipple valve prevented transmission of the increased intravesical pressure to the upper urinary tract.

I believe that the intussuscepted ileum can be secured by our procedure and can prevent reflux even though it is incorporated into the urinary system itself.

(Acta Urol. Jpn. 42 : 289–294, 1996)

Key words : Non-refluxing ileal ureter, Intussuscepted nipple valve, Experimental study

INTRODUCTION

The ileal ureter has become a valuable part of the urological armamentarium since its introduction more than 80 years ago[1]. The technique has been utilized to reconstruct the urinary tract when extensive loss of the native ureter has occurred. To avoid the detrimental effects of persistent reflux of urine, one should attempt to reconstruct the urinary tract with a non-refluxing unit. Herein, I describe a new technique employing a non-refluxing intussuscepted ileal nipple valve.

MATERIALS AND METHODS

Five adult male mongrel dogs each weighing approximately 20 kg were placed on a water diet 24 hours preoperatively. Serum electrolyte chemistries and intravenous urograms (IVU) were performed prior to surgery. Prophylactic antibiotics were administered during the perioperative period. Ileal ureter replacement was performed on the right side under general anesthesia. The left side was undisturbed and served as a control. The abdomen was explored through a midline incision. Approximately 20 cm of ileum was isolated for ureteral substitution. Ileoileostomy re-established the continuity of the gastrointestinal tract.

A nipple valve measuring 4 cm in length was created just above the level of the ileovesical anastomosis, avoiding the use of nonabsorbable materials such as staples where urine would be in contact with the anastomosis. The mesentery of the distal 5 cm of the isolated ileum remained intact, while the mesentery of the next 8 cm, which is required to construct the nipple valve, was detached (Fig. 1A). To create a nipple valve, the central 8 cm segment of the ileum with detached mesentery was intussuscepted into the distal 5 cm (Fig. 1B). The nipple valve was fixed using a modified procedure described by King and associates[2]. To secure the valve, an incision 2 cm in length was made extending through the serosa, muscularis, and mucosa of the distal ileum. This incision was deepened to include the mucosa and muscularis of the intussuscepted segment. The two layers were then approximated using 3-0 Dexon interrupted sutures (Fig. 1C). The outer layer was closed with 3-0 Dexon sutures (Fig. 2A). To add further stability, a single layer of interrupted suture was placed in the seromuscular layer between the base of the intussusception and the distal ileum with 3-0 silk (Fig. 2B).

The proximal end of the ileum was closed with 3-0 Dexon sutures. The ureter was spatulated, and an end-to-side ureteroileal anastomosis was made. The distal end of the ileum was anastomosed end-to-side to the bladder using 2-0 Dexon sutures (Fig. 2C).

Serum electrolytes, blood urea nitrogen (BUN) and creatinine determinations as well as urine cultures

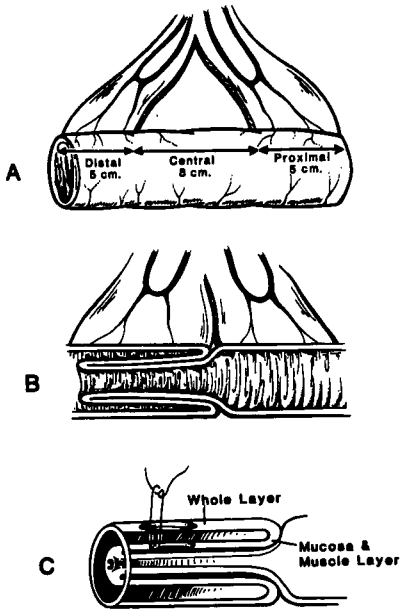

Fig. 1. Construction of non-refluxing ileal ureter. A: Mesentery is detached from the central 8 cm segment of isolated ileum, and a single arcade is left intact. B: Central 8 cm segment is intussuscepted into distal portion. C: A 2 cm incision is made through and through the distal ileal wall and includes muscle of outer layer of intussuscepetion. Both cut edges are approximated with absorbable materials.

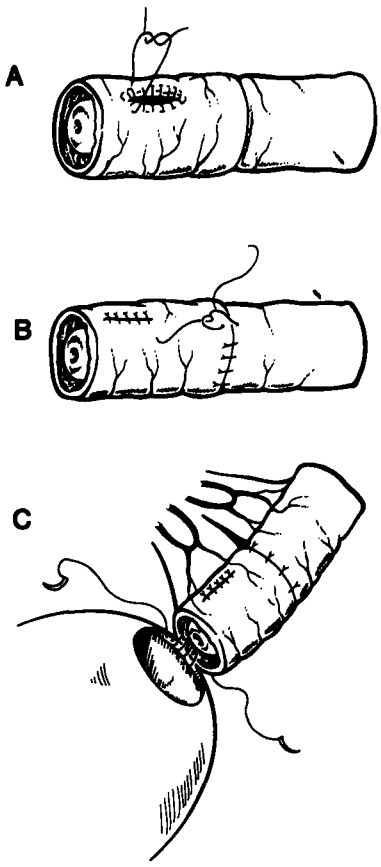

Fig. 2. Final steps. A: Incision is closed with absorbable materials. B: Single layer of nonabsorbable sutures is placed at base of intussusception. C: Distal ileum is anastomosed to bladder.

were obtained preoperatively and 6 months postoperatively. IVUs and cystograms were performed preoperatively and at 3 and 6 months. Under intravenous anesthesia cystograms were performed by perfusing contrast medium through a urethral catheter at a flow rate of 20 ml/min until spontaneous voiding occurred.

After a 6-month waiting period, under general anesthesia, the abdomen was re-opened through the previous incision. Two 27-gauge angiocatheters were inserted into the renal pelvis through the wall of the pelvis. An 8 Fr feeding tube was inserted through the wall of the ileal ureter above the nipple valve. Two 8 Fr feeding tubes were placed in the bladder; one catheter was used for infusion and drainage while the other served as a manometer. A Whitaker constant flow study was performed by infusing saline at 12 ml/min through one of the angiocatheters in the renal pelvis[3] Pressure in the renal pelvis and ileal ureter were monitored by a manometer.

Cystometrograms were performed by perfusing saline at 20 ml/min through the urethral catheter, and the pressure in the bladder, ileal ureter, and renal pelvis was measured simultaneously.

After these studies were completed, the kidneys, ureters, ileal segment, and bladder were removed en bloc and submitted for histological study. The dogs were then killed with an overdose of intravenous barbiturate. The specimens were fixed in 10% formaldehyde. Multiple sections were obtained on all specimens.

RESULTS

Preoperative laboratory determinations and IVU were normal in all dogs. The five dogs were followed for 6 months after the operation, and no complications were encountered.

Laboratory testing, including blood counts, BUN, serum creatinine, and serum electrolytes, demonstrated no change between the preoperative and postoperative period. Catheterized urine specimens were sterile in all cases prior to surgical intervention. However, 6 months postoperatively urine culture were positive in 3 of the 5 dogs; 10^5/ml of *E. coli* in dog number 5 and 10^2/ml of *P. aeruginosa* in dogs numbered 2 and 4 were noted. Mucus was seen in the bladder of all dogs.

Table 1 shows the results of the IVU, and cystograms at 6 months. Only one cystogram (dog number 5) demonstrated reflux. The nipple valve of this dog had everted and the entire unit was freely refluxing on the cystogram (Fig. 3B). The IVU

Table 1. Postoperative findings in 5 dogs with modified ileal ureter 6 months postoperatively

Animal No.	IVP	Reflux on cystogram	Pathology of kidney	Maximum pressure in Whitaker test (cmH_2O)		Maximum pressure in cystometrogram (cmH_2O)		
				Pelvis	Ileum	Pelvis	Ileum	Bladder
1	Normal	No	Normal	10	0	10	10	36
2	Mild hydronephrosis	No	Mild chronic pyelonephritis	4.0	0	8	8	30
3	Mild hydronephrosis	No	Normal	5.6	0	3.6	2	33
4	Mild hydronephrosis	No	Mild chronic phyelonephritis	7	0.2	5	5	18
5	Mild hydronephrosis	Yes*	Marked chronic pyelonephritis	7.2	0	30	30	30

* Valve had everted.

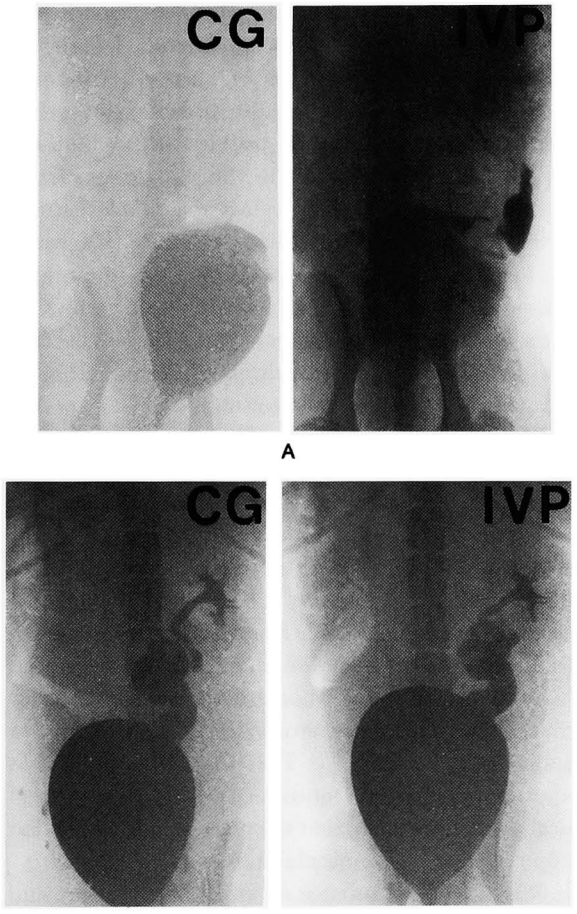

Fig. 3. IVUs and cystograms from dogs without reflux (A) and with (B) reflux.

demonstrated a slightly dilated renal pelvis and ureter in all dogs except number 1, which had a normal upper tract (Fig. 3A). There was no evidence of dilation in any ileal segment except in dog number 5, and urinary outflow was not obstructed by the nipple.

Urodynamic studies were performed 6 months postoperatively (Table 1). Resting intrapelvic and intraileal pressures were low in all dogs. During the Whitaker studies, the pressure in the renal pelvis remained below 10 cmH_2O in all cases, and there was no increase in intraileal pressure during the study. To examine the effects of increased intravesical pressure on the upper urinary tract, the bladder was perfused at 20 ml/min. until voiding occurred. The amount of fluid required to fill the bladder ranged from 200 to 350 ml, and the maximal intravesical pressure ranged from 18 to 36 cmH_2O (Table 1). The intravesical pressure profile was different in each case. However, in the four dogs without reflux, pressure in the renal pelvis and ileal ureter remained below 10 cmH_2O despite an increasing intravesical pressure (Fig. 4A). The dog with reflux demonstrated an increase in pressure paralleling the rise in intravesical pressure (Fig. 4B).

Grossly, the animals without reflux had bridge-like scars between the nipple valve and the ileal wall (Fig. 5). Microscopic examination revealed chronic pyelonephritis in 3 dogs. One of these dogs had reflux, and this dog showed marked chronic pyelonephritis. There were no other marked histologic findings except mild chronic cystitis in all of the bladders.

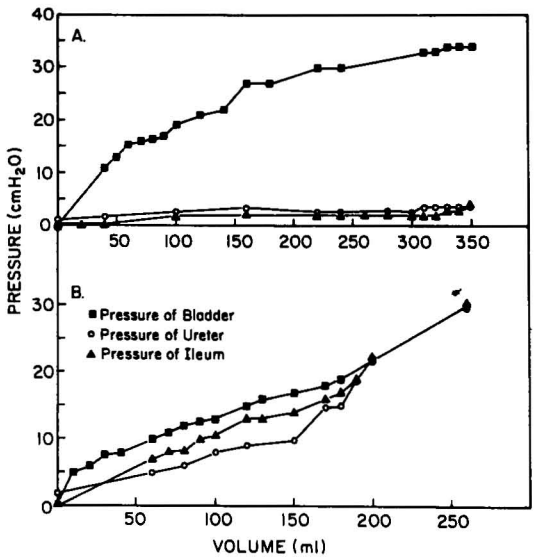

Fig. 4. Typical pressure profiles of cystometrograms from dogs without (A) and with (B) reflux.

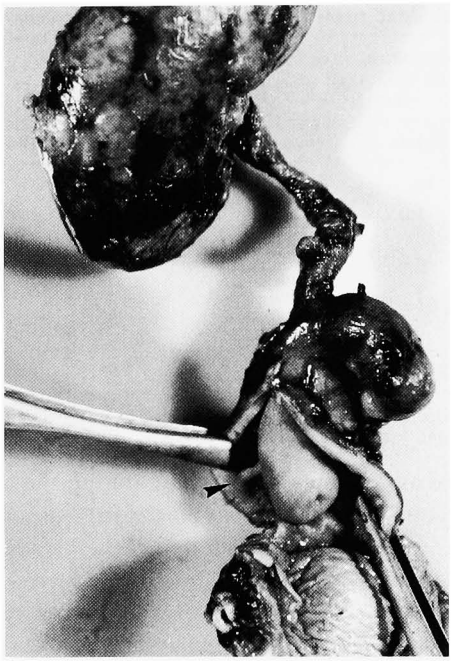

Fig. 5. Gross specimen of urinary tract from dog without reflux. There is a bridge-like scar (arrowhead) between nipple valve and ileal wall, which is created by approximating both muscular layers.

DISCUSSION

Procedures employing intestinal segments to replace portions of the ureter were first described in 1906[1] However, controversy still remains regarding the optimal procedure. Boxer and associates reported excellent long-term results of ureteral substitution with ileum without antireflux mechanisms[4] However, most studies using the same technique have offered disappointing results[5,6] For example, Tanagho noted severe complications with refluxing ileal ureters, including dilation and decompensation of the ileum caused by intermittent exposure to high pressure during voiding. He suggested that the only way to avoid dilation of the new ureter was to develop an antirefluxing mechanism at the level of the ileovesical anastomosis. Furthermore, data accumulated from urinary diversion procedures suggest that backflow of urine to renal units is deleterious to kidney function[7,8], and the incidence of urinary tract infections secondary to stasis of urine and electrolyte imbalances as a result of prolonged contact of the urine with the ileum will be increased in refluxing ureteral replacement. Therefore, I believe that creation of an antireflux mechanism is essential.

Several antireflux techniques have been described previously. These procedures are classified into three major categories: (1) creating a non-refluxing ureteroileal reimplantation[9,10] (2) the use of tapered ileum[11,12] and (3) the use of an intussuscepted nipple valve[13~17] It is doubtful that non-refluxing reimplantation can be used safely in the ileal ureter, because this procedure does not prevent increased pressure in the ileum, as noted by Tanagho. Hendren created a tapered ileum with a tunneled reimplantation[12]. However, they encountered strictures as a late complication presumably because of ischemic injury to the bowel segment during tapering[15].

An intussuscepted nipple valve has been widely used in continent urinary reservoirs, and has proved to be a reliable method to prevent reflux. However, there are several reports on valve failure, mainly because of insufficient fixation or ischemia of the devascularized nipple[18] Also, the use of non-absorbable materials to create the valve appears to increase the risk of subsequent stone formation[18] In order to avoid these problems, I used a modification of the King procedure for a continent reservoir. King and associates fixed the intussuscepted ileum to the cecal wall by cutting both the nipple and the cecal wall to the muscle layer and sewing muscle to muscle using absorbable sutures with good results. Using this procedure, Hagiwara et al. obtained successful stabilization of the nipple valve in the afferent limb of Kock & Mainz pouch[19] This procedure is based on the observaton that muscle bonds firmly to muscle after healing. It is the scar tissue that forms between muscle layers that holds the tissues together. This was confirmed in our pathologic review of the specimens. In dog number 5, which developed reflux, the nipple valve completely broke down and no scar formation was seen between the muscle layers of the nipple and distal ileum. In this case, I believe that a technical error was made, and the incision in the nipple was not deep enough to include the muscle layer. Similarly, Cranley and McKelvey noted that deep seromucular diathermy and mesenteric stripping produced a stable valve in dogs[20] Therefore, I conclude that approximation of the mucosa of the nipple valve and ileal wall is not suffiicient to create stability and that apposition of the muscular layers is essential.

Only a few reports exist regarding the pressure and flow across the nipple valve. Tschroll and associates performed Whitaker flow studies on pigs with intussuscepted nipple valves in the ileal ureter and reported low intrapelvic pressures of 2.8 cmH_2O[14]. Similarly, Lieskovsky and coworkers reported minimal complications of the upper urinary tract when using continent urinary reservoirs[18] I believe these data indicate that nipple valves do not increase the resistance in the intact urinary system. I had similar findings. Despite the slight dilation of the renal pelvis and ureter seen on IVU, the pressure in the renal pelvis remained low (below 10 cmH_2O) during the Whitaker flow study. The small degree of dilation may be the result of technical error in the anastomosis of the small dog ureter to the ileum.

Nonetheless, no significant obstruction was identified according to the criteria described by Whitaker[3]

Intravesical pressure during urination is higher than the intraluminal pressure of the Kock pouch, which is reported as 5 to 10 cmH_2O[21] However, no reflux was demonstrated in our animals as long as the nipple valve was in place. In addition, the urodynamic studies showed only a minimal increase in intrapelvic pressure although intravesical pressure exceeded 30 cmH_2O. This suggests that a nipple valve can sustain the increased intravesical pressure of voiding and can be applied to the ileal ureter.

However, as these observations are obtained from an experimental study with a short-term follow-up, long-term clinical observation is needed. Therefore this procedure should be applied only when the urologist is confronted with the loss of a significant ureteral length, which cannot be compensated for by using established procedures, such as psoas hitch and Boari's procedure.

CONCLUSION

I have developed an easy and reliable method to construct a non-refluxing ileal ureter. These studies and observations indicate that ileal substitution with an intussuscepted nipple valve secured by absorbable materials is a valid option for replacement of the ureter in selected cases.

REFERENCES

1) Melinkoff AE : Sur le replacement de l'uretere par anse isolee de l'intestin grele. Rev Clin d'Urol **1** : 601–605, 1912
2) King LR, Robertson CN and Bertram RA : A new technique for the prevention of reflux in those undergoing bladder substitution or undiversion using bowel segment. World J Urol **3** : 194–196, 1985
3) Whitaker RH : The Whitaker test. Urol Clin North Am **6** : 529–539, 1979
4) Boxer RJ, Fritzsche P, Skinner DG, et al. : Replacement of the ureter by small intestine : clinical application and results of the ileal ureter in 89 patients. J Urol **121** : 728–731, 1979
5) Bazeed A, El-Rakhawy M, Ashamallah A, et al. : Ileal replacement of the bilharzial ureter : Is it worthwhile ? J Urol **130** : 245–248, 1983
6) Tanagho EA : A case against incorporation of bowel segment into the closed urinary system. J Urol **113** : 795–796, 1975
7) Waters WB, Herbster G, Jablokow VR, et al. : Ureteral replacement using ileum in compromised renal function. J Urol **141** : 432–436, 1989
8) Pitts WR Jr and Muecke EC : A 20-year experience with ileal conduits : the fate of the kidneys. J Urol **122** : 154–157, 1979
9) Lockhart JL and Bejany DE : Anti-reflux ureteroileal reimplantation : an alternative for urinary diversion. J Urol **137** : 867–870, 1987
10) Kiesswetter H : Non-refluxing ureteroileal cystoplasty for bladder augmentation or replacement of ureters : long-term results of own technique. J Urol **134** : 741–744, 1985
11) Charghi A : Ureteral replacement using a new variation of the tailored ileal segment. J Urol **121** : 598–601, 1979
12) Hendren WH : Tapered bowel segment for ureteral replacement. Urol Clin North Am **5** : 607–616, 1978
13) Weinberg AC, Xie HW, Hardy BE, et al. : Non-refluxing ileal ureteral replacement using the intussuscepted ileal nipple : laboratory studies. J Urol **144** : 1041–1043, 1990
14) Tscholl R, Tettamanti F and Zingg E : Ileal substitute of ureter with reflux-plasty by terminal intussusception of bowel. Urology **9** : 385–389, 1977
15) Hendren WH and McLorie GA : Late stricture of intestinal ureter. J Urol **129** : 584–590, 1983
16) Masaki Z, Yoshinaga H, Kuratomi K, et al. : Non-refluxing substitution of ureter by the intussuscepted ileal segment : a case report. Clin Urol **43** : 161–164, 1989
17) Janknegt RA : Construction of ileal nipples as anti-reflux valve technique. Eur Urol **14** : 46–52, 1988
18) Lieskovsky G, Skinner DG and Boyd SD : Complications of the Kock pouch. Urol Clin North Am **15** : 195–205, 1988
19) Hagiwara M, Asakura H, Nakazono M, et al. : Continent urinary reservoir for supravesical diversion ; stabilization of intussuscepted nipple valve without using metal staples. Jpn J Urol **79** : 1587–1591, 1988
20) Cranley B and McKelvey STD : The Kock ileostomy reservoir : an experimental study of methods of improving valve stability and competence. Br J Surg **68** : 545–550, 1981
21) Chen K, Chang LS and Chen M : Urodynamic and clinical outcome of Kock pouch continent urinary diversion. J Urol **141** : 94–97, 1989

(Received on October 6, 1995
Accepted on January 5, 1996)

和文抄録

ニップルバルブ（重積弁）を用いた非逆流型回腸代用尿管

From the Department of Urology and Pathology, New York Medical College

塚　本　拓　司*

非失禁型代用膀胱の成果から，回腸を重積させる手技は逆流防止に関し有効であると証明されているが，回腸代用尿管において，この手術手技はほとんど用いられていない．回腸重積により作成されたニップルバルブが回腸代用尿管においても逆流を防止できるかを検討するために，イヌを用いて実験を行った．

今回ニップルバルブを作成するのに新しい方法を用いた．すべてのイヌは，6カ月間経過観察をし，BUN，クレアチニン（Cr），血清電解質，尿培養，IVP，膀胱造影，尿流動態検査を施行した．

すべてのイヌにおいて，術前と術後6カ月のBUN，Cr，電解質の値に変化はなかった．ニップルバルブの重積が滑脱した1例のみが逆流を示した．IVP や Whitaker 試験では尿路閉塞は認められなかった．さらに，ニップルバルブにより膀胱内圧の上昇は上部尿路に伝達されなかった．

尿路に用いても，重積させたニップルバルブはわれわれの手技で固定させることが可能であり，逆流を防止する事が可能であると思われた．

（泌尿紀要 **42**：289-294，1996）

* 現：立川共済病院泌尿器科