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Covering of the terminal ureter with de-serosalized muscle layer of the ileum for antireflux ureteroileostomy: an experimental study in dogs and a preliminary clinical trial

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Abstract We demonstrated a new operative technique for antireflux ureteroileostomy in dogs. The severed ureter was reimplanted into the isolated ileum. Ten terminal ureters were covered with a $2 \times 2$ cm² section of de-serosalized ileal wall after direct ureteroileostomy, and another six terminal ureters were covered with a $2 \times 2$ cm² section of non-de-serosalized full-thickness ileal wall. Thirteen ureters were directly anastomosed to the ileum without any additional procedures. The bladder was augmented by the detubularized ileum with the ureter. Postoperative evaluations on ureteral stenosis and reflux were performed monthly for 3 months. The ureters covered with the de-serosalized ileal wall prevented ureteral reflux even when the intravesical pressure climbed as high as 100 cm H₂O. Although two of these ten ureters demonstrated strictures at the precise site of direct ureteroileostomy, the sections of the ureters covered with the de-serosalized ileal wall were opened and did not collapse. In the resected specimens, the terminal ureters were found in the intramural part of the ileum. The ureters covered with the full-thickness of ileal wall did not prevent reflux. Our method of covering the terminal ureter with the de-serosalized ileal wall worked well as an antireflux mechanism, and the intramural ureter did not cause ureteral stricture. After this animal experiment, we introduced this antireflux mechanism clinically.

Keywords Ureteroileal anastomosis · Antireflux technique · De-serosalized ileum · Continent urinary diversion · Orthotopic ileal neobladder

Introduction

The ileum has been commonly used for many types of urinary diversion. Although it remains controversial whether reflux actually needs to be prevented in the low-pressure reservoir, the belief that reflux of the ureteroileal anastomotic site is harmful to the kidneys has led to the widespread use of antireflux ureteroileal reimplantation into ileal pouches (11). Postoperative ureteral stricture at the site of ureteroileostomy is a troublesome complication after urinary reservoirs are formed using the ileum. Although several antireflux ureteroileal anastomotic methods have been designed and clinically used (2, 6, 13, 18, 21), no method has achieved the absolute prevention of postoperative ureteral stricture.

Ureteral stricture following antireflux ureteroileostomy is one of the most serious complications in ileal neobladders. Some patients with anastomotic ureteral strictures have received nephrostomy or ureteral reimplantation because of the difficulty of endoscopic repair of the ureteral strictures (9, 14, 17). To resolve this problem, an antireflux ureteroileal anastomotic technique without stricture has been awaited as a mean to form ileal neobladders safely.

The cause of ureteral stricture following antireflux ureteroileostomy has not been clarified. Recently, some studies have reported that the most widely used technique for ureteroileostomy, the Le Duc method, caused postoperative ureteral strictures in 1.5 to 29% of patients who underwent ileal neobladder (5, 9, 14, 21). In the Le Duc method, the ureteral adventitia is not covered with the ileal mucosa and the intraluminal ureter stays in contact with the urine after surgery until epithelization over the intraluminal ureter is spontaneously completed. Inflammatory scarring at the intraluminal ureteral wall resulting from urine contact with the ureter might cause ureteral stricture using this technique (13). Animal experiments performed by Abol-Enein et al. showed that inflammatory scarring of the ureteral wall occurred when the ureteral adventitia was exposed to the urine during
the early postoperative period (3, 4). They emphasized the need to completely cover the ureter with the mucosa and also the need for a definitive anastomosis between the ureter and the ileal mucosa to prevent postoperative ureteral stricture.

After performing an antireflux ureteroileal anastomosis with complete covering of the introduced intraluminal ureter with the ileal mucosa over a length of 3 cm, Wendelrath et al. reported that the rate of ureteral stricture at the reimplantation site was 8% at 1–36 months follow-up (21). On the other hand, Schwiabold et al. achieved a postoperative ureteral stricture rate of 3% after performing a modified Le Duc method that diminished the length of the intraluminal ureter without mucosal covering. (19). The experimental study performed by Abol-Enein and the clinical reports on antireflux ureteroileostomy indicate that ureteral stricture cannot be completely prevented merely by protecting the ureteral adventitia from urine contact.

To prevent ureteral stricture after antireflux ureteroileostomy, the ureteral adventitia should be protected from urine and definitive anastomosis between the ureter and ileal mucosa should be performed. We hypothesized that postoperative ureteral stricture may be prevented by loosening the periureteral tissues when performing the complete mucosal covering and definitive anastomosis described above. We performed a new technique in dogs based on the principle of the complete and loose covering of the terminal ureter. In this technique, the ileum was de-serosalized to cover the ureter loosely and the terminal ureter was placed outside the ileal lumen to prevent urine contact with the ureteral adventitia. We describe the operative technique and the results of our animal experiment, as well as report the first use this technique for a clinical case.

![Fig. 1](image)

**Fig. 1** a Each medial side of the U-shaped ileum is conjoined. b Direct ureteroileostomy is performed. c A 2 × 2 cm² of the ileal wall is de-serosalized. d The terminal ureter is covered with de-serosalized muscular layer of the ileum, and the ileal dome is Anastomosed to the bladder

**Materials and Methods**

A total of 15 female mongrel dogs, weighing 10.5–22 kg, were used for these experiments. The surgical procedures were carried out under general anesthesia with thiopental sodium. A segment of the terminal ileum measuring 15 cm in length was isolated and formed into a dome shape using an intestinal stapler (Fig. 1a). The ileum was secured at the ureterovesical junction. The first 5 mm of the distal end of the ileum was spatulated, and then a direct end-to-side anastomosis between the ureter and the ileum was performed using 5–0 polyglactin sutures (Fig. 1b). A total of 29 ureters were reimplemented into the ileal dome, bilaterally in 14 dogs and unilaterally in one. Two types of antireflux procedures were added to the direct ureteroileostomy in 16 ureters. The remaining 13 ureters did not receive any additional antireflux procedures.

A 2 × 2 cm² section of the ileal wall at the cranial site of the ureteroileostomy was de-serosalized by peeling off the serosa using a pair of forceps (Fig. 1c). Hemostasis on the de-serosalized surface was achieved by direct pressure and electrodathermy. To cover the extraluminal terminal ureter with the de-serosalized muscle layer, the bilateral longitudinal edges of the de-serosalized area were sutured together over the terminal ureter using 3–0 polydioxanone sutures (Fig. 1d). A 2-cm section of the terminal ureter was completely covered with the de-serosalized ileal muscle layer (type A antireflux method). Ureteroileostomy with this method was performed on ten ureters.