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# Optimization of uretero-intestinal anastomosis in urinary diversion: an experimental study in dogs

## II. Influence of exposure to urine on the healing of the ureter and ileum

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**Summary.** The influence of exposure to urine on the ureteric adventitia and the ileal mucous membrane was studied in 10 mongrel dogs. When the ureter was implanted freely into the lumen of the bladder its adventitia became the seat of granulation tissue formation. This is later covered by creeping of transitional epithelium lining the ureter, forming what is in effect a ureteral nipple. Final healing is associated with an unpredictable amount of scarring. Furthermore, it was noted that healing and creeping of the ileal mucous membrane are impeded in the presence of urine. The sum of these effects is that ureters implanted in an open sulcus of the small intestine are not covered by intestinal epithelium, they tend to form spontaneous nipples and their healing is associated with either stenonis or reflux in some 30% of cases.

**Key words:** Ureter – Ileum – Implantation – Healing

Clinical reports indicate that there is a 15–30% complication rate following uretero-ileal anastomosis using Le Duc technique [2–5]. Our experimental findings revealed that 40% of the reimplanted ureters using this technique showed evidence of stenosis and/or reflux [1]. The current series of experiments was designed to outline the natural history of the healing process of the ureter and intestinal mucosa when exposed to the urinary stream, in an effort to explain the unpredictable outcome following the Le Duc technique.

## Materials and methods

### *Experimental animals*

Ten mongrel dogs weighing 12–15 kg were used for the experiments. The procedures were carried out with the animals under general anaesthesia. Thiopental sodium (10 mg/kg) was used for induction and maintenance of anaesthesia, with endotracheal intubation and mechanical ventilation.

### *Experimental groups and operative procedures*

*Group I.* Through a ventral mid-line approach, the left ureter was identified and severed at its juxtavesical part. The urinary bladder was opened. The ureter was reimplanted into the bladder through a "button-hole" in its posterior wall. The distal 3 cm of the reimplanted ureter were left exposed to the urinary stream in the bladder cavity. The spatulated end of the ureter was fixed to the bladder wall by one deep stitch (Fig. 1). A ureteral catheter (4 ch) was left as a stent. The ureteral adventitia was fixed to the edges of the button-hole to avoid traction on the reimplanted ureteral segment. The bladder was closed leaving a small suprapubic tube anchored to the ureteral stent.

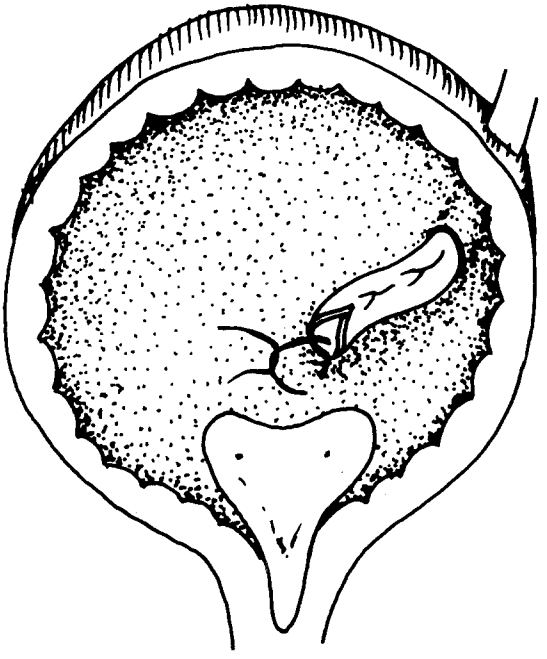

**Fig. 1.** Free ureteral reimplantation into the bladder leaving the distal 3 cm exposed to urine

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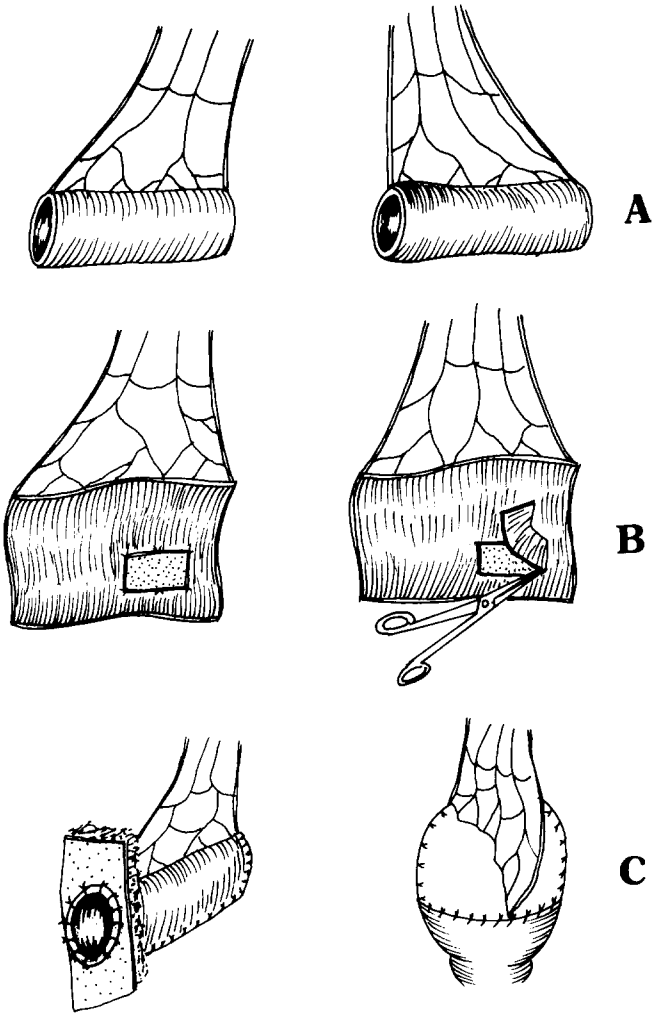


**Fig. 2A–C.** The experimental model for studying the influence of urine on the healing of intestinal epithelium. **A** Isolation of the two equal parts of the terminal ileum. **B** The antimesenteric border of the ileum is opened and a 3 cm × 1 cm area of the ileal mucosa stripped. **C** One ileal patch is patched to the opened bladder, while the other one is closed again and brought out via a cutaneous stoma

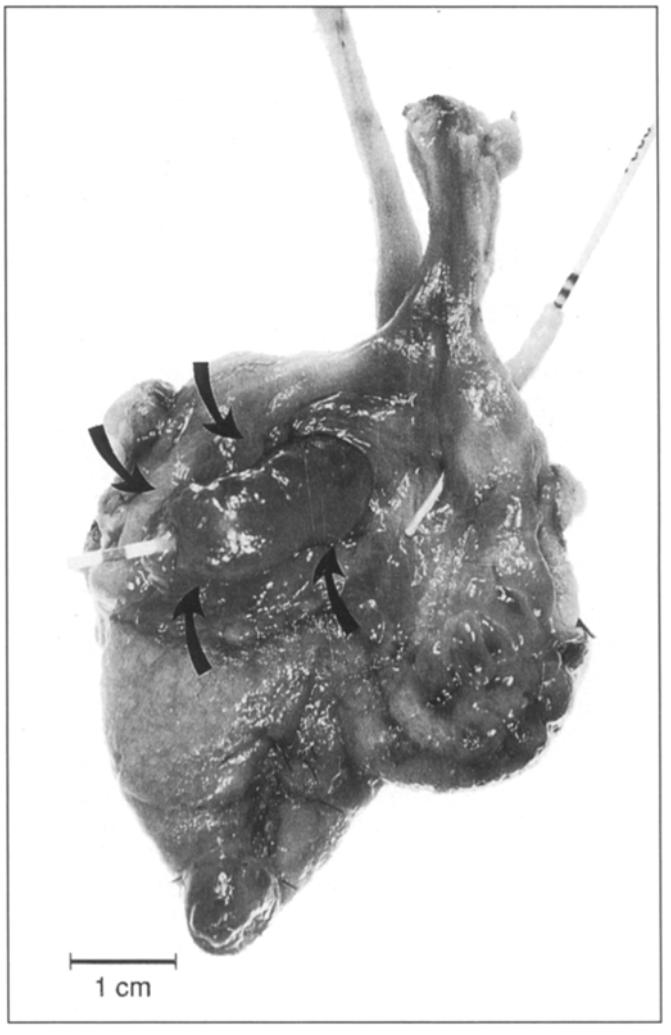


**Fig. 3.** Autopsy specimen on the 7th postoperative day. The bladder is opened to show the formed ureteric nipple covered with granulation tissue

*Group II.* A segment of the terminal ileum 15 cm long was isolated and continuity of the small intestine re-established. The isolated segment was divided into two equal halves. Each half was opened at its antimesenteric border to obtain an intestinal sheet. The ileal mucosa was stripped in an area 3 cm × 1 cm in the middle of each intestinal patch.

The stripped area was labelled at its angles by non-absorbable fine prolene sutures to allow easy identification later. One ileal sheet was patched to the opened bladder using 4/0 PDS sutures. In this fashion regeneration of ileal mucous membrane will occur while it is exposed to urine. The other ileal patch, used as a control, was closed again as a blind conduit. Its distal end was brought out as a cutaneous stoma in the lower right abdominal quadrant to avoid mucous retention (Fig. 2).

### *Evaluation*

One dog from each group was killed sequentially every week for necropsy. Histological examination of the implanted ureters (group I) and the sites of mucosal stripping in the ileal patches (group II) was carried out.

## Results

### *Group I*

*Effect of urine on the healing of uncovered ureters.* All the reimplanted ureters showed a tendency for spontaneous nipple formation. On the 7th postoperative day gross examination showed granulation tissue covering these nipples (Fig. 3). Histological examination revealed transitional epithelium covering the tip of the nipple. Complete covering of the nipple with transitional epithelium was observed at the end of the 2nd week. The inflammatory reaction and the amount of granulation tissue diminished progressively with time. At the end of the 5th week a


**Fig. 4.** Autopsy specimen at the end of the 5th postoperative week. The bladder is opened to show the fibrosed calcified short nipple

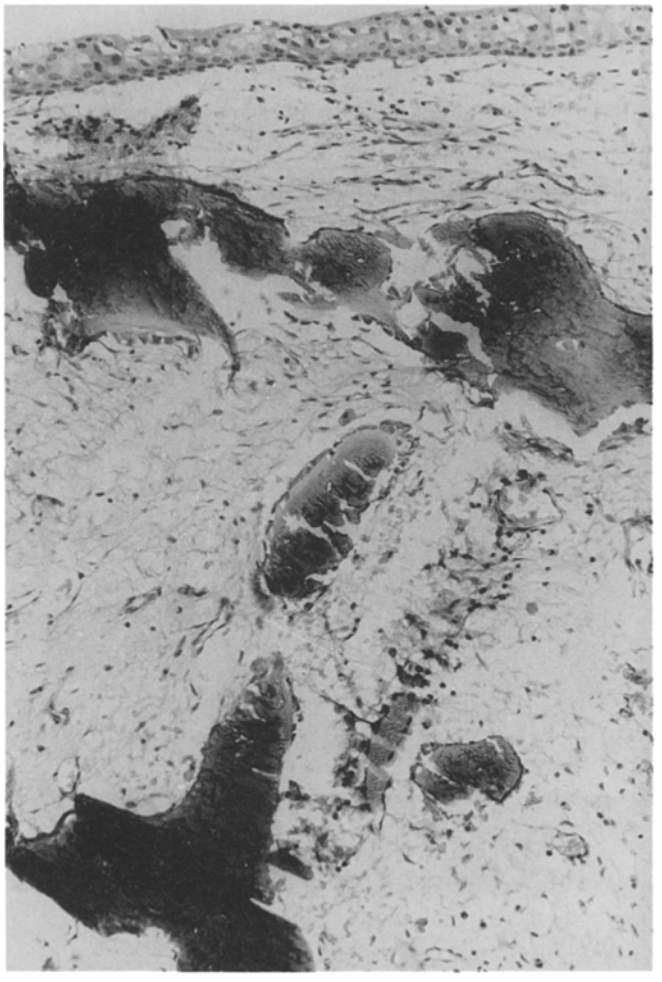

**Fig. 5.** Histopathological picture of the formed nipple at the end of the 5th postoperative week. The nipple is formed of fibrous tissue with areas of calcification, and is covered with transitional epithelium. H&E, ×100

variable amount of scarring and areas of calcification were observed grossly (Fig. 4) and microscopically (Fig. 5).

*Group II*

*Healing of the ileal mucosa in presence of urine.* The healing of the mucous membrane was slow. By the end of the second week incomplete mucosal covering of the denuded area was still observed (Fig. 6). Microscopic examination revealed creeping of the adjacent mucosa from both edges to cover the denuded ulcerated area, which was infiltrated by chronic inflammatory cells.

*Healing of the ileal mucosa in absence of urine.* In this setting the mucosal healing proceeded in a different way. The severity of the inflammatory reaction and the amount of granulation tissue were reduced and the area was completely covered by healthy ileal mucosa at the end of the 2nd postoperative week. No areas of ulceration or mucosal defects were observed (Fig. 7).

## Discussion

This series of experiments was designed to explain the unpredictable outcome following the Le Duc technique, which has been observed in clinical as well as experimental settings.

When the ureteric adventitia is left uncovered and exposed to the "irritant" effect of urine a type of periureteritis was noted. Granulation tissue was seen to form over these exposed ureters. The ureteral mucous membrane creeps to cover this granulation tissue. The result is formation of a nipple covered on its outer surface by transitional epithelium. The functional outcome of this process is either sound healing with provision of unidirectional, non-impeded flow of urine or healing associated with dense scarring and calcification that ultimately

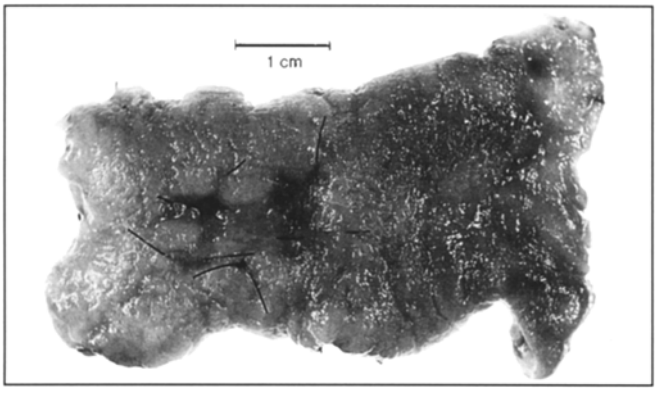


**Fig. 6.** Autopsy specimen of the ileal sheet patched to the bladder during the second postoperative week. Note the incomplete mucosal covering with ulceration

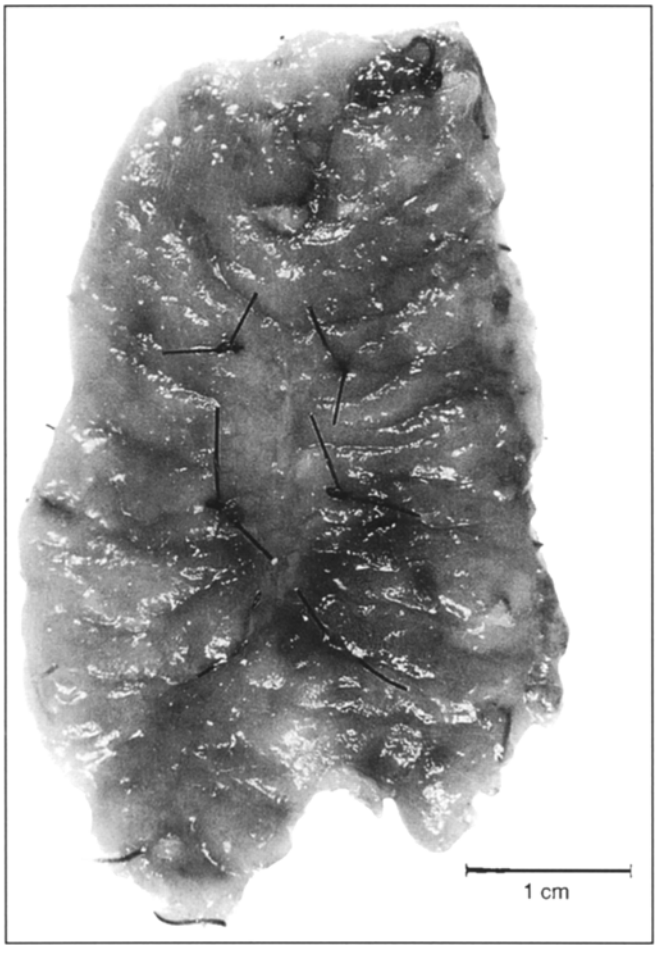


**Fig. 7.** Autopsy specimen of the control ileal sheet. Note the complete mucosal covering of the denuded area in the second postoperative week. The *scale* is in centimeters

results in stenosis or reflux. The factor(s) that may dictate the final outcome include the vascularity of the ureter and the presence of urinary infection. Furthermore, it was clearly demonstrated that healing and creeping of the intestinal mucosa are impeded in the presence of urine. Following the Le Duc technique the transitional epithelium covers the ureteral nipples before the creeping of intestinal epithelium is complete. Accordingly, following embedding of ureters in an open sulcus of the small intestine, a submucous tunnel is not obtained.

This series of experiments provides an explanation for the reported 15–30% failure rate following the Le Duc technique. Furthermore, it emphasizes the critical importance of covering the ureteric adventitia with an epithelial-lined surface to protect it from the effect of exposure to urine. This allows sound healing with minimal scarring and ensures a predictable functional outcome.

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