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Augmentation Ileocystoplasty: An Experimental Study in Dogs

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Summary. We report a technique of ileal augmentation cystoplasty allowing the tailoring of a "made-to-measure" cystoplasty of an adequate size with two or three ileal loops. The wound healing at the borderline between the bladder plate and the pediculated transplant is studied by light- and electron microscopic techniques.

Key words. Ileocystoplasty, Augmentation cystoplasty.

Augmentation cystoplasty involves the replacement of part of the bladder after subtotal cystectomy retaining the base plate, bladder neck and sphincter control mechanism. Tizzone and Foggi (1888) [22] were the first to report an ileocystoplasty they performed in a dog, but it was not until 1899 that Mikulicz [15] and Rutkowski [19] performed the first ileocystoplasties in men for small contracted bladders. After Scheele's Ringplastik [20] in 1923, Cibert [5], Couvelaire [6] and Küss et al. [14] in France, Pyrah and Raper [18], Turner-Warwick and Handley Ashken [23], Tasker [21] in England, Gil-Vernet [9] in Spain, Giertz and Franksson [8], Ekman and co-workers in Sweden [7], Goodwin et al. [10] in the United States and others authors have contributed to our knowledge of bladder enlargement by small and large bowel. Although ileocystoplasty has many advantages, it is no longer the most widely used form of bowel replacement of the bladder; but there are still some authors using this method with excellent results [2, 4].

The purpose of this experimental work is in the first place to propose a useful modification of ileocystoplasty using two loops and an innovation using three ileal loops in order to allow better adaptation to the extension of enlargement needed. Secondly, we studied wound healing at the junction between the bladder plate and the bowel segment by light- and electron microscopic techniques.

Methods and Materials

8 adult mongrel dogs of both sexes, 4 males and 4 females, weighing between 18 and 30 kg, were used.

Anaesthesia

Pentothal i.v. 30 mg/kg of bodyweight. Intubation. Cyclopropane/Oxygene 2:1 l/min with 0.8–1.5 vol.% Fluothane.

Operative Technique

The abdomen was opened by a midline incision. An ileal loop of adequate length was isolated 20 cm above the ileo-caecal valve. The continuity of the intestinal tract was re-established by a one-layer extramucosal end-to-end anastomosis with Polyglactin 910 4-0 (Vicryl). The isolated ileal segment was folded in a U-form. Both loops were sutured together along their mesenteric border with a running chromcatgut suture 3-0. Both arms of the U-shaped intestinal loop were divided along this suture line. The mucous layer was sutured with continuous 3-0 chromic catgut. The two limbs then formed an intestinal plate (Fig. 1). The mucosa of this intestinal plate was thoroughly cleaned with an aqueous solution of chlorhexidine 0.05%.

Subtotal cystectomy resecting the bladder just above the ureteric entry was performed. The intestinal plate was easily adapted to the remaining bladder plate and sutured in two layers with continuous chromcatgut sutures 3-0, thus forming a cap over the bladder plate (Fig. 2). The mesentery was situated without tension at the top of the cap. If necessary, the length of the intestinal loop could be changed; a longer loop could be folded in three sections thus obtaining a larger intestinal plate (Fig. 3).

No antibiotics were administered. The capacity of the bladder was measured before and after operation.

Four dogs were sacrificed 12 weeks after operation for radiography and autopsy. 4 dogs were used at different intervals, on the 14th, 21st, 32nd and 60th day, for histological and scanning electron microscopical study.

Histological and Scanning Electron Microscopic Technique

The tissue samples were vigorously rinsed in a buffer solution and immersed in sodium phosphate buffered 2.5% glutaraldehyde at a pH of 7.4 and an osmolarity of 420 mosmo. After fixation for 48 h, the specimens were washed in several changes of phosphate buffer and post-fixed in 1% osmium tetroxide for 16 h. Following fixation, the samples were dehydrated through an increasing concentration of cold acetone. The blocks were prepared by cryofracturing in liquid nitrogen or cutting. Subsequently, the tissue was subjected to critical point drying using liquid CO_2. Dried specimens were mounted on

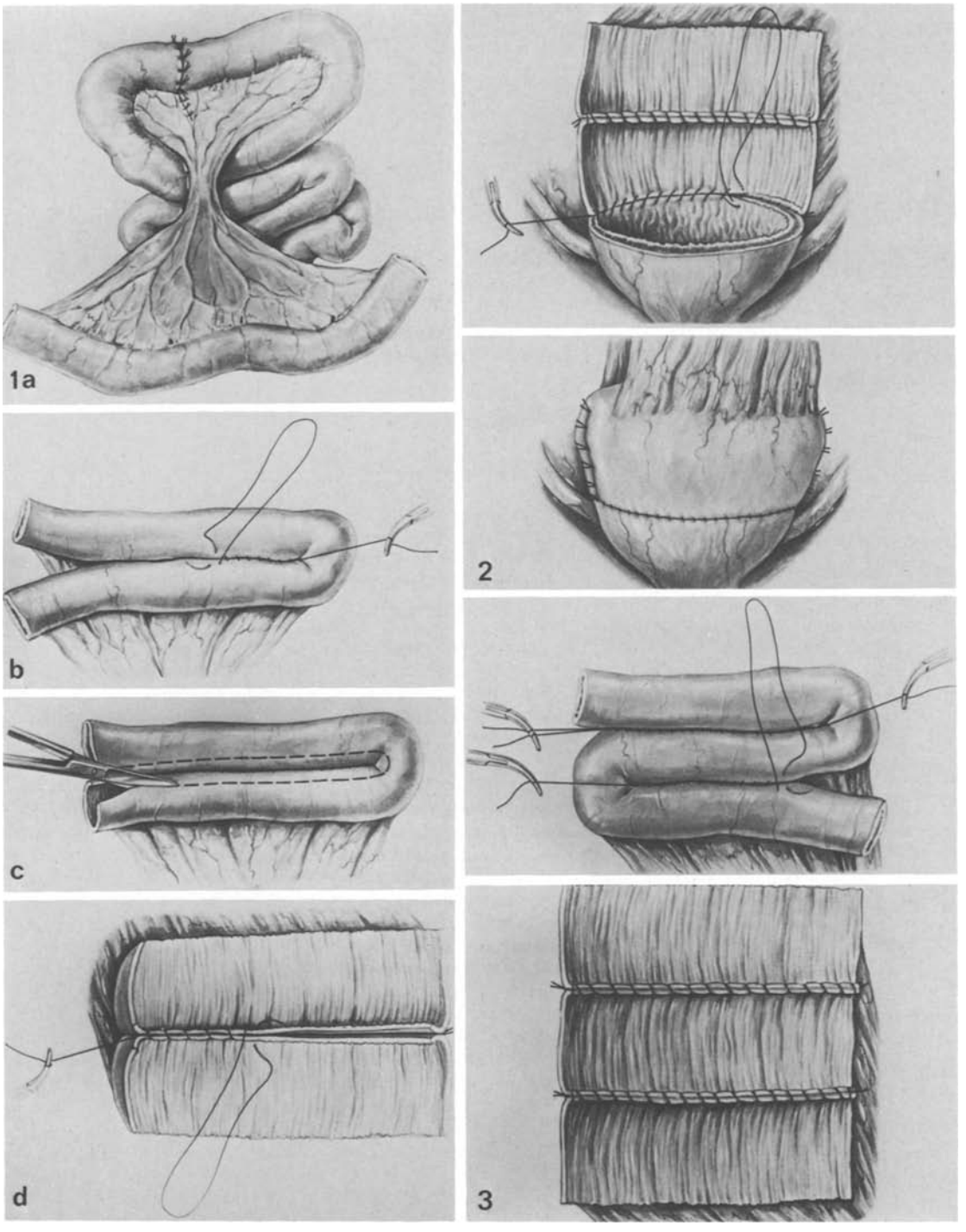


Fig. 1a–d. The ileum is divided (a); two intestinal loops are sutured together along their mesenteric border (b); divided along the suture line (c); suture of the mucous layer; the two limbs form now an intestinal plate (d)

Fig. 2. Adaptation of the intestinal plate to the remaining bladder base

Fig. 3. Preparation of a larger bladder dome by suturing together three intestinal loops to form a bigger intestinal plate

aluminium studs utilizing conducting silver paint and coated promptly with gold in a sputtering device. The scanning electron microscope used was an Autoscan-etec, equipped with a 150 μ aperture and operated with an accelerating voltage of 20 kV. Images were photographed on Polaroid 55 P/N.

Tissue samples to be used for light microscopy were fixed with 10% formalin, dehydrated with alcohol and embedded in paraffin. Thereafter, they were sectioned at 5 μm, stained by hematoxylin and eosin and v. Gieson. A Zeiss microscope was used, photomicrographs were taken with Agfa Professional 50 L-Film.

Results

All the dogs did well, maintaining a constant weight during the postoperative period. No digestive or voiding problems, no intestinal obstruction and no urinary leakage were observed. All dogs were continent of urine. Infection did not occur. At autopsy the bladder had a normal size and a capacity compared to the preoperative state, ranging between 120 and 150 ml. Bacterial cultures were sterile. The orifice of the ureters had a regular slit-like form. The bladder neck was normal. Although the intestinal mucosa appeared to retain its characteristics and produced mucus, there were no mucous plugs; the mucus was voided with urine. The postoperative radiographs showed a normal bladder shape (Fig. 4).

Gross Observation

Macroscopically a differentiation of the bladder from the intestinal cap was possible due to the thicknes of the bladder wall; there was a marked edge at the borderline between the original bladder and the ileal segment.

The microscopical findings at different intervals after operation can be summarised as follows: The original mucosa of the bowel persisted 60 days after cystoplasty, in spite of its entirely new environment. Distinct degenerative changes of the intestine were not visible. Goblet cells predominated in the mucosa of the bowel. The surface of the mucosa was covered by a large amount of mucus; possibly this coating protects the intestinal cells against the damaging influence of the urine. The villi of the small bowel remained high and slender and showed distinct horizontal creases – possibly indicating flexibility and motility. Slight villous atrophy and a total loss of microvilli could be noted throughout the experiment. The intestinal wall was richly penetrated by an extensive network of blood capillaries.

During the first weeks after operation the bladder surface revealed degenerative changes close to the suture line.

After 21 days postoperatively (Fig. 5) a moderate cellular infiltration was present in the lamina propria of ileum; suture strands remained compact and were surrounded by a minimal zone of reaction. Inflammatory cells tended to penetrate the outer periphery of the catgut.

After 32 days (Fig. 6) the transitional epithelium regained its typical morphology. At this interval only 75% of the suture material remained visible. The margin of the bladder showed a hyperplastic condition over the entire period of observation. Only in the animal sacrificed 60 days after operation (Fig. 7) was regenerative growth of the bladder epithelium visible. It originated from the preserved edges of the urinary bladder and progressed very slowly toward the centre of the intestinal patch. A precise evaluation of the cellular renewal rate in the epithelium was not feasible with our method.

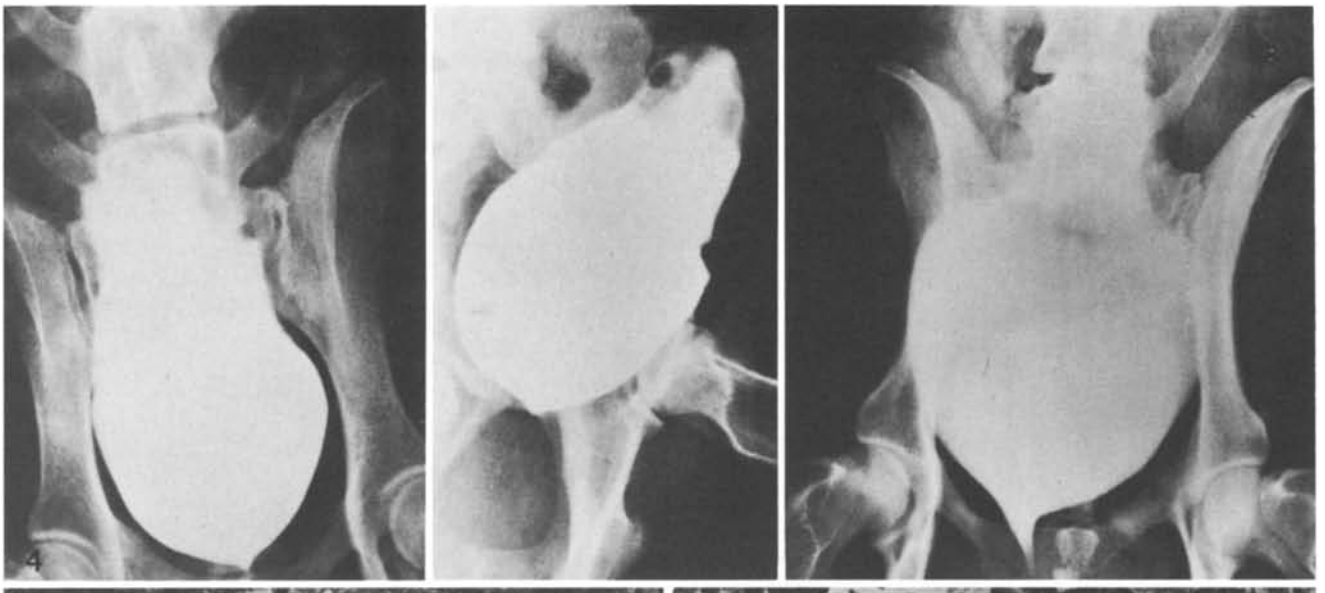
The reluctant regeneration of the bladder epithelium could be explained by a blocking effect of the intestinal mucosa on the regenerative power of the urothelim. Persistance of the intestinal epithelium over long intervals is mentioned by many authors. Baker and his co-workers [1] found intestinal mucosa still present 18 months after sigmoidocystoplasty. A more rapid covering with vesical epithelium of an intestinal segment that was stripped of its own mucosa previously was demonstrated by Hakim et al. [11, 12]. Hansson et al. [13] noted a loss of villous elements with regressive changes reducing the absorptive area one year after construction of a urinary ileal reservoir.

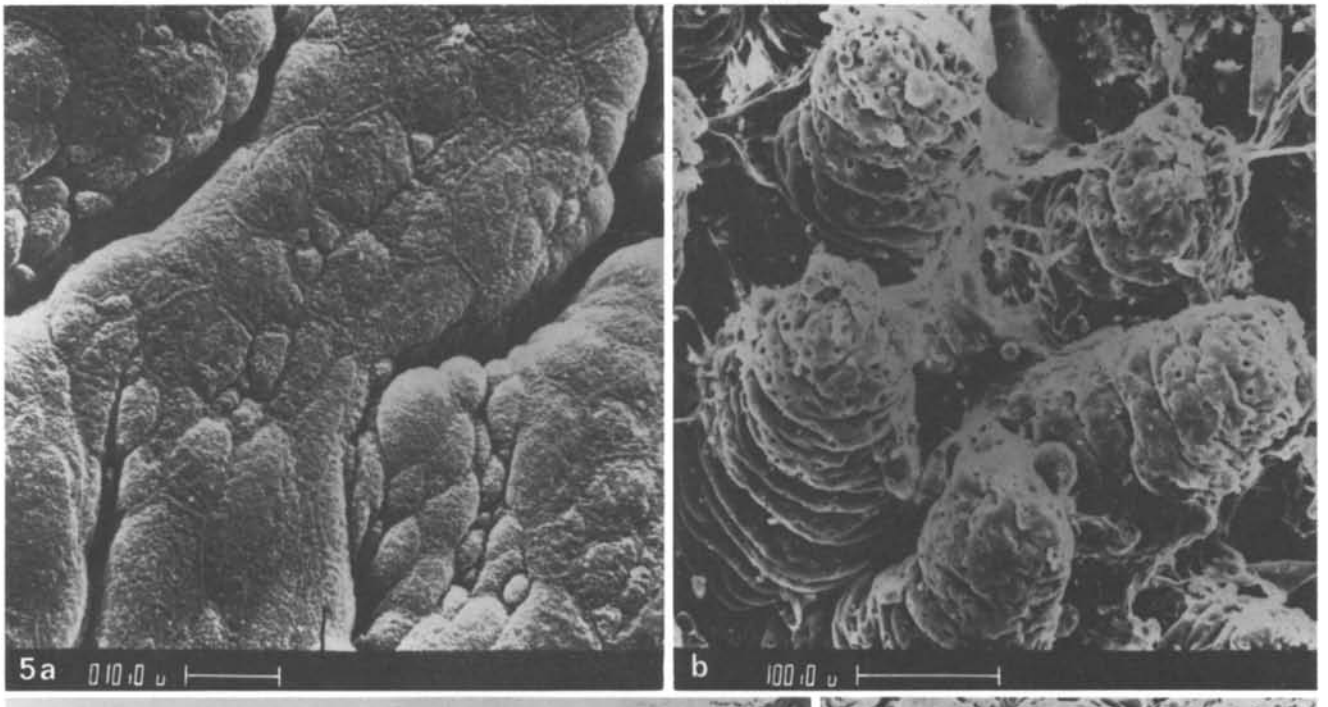
Discussion

Vesical enlargement should be considered in cases of bladder contracture due to interstitial cystitis, tuberculosis, irradiation, bilharziasis, chemical cystitis, after multiple surgical procedures such as subtotal cystectomy for tumours of the bladder and in congenital anomalies such as exstrophy of the bladder. Augmentation cystoplasty may also be used for neuropathic dysfunction of the bladder complicated by alterations of the kidney and in some malformations associated with sacral agenesis. In fact, considerable deterioration of the detrusor because of neurogenic bladder dysfunction may limit the possibility of conservative management such as intermittent catheterisation, artificial sphincter or continent transappendicular cystostomy as indicated by Mitrofanoff [16]. Bruce and co-workers [3] reconstructed a bladder in two patients with neurophatic bladders using a technique of colocystoplasty; one of the patients had two normal pregnancies since her colocystoplasty. Recently, at the 39th meeting of the French Association for Paediatric Surgery in 1982, Mollard and Jourda [17] and Weisgerber [24] reported their experience with colocystoplasty in the treatment of neurological bladder in spina bifida children. Ballanger and co-workers [2] reported excellent results with ileocystoplasty at the French-Egyptian Surgical Meeting in Cairo, November 1981; Camey and Le Duc [4] also continue to use enterocystoplasty with good results.

It is obvious that the bigger the communication between the bowel loop and the bladder, the easier would be the emptying, provided the bowel graft were contractile [23]. The peristaltic characteristics of ileum and colon are very similar urodynamically as a substitute for the detrusor. Their electrolyte reabsorption characteristics do not differ significantly. No really serious electrolyte disturbances occur: the absorption from both colon and ileum is apparently so slight as to have no clinical significance. Among the bowel segments used the sigmoid colon is more often involved in diverticular disease than other parts of the intestinal tract; the end-to-end anastomosis of the colon not only carries a higher morbidity rate, but also is situated close to the cystoplasty implicating a risk of vesico-colic fistula.

In order to obtain a more bladder-like substitute an isolated loop of the small intestine has been split and then

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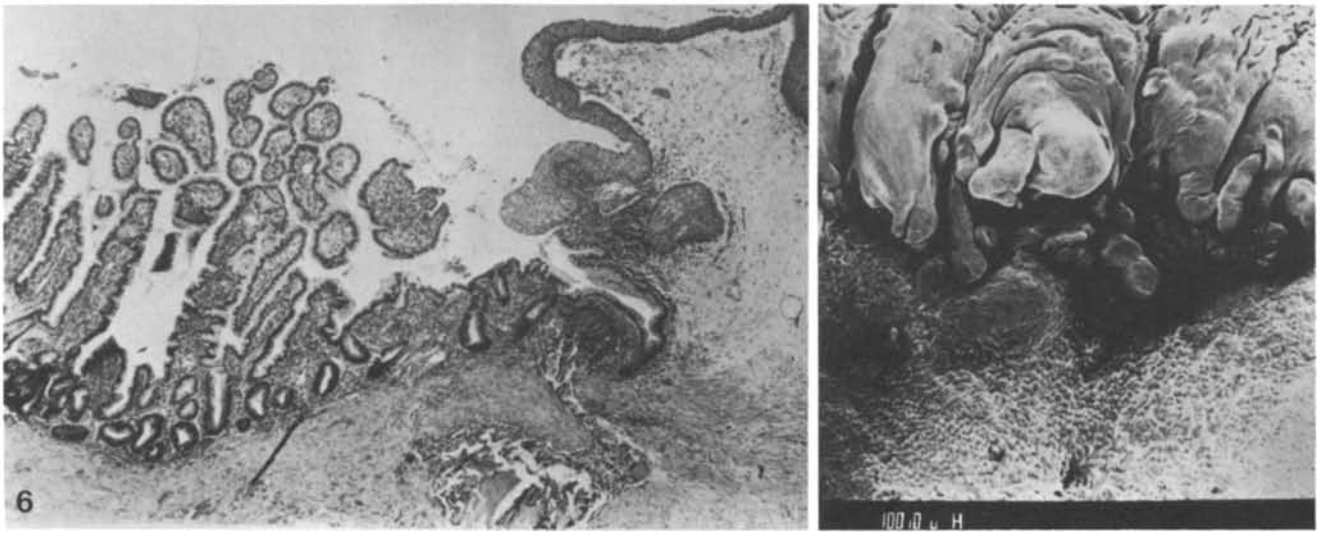
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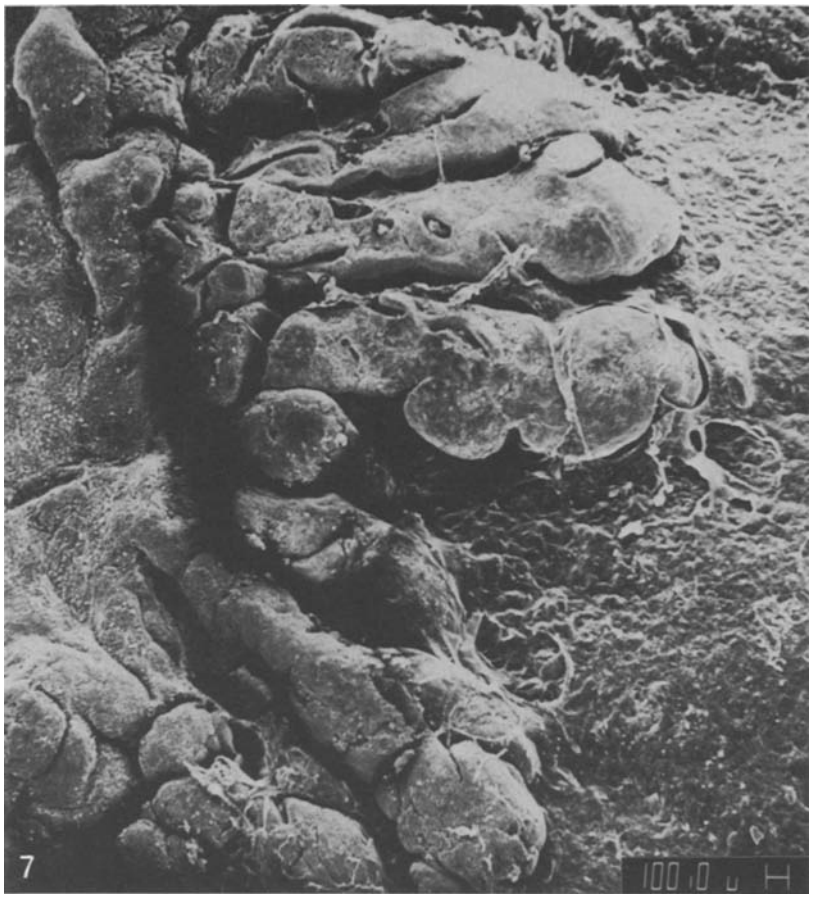

Fig. 7. SEM-micrograph showing encroachment of uroepithelium (*left*) toward the intestinal segment (*right*) 60 days postoperatively. x17

closed as a cap by Tasker [21], Giertz and Franksson [8], and Goodwin et al. [10]. These authors first open the ileal loop by cutting along the antimesenteric border; the flat patch of ileum then formed is pulled together in the form of a U and sutured together. The flattened loop is curved again on itself from top to bottom to form a cap. By this folding method, the intestinal border of the mesentery extends into the lesser pelvis down to the bladder neck region, so there is a risk of stretching of the ileal vessels, thus compromising the vascularization at the anastomosis. In the technique we propose the ileum loops are first sutured together in a U-form and then opened along this suture line, thus allowing easily the exact performance of a watertight double-layer anastomosis. The intestinal border of the mesentery is situated at the cephalad border of the new bladder dome in a physiological pleating, avoiding any stretching of the ileal vessels.

By folding the ileal loop, the motor activities in the different parts of the substitute counteract each other, and there is no summation of the pressures which might cause incontinence at night-time.

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◀ Fig. 4. Postoperative cystoradiographs. The identation suggests suture line situated immediately above the ureteric openings which are located high in dog's bladder

Fig. 5a, b. SEM-micrograph 21 days postoperatively (a). Folded bladder epithelium in close vicinity to the suture. Prominent boundaries of the polygonal cells give the surface a cobblestone appearance (x1300). SEM-micrograph (b). Luminal surface of the ileum 21 days after surgery. Dark pits indicate the opening of goblet cells (x200)

Fig. 6. Passage zone 32 days after ileocystoplasty: ileum (on the *left*), urinary bladder (to the *right*). The *bottom* center zone contains suture material; approximately 75 percent of cross sectioned area remain. (hematoxylin and eosin). x10. SEM-micrograph: 32 days postoperatively. Bladder wall – on the *top* of the picture, intensively folded. The *bottom* half depicting the luminal surface of ileum (x10)

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