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Evaluation of Ileum Interposition in Ureterosigmoidostomy: Experimental Studies

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Summary. Experiments in juvenile house pigs with a valved uretero-ileosigmoidostomy were performed, and the advantages of this procedure as against common methods were assessed. Postoperative studies up to 6 months revealed encouraging results in respect of function, infection rate, kidney function, serum electrolyte pattern and as to macro- and microhistological appearances. The results were considered superior to those obtained by simple ureterosigmoidostomy as shown by control groups.

Key words: Uretero-ileo-sigmoidostomy, Urinary diversion, Intestinoureteric reflux, Urinary tract infection.

Introduction

One of the first urinary diversions utilising bowel in a patient suffering from exstrophy of the bladder was performed by Simon [33] in 1852. Since then, various attempts have been made to solve the problem of ureterointestinal diversion [3, 20]. One of the main disadvantages of ureterosigmoidostomy was the reflux of faecal material into the upper urinary tract. In 1911 Coffey [6] developed an antireflux technique in ureterointestinal anastomosis by creating a submucosal tunnel in the sigmoid-colon. Up to 1950 this method and its modifications [15, 18, 19, 25, 40] were the most frequently used until Ferris and Odel [12] reported on the problems connected with electrolyte abnormalities in patients with uretero-sigmoidostomy. These problems and a high infection rate of the upper urinary tract brought about a critical approach towards the problem of urinary diversion which finally resulted in reverting from internal to external cutaneous diversion methods with either ileum [4] or a segment of colon [11, 12, 16, 17, 21, 30] as a conduit.

Recent publications concerning lon-term follow-up investigations after uretero-ileoostomy [10, 26, 31, 35] have shown a relatively high complication rate. These facts have led to a revival of the old method of ureterosigmoidostomy in recent years in spite of the reports of occasional malignant tumour growth at the site of ureterointestinal anastomosis [28, 34].

This concern about ureterointestinal diversions and additional psychological problems resulting from cutaneous stoma has led us to investigate the value of a nippled ileum interposition between ureter and the distal sigmoid colon in animal experiments.

Material and Methods

Two groups of experiments were performed in young housepigs which were labelled alphabetically.

Group I consisted of nine animals in which ureteroileo-sigmoidostomy was performed with Group II serving as a control group and comprising six animals in which ureterosigmoidostomy following Cordonnier's method [7] was performed.

In Group I young female housepigs weighing between 16 and 20 kg were investigated. In only one instance [1] the weight was 62 kg at the time of operation. Food and water was withheld for 12h prior to operation and as premedication the animals received Azaperon (40 mg/kg). Anaesthesia was initiated with Halothane-O_2 and continued with endotracheal N_2O_2 administration. Thereafter the jugular vein was dissected free and a 16 Gauge cannula inserted as far as the right atrium if possible. Preoperatively blood was drawn to evaluate several serum parameters as listed in Tables 1 and 2 and blood gases were measured. Next, a median laparotomy was performed and a distal ileum loop of 15 cm length prepared. The proximal end of the loop was closed and the severed ileum reanastomosed. Both ureters were then freed up, spaltulated and a mucosa-mucosa end-to-side anastomosis with the ileum carried out. No attempt was made to create an antireflux anastomosis. In order to ensure that the anastomosis was watertight the loop was then filled with saline solution. After this a nipple of approximately 3 cm in length was created at the distal end of the ileal loop. An incision was then made at the distal end of the sigmoid colon close to the rectum according to the diameter of the ileum loop. The nipple end was inserted and anastomosed with a continuous suture using 000 chromic catgut. An additional layer of interrupted 000 silk sutures was superimposed (Fig. 1). After completing the intestinal anastomosis the abdominal wall was closed in three layers.

Table 1. Laboratory findings in six animals of Group I

A) BUN: mmol/l (mg/l)			B) Creatinine: μmol/l (mg%)		C) K^+: mmol/l (mol)	
Animal	preop.	postop.	preop.	postop.	preop.	postop.
A	2 (12)	8.3 (49)	150 (1.7)	195 (2.2)	4.25	4.0
C	5 (30)	6.2 (37)	140 (1.6)	140 (1.6)	4.0	4.6
D	4.5 (27)	8 (49)	132 (1.5)	168 (1.9)	3.35	3.9
F	4.7 (29)	4.7 (29)	98 (1.1)	115 (1.3)	3.8	3.7
I	7.7 (46)	8.4 (50)	132 (1.5)	140 (1.6)	3.78	3.9
L	9.2 (55)	4.2 (25)	98 (1.1)	115 (1.3)	4.0	4.4
D) Cl: mmol/l			E) Ammonia: μmol/l (μg/l)		F) P: mmol/l (mg%)	
Animal	preop.	postop.	preop.	postop.	preop.	postop.
A	105	107	24 (40)	26 (45)	2.5 (7.45)	2.75 (8.6)
C	106	105	57.5 (97)	55.5 (96)	2.75 (8.6)	2.42 (7.5)
D	103	104.5	28.5 (48)	51 (87)	2.65 (8.3)	2.55 (8.0)
F	102	104	71 (120)	80 (137)	2.55 (8.0)	2.50 (7.82)
I	104	102	25 (42)	61 (104)	2.52 (7.9)	2.5 (7.82)
L	110	108	52 (88)	85 (144)	1.80 (5.65)	2.2 (6.9)

Table 2. Laboratory findings in four animals of Group II

A) BUN: mmol/l (mg/l)			B) Creatinine: μmol/l (mg%)		C) K^a: mmol/l	
Animal	preop.	postop.	preop.	postop.	preop.	postop.
B	4.8 (28)	11.7 (70)	122 (1.35)	195 (2.2)	3.9	3.75
K^a	5 (30)	6.7 (41)	125 (1.4)	90 (1.0)	3.7	3.70
M^a	3.8 (21)	5.7 (34)	125 (1.4)	125 (1.4)	4.4	4.1
N	2.5 (15)	4.2 (25)	160 (1.8)	160 (1.8)		
D) Cl: mmol/l			E) Ammonia: μmol/l (μg/l)		F) P: mmol/l (mg%)	
Animal	preop.	postop.	preop.	postop.	preop.	postp.
B	101	113	57 (97)	121 (205)	2.72 (8.5)	2.48 (7.75)
K^a	99	108	31 (53)	201 (342)	2.52 (7.85)	2.16 (6.58)
M^a	102.5	100	141 (241)	77 (131)	2.35 (7.35)	2.40 (7.2)
N	135	108	58 (99)	75 (121)	3.00 (9.4)	2.25 (7.1)

[a] Values obtained 1 month postoperatively since animal died before the 3 months period

Group II (control group): the same procedure was performed as in Group I but instead of ureteroileosigmoidostomy only an end-to-side ureterosigmoidostomy was performed according to the method described by Cordonnier [7].

No antibacterial drugs were administered during the postoperative period. From the first postoperative day the animals were allowed to feed and drink freely. For further investigations blood was drawn daily during the first week for blood gases and serum electrolyte determinations. The animals' weight was checked continuously and after 3 months an IVU was done. After this period, and, in one instance, after 26 weeks, the animals were sacrificed by administering an overdose of Sodiumpentobarbital. An autopsy was then carried out and the urinary and intestinal organs subjected to macroscopical and microscopical investigations. Prior to this, urine from the renal pelvis was taken by puncture for bacteriological culture.

Results

Group I

In Group I, six animals survived the experiment and were available for postoperative studies. Of the remaining three, one pig (G) died due to a cardiac arrest during the operation,

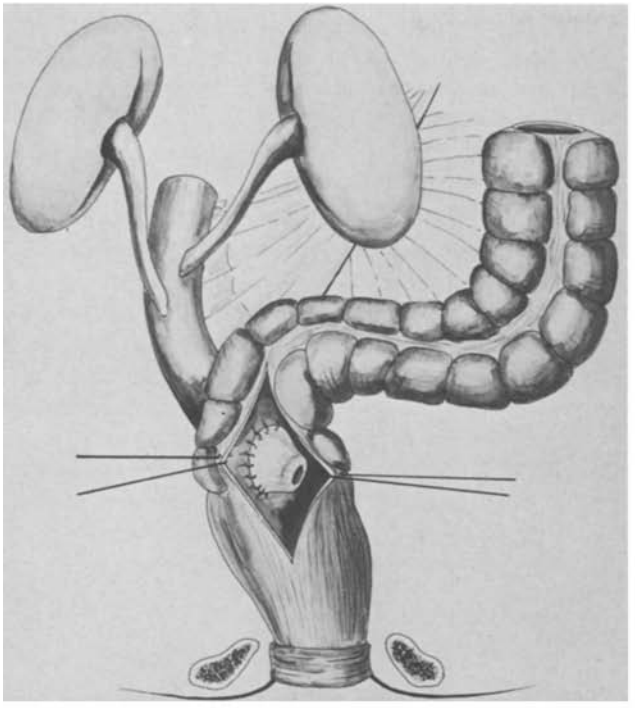

Fig. 1. Diagram showing completed ureteroileosigmoidostomy

Fig. 2. IvP of pig L (115 kg) 26 weeks after ureteroileosigmoidostomy illustrating normal appearance of upper urinary tract

the second (H) died on the first postoperative day of spontaneous pneumothorax, and the third animal (E) died one month after operation because of severe pyelonephritis following ureteric obstruction. The obstruction, however, resulted from the fact that in two cases (D, E) a seromuscular layer was placed on top of the ureteroileal anastomosis in order to achieve a watertight anastomosis. This caused a pronounced ureteric obstruction in animal D, and a fatal pyonephrosis in animal E. In the other six animals the postoperative course was uneventful. The average weight gained after 1 month was 12.7 kg, after 3 months the maximum weight gain was 37 kg, the minimum 23 kg, with an average of 29.3 kg. Pig "L" was kept alive for 26 weeks and the weight gain was then 95 kg.

The discharge of urine and stood occured at more or less regular intervals in most instances as a fluid mixture of urine and faeces, but occasionally as formed stool and rather clear urine. The results of the principal laboratory findings, which were determined in order to judge kidney function and serum electrolyte composition, are listed in Table 1, with figures based on mean values of three assesments.

The IVUs 3 months after operation revealed a normal appearance of the upper urinary tract in four cases (C, F, I, L; Fig. 2) while in two cases (A, D) a dilated upper tract could be observed which was especially marked in animal "D". The cultures of the pelvic urine were negative in four instances (C, F, I, L), whereas positive cultures (E. coli, Proteus, Strept. faecalis) were obtained from the urine of animals A and D. The cultures of the urine collected from the ileal loop were positive in all instances; however, this fact could be the result of post mortem manipulations.

The macroscopic pattern of the kidneys was virtually normal in three cases. Only in one case [1] very slight pyelonephritic changes could be observed. The histological investigations revealed findings which corresponded entirely with the macroscopic appearance. The ureteroileal anastomoses were generally intact and unobstructed except in animals D and E. Histology of the ureteroileal anastomosis at the border between the ureteral end and the ileal mucosa revealed a layer of indifferent epithelium above nonspecific granulomatous tissue. Adjacent to this top layer the urothelium showed increased degenerative vacuolar changes on its surface as well as signs of cellular regeneration. The sigmoid mucosa, however, showed a completely normal appearance at the site of the ileal anastomosis without any inflammatory signs. On the other hand, the ileal mucosa in some instances revealed a marked thickening of the villi (Fig. 3), with slight changes of the surface epithelium. The mucosa itself consisted mainly of enterocytes which had replaced the goblet cells. Yet, goblet cells could still be identified but only in the depth of the crypts. The Paneth cells remained intact. In the stroma of the crypts there were dense infiltrations of plasma and lymphoid cells besides phagocytes. In contrast, the histological changes of the ileal mucosa in animal "I" with a weight of 62 kg at the time of operation, and being therefore considered more adult, the villi had a more normal pattern and the histological changes were thus of minor significance.

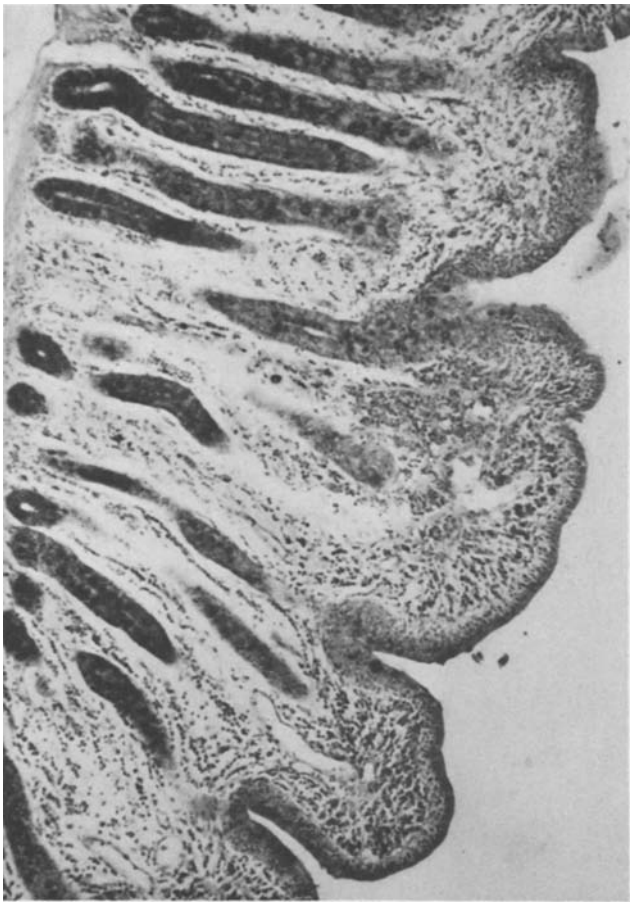

Fig. 3. Histological section of interpositioned ileum (PAS strain) showing marked thickening of the villi with phagocytes and cell infiltration in the stroma. Only enterocytes appear on villi surface

Whereas crystalline structures derived from the urine could not be detected in the phagocytes by polaroid microscopy, uric acid crystals could be seen on the surface of the epithelium.

Group II (Control Group)

Only two out of five animals (B, N) survived 3 months. Two animals (J, K) died 14 days and one (M) 1 month after operation due to massive pyonephrosis with extensive pyogenic spread involving the joints of the extremities. There was a marked difference in the postoperative course compared with Group I. In the control group food uptake was significantly lower and the animals developed fever and chills on the second and third postoperative days. The maximum weight gain during the first postoperative month was 5 kg, but in one case there was a loss of 1 kg. The average gain after 1 month was 2 kg. In the two pigs (B, N) that lived up to 3 months, the weight gain was 24 kg and 11 kg respectively with an average of 17.5 kg.

Animals that recovered from the first attack of pyelonephritis survived. In contrast to Group I animals, the discharge from the bowels consisted regularly of a fluid mixture of faeces and urine. All five animals showed a severe acidosis that was more pronounced than in Group I. The laboratory findings of Group II are listed in Table 2. IVUs after 3 months showed evidence of urinary tract dilatation and pyelonephritis in all cases. However, an IVU taken 1 month postoperatively showed, in one instance only, a very slight dilatation of the ureter and the collecting system. Autopsy 2 months postoperatively revealed a marked dilatation even if the ureter-colon anastomosis was intact and showed no signs of obstruction. Postmortem findings in all animals showed severe signs of pyelonephritis with multiple parenchymal abscesses, and in two cases faeces could even be observed in the renal pelvis. Histological examination generally revealed signs of chronic pyelitis with an ascending and partially scarring pyelonephritis. Frequently we observed cystic dilatation of the collecting ducts in the neighborhood of scars. Moreover, the ureter evidenced a severe inflammatory infiltration of the mucosa and epithelial degeneration. The sigmoid mucosa distal to the ureteral anastomosis was almost unchanged.

Discussion

There is no doubt about the necessity for urinary diversion in the treatment of a variety of diseases and malformations of the bladder. Several methods of urinary diversion are practised at present and are either internal or external forms of diversion. Up to 1950 ureterosigmoidostomy with its various modifications [6, 15, 18, 19, 25, 28, 37, 40] was the method of choice. Subsequently, however, ureteroileostomy as described by Bricker [4] became the preferred method, especially for malignant diseases of the bladder.

All procedures for ureterointestinal diversion are accompanied by a high complication rate with possible infection of the upper urinary tract causing damage to the kidney, but especially with ureterosigmoidostomy [16, 31, 37]. Electrolyte abnormalities, especially hyperchloraemic acidosis, hypokalaemia, and increased blood levels of ammonia after utereosigmoidostomy may cause severe complications but in most cases will be successfully controlled by administration of drugs or short term catheter drainage of the rectum [5, 12, 23, 36, 37].

A severe disadvantage of ureterosigmoidostomy also lies in the fact that malignant tumours may develop at the site of the ureterosigmoid anastomosis after many years. This is particularly true in children in whom a long survival time may be expected after the diversion had been done in the course of treating vesical malformations [28, 34]. The aetiology of tumour formation, however, is still not clear and it has been suggested that contamination of the ureter by faeces may be responsible [27]. A second explanation is to be found in carcinogenic substances that might be activated in the faeces by urine [8].

The external forms of ureterointestinal diversions have also shown a relatively high complication rate [10, 26, 31, 35] if the follow-up is long enough. It has been claimed that

the best results are obtained in children with a colon conduit [1, 2, 17, 21], but even in these cases the complication rate after a longer period may be high [11]. One problem, however, in all forms of external urinary diversion which must not be neglected is the psychological aspect of a cutaneous stoma which becomes especially prominent and critical when young people become interested in the opposite sex [14]. Therefore, methods of undiversion were developed especially in the USA [14, 17]. In order to eliminate some of these problems ureter oileosigmoidostomy may be advisable. This procedure, although carried out both experimentally [22, 38] and clinically [9, 24, 27, 39] before, appears to offer – in our modified form – a number of advantages. The main criticism is that too large a section of intestine is exposed to urine which might cause uraemia and electrolyte imballance. In our experiments and in two clinical cases, however, hyperchloraemic acidosis, and other electrolyte abnormalities were found to be less than where simple ureterosigmoidostomy was done. The reason for this may be that the ileosigmoid anastomosis is situated below the linea terminalis, and in an erect position only a small part of the colon is exposed to urine.

The main advantage of the procedure described lies not only in the absence of an external stoma but also in the ureterointestinal anastomosis technique itself which is carried out by direct mucosa-mucosa anastomosis without tunnel formation, thus lowering the danger of ureteral stenosis. In contrast to experimental results by Moors et al. [22], the interposition of the ileum in the described manner has shown in over 50% of cases a significant protective barrier against any germs ascending from the colon into the upper urinary tract. Also, in two clinical cases where this procedure had been applied, there was no evidence of pyelonephritis even without antibacterial medication (follow-up time in one case 10 months, in the second 4 months). In ileosigmoidostomy no case of stenosis was observed, which is striking since stenosis of cutaneous stoma is one of the most frequent complications in external urinary diversion [10,11, 26,35].

The procedure of ureteroileosigmoidostomy is technically simple to perform, but in case of unexpected complications it may at any time be converted to a cutaneous ureteroileostomy. On the other hand, it is not too difficult to change an ileal conduit into an ileosigmoidostomy for the purpose of undiversion.

Conclusions about ileum interposition influencing tumour induction in the sigmoid colon cannot be drawn at present. Histological examinations done 6 months postoperatively did not reveal any evidence of metaplastic lesions of the intestinal mucosa indicating suspicious tumour growth.

Any histological changes except some minor stromal reactions corresponding with the findings published previously [13, 14] were of no significance in respect of possible cancerous lesions.

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