

Ureterorectal diversion with rectal augmentation*

Morphological and manometric study in the dog

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Accepted: December 1, 1991

Summary. Uretersigmoidostomy in the adult has progressively been abandoned because of its high complication rate (both metabolic and functional). We have studied the feasibility of a new model of ureterorectal diversion in 12 Beagle dogs, with the aim of increasing rectal capacity and decreasing rectal pressure. A segment of the ileum was isolated and opened along its antimesenteric border to obtain a patch into which the right ureter was implanted, the left ureter being left intact to allow comparison of the kidneys postoperatively. The patch was then sutured to the edges of a large anterior rectotomy. Modifications of rectal physiology were studied by recording the rectal pressure after distension by a latex balloon both preoperatively and 3 months postoperatively, so that it was possible to evaluate the elasticity of the rectal wall. Radiographic studies and examination of autopsy specimens after 3 months yielded the impression of a reservoir added to the rectal space. Intrarectal pressure was significantly decreased (50% of the preoperative value) for a given distension volume following rectal augmentation ($P < 0.01$). The elasticity of the rectal wall was not modified but the capacity of the reservoir was increased. The ureteroileal implantation was patent in two of the five evaluable dogs out of seven implantations performed. In these cases, signs of pyelonephritis were found in the right kidneys. In the remaining cases the implantation became obstructed for reasons mainly related to canine anatomy and experimental conditions. These technical difficulties in the dog make it impossible to assess the quality of this reimplantation technique in this model. After this type of rectal augmentation in ureterorectal diversion, a high-quality reservoir can be obtained leading to significantly lower rectal pressure than preoperatively for a given volume of distension. This suggests that the upper urinary tract may be better protected than after classic uretersigmoidostomy and continence may be improved, making this technique suitable for clinical trials.

Key words: Urinary diversion – Rectum – Experimental – Manometry

Following radical cystectomy for bladder cancer, uretersigmoidostomy is now used less and less, because long-term complications of this kind of diversion are still frequent. They include ascending pyelonephritis due to stenosis and reflux of the ureteral implantations, incontinence and metabolic disorders [2, 12, 13, 16]. Different diversion techniques with better results are now proposed: substitution enterocystoplasty anastomosed to the urethra, and cutaneous diversions, continent or incontinent. However, when the urethra cannot be used for enteroplasty, a cutaneous diversion, with the obvious disadvantage of an external diversion is indicated. In these cases, a colonic diversion, creating a bladder substitute controlled by the anal sphincter, could be an alternative to external diversion if the complication rate were acceptable. The aim is to study a model in which these complications are limited. The rectum is augmented by an ileal patch to reduce rectal pressure, thereby improving continence and limiting pyelonephritis. The ureters are implanted into the patch of small intestine using the antireflux technique described by Le Duc and Camey [11] which has given excellent results in other types of diversion.

We present results relating to the reservoir obtained, the modifications of rectal pressure following enlargement and the quality of the ureteral reimplantation.

Materials and methods

Twelve beagle dogs weighting 9–15 kg were used. Five dogs underwent rectal augmentation only (group I) and the other seven underwent both enlargement and diversion of the right ureter, the left ureter being left intact to allow comparison of the kidneys postoperatively for signs of ascending pyelonephritis (group II). Modifications of the rectal physiology were evaluated by means of

*Supported by grants from Le Comité de Paris de la Ligue Nationale Française Contre le Cancer et les Laboratoires Ethnor

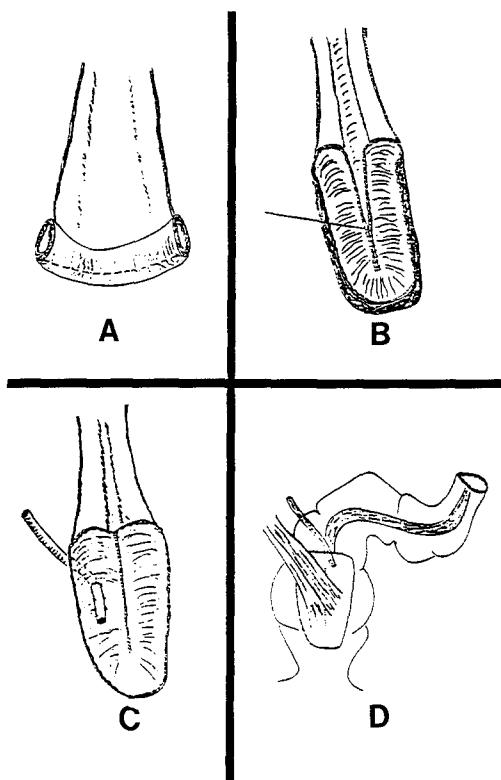


Fig. 1A-D. Operative technique. A An ileal graft is isolated and opened at its mesenteric border. B Creation of the patch. C Ureteral implantation with the Le Duc-Camey technique. D The ileal patch is sutured to an anterior rectotomy

manometric studies both preoperatively and 3 months postoperatively. Radiological examinations (intravenous urography and rectal radiography) were done at these dates during the same anesthesia. The dogs were sacrificed 3 months after the operation by thiopental overdose.

Operative technique (Fig. 1)

After the induction of anaesthesia and intubation, a midline incision was made in the abdomen, Douglas' pouch was incised, and the anterior surface of the rectum was dissected. A 10-cm length of ileum was isolated and opened along its antimesenteric border. The patch thus obtained was folded into a U-shape and the internal edges of each branch were sutured together with slow-resorption 4/0 sutures to obtain a patch 5 cm in length. The right ureter was dissected, cut and reimplanted into the patch using the antireflux technique of Le Duc and Camey [11]: Briefly, a 2-cm incision was made in the ileal mucosa and the edges of the incision were separated from the submucosal tissue for 2 mm. The ureter was passed through the ileal wall via an orifice at the proximal end of the mucosal groove and held flat within the groove by means of several stitches made with 6/0 absorbable suture, fixing the ileal mucosa to the ureteric adventice. The ureter was also fixed to the external surface of the seromuscular layer of the ileum using three sutures. The first three ureteroileal implantations were nonintubated and were eventually strictured. In the next cases the anastomosis was intubated using a 6-F ureteral tube exiting via the anus. The lower anterior surface of the rectum was incised longitudinally for 5 cm and the ileal patch containing the right ureter was sutured to the edges using slow-resorption 4/0 sutures.

Manometric studies were done by means of a previously described technique [1, 3] during standardized general anesthesia

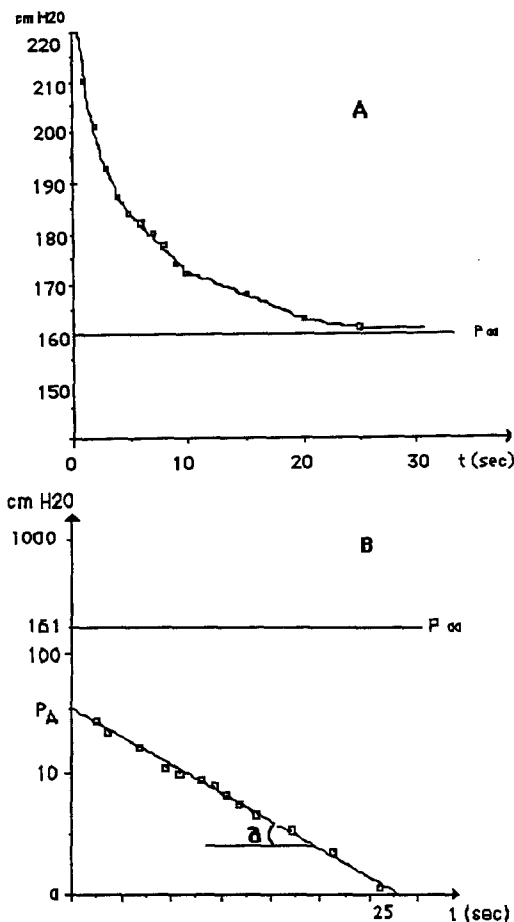


Fig. 2A, B. Graphical analysis of the intrarectal pressure after balloon distension with 40 ml of air in dog 2. A Experimental decrease of pressure with time, B linearized when plotted on a semilogarithmic paper with P_{∞}

(induction with 10 mg/kg thiopental, orotracheal intubation, ventilation with room air and maintenance with 0.5% halothane). This technique consists of measuring rectal pressure variations with time for a given volume of distension and determining changes in the elasticity of the rectal wall after surgery. A latex balloon is fixed to the end of a twin catheter (Marquat, BP 471 Boissy Saint-Leger Cedex, France) and introduced into the rectal ampulla. The balloon is filled in 0.1 s using one of the outlets, to various volumes of air (30, 40, 50 and 60 ml in random order) for 1 min, while the other outlet is connected to a manometer to record pressure within the balloon. The procedure is immediately carried out again in vitro in the same conditions (temperature, humidity, time of distention), and the values obtained are used to calculate the contribution of the rectum and its environment to balloon pressure.

A previous study [1] has shown that pressure quickly reaches a maximum then declines exponentially with time, stabilizing close to an asymptotic pressure (P_{∞}). The curve obtained corresponds to the equation $P(t) = P_{\infty} + PAe^{-at}$ (Fig. 2), where $P(t)$ is the pressure as a function of time, PA and a are respectively the pressure at T_0 and the slope of the line obtained in semilogarithmic coordinates after subtracting P_{∞} . On the basis of the values obtained, the tension of the rectal wall is calculated using Laplace's law ($T = 981 P \cdot r/2$), where r is the radius of the balloon in centimeters, P is the pressure in centimeters of water, and T is the tension (Dyn/cm). The values of r were determined taking the actual volumes of the latex balloon for distension volumes of 30, 40, 50 and 60 ml as 25.2, 37.4, 48.0 and 59.0 ml [1]. The relationship between wall tension T and balloon radius r

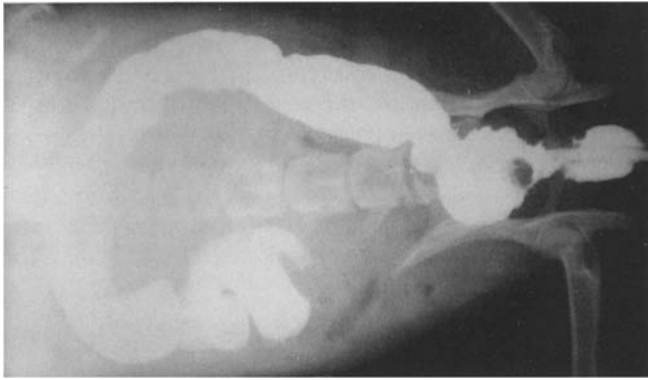


Fig. 3. Rectal opacification showing the rectal reservoir added to the rectum

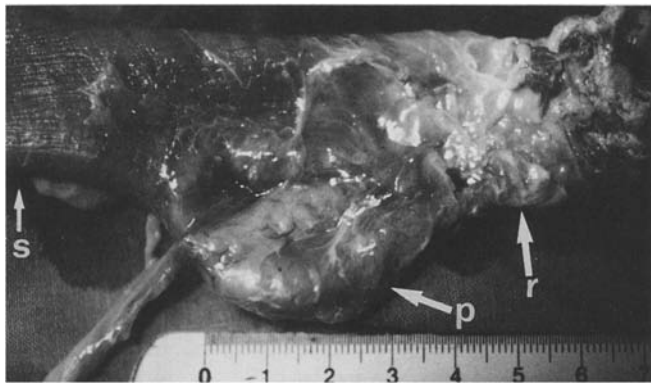
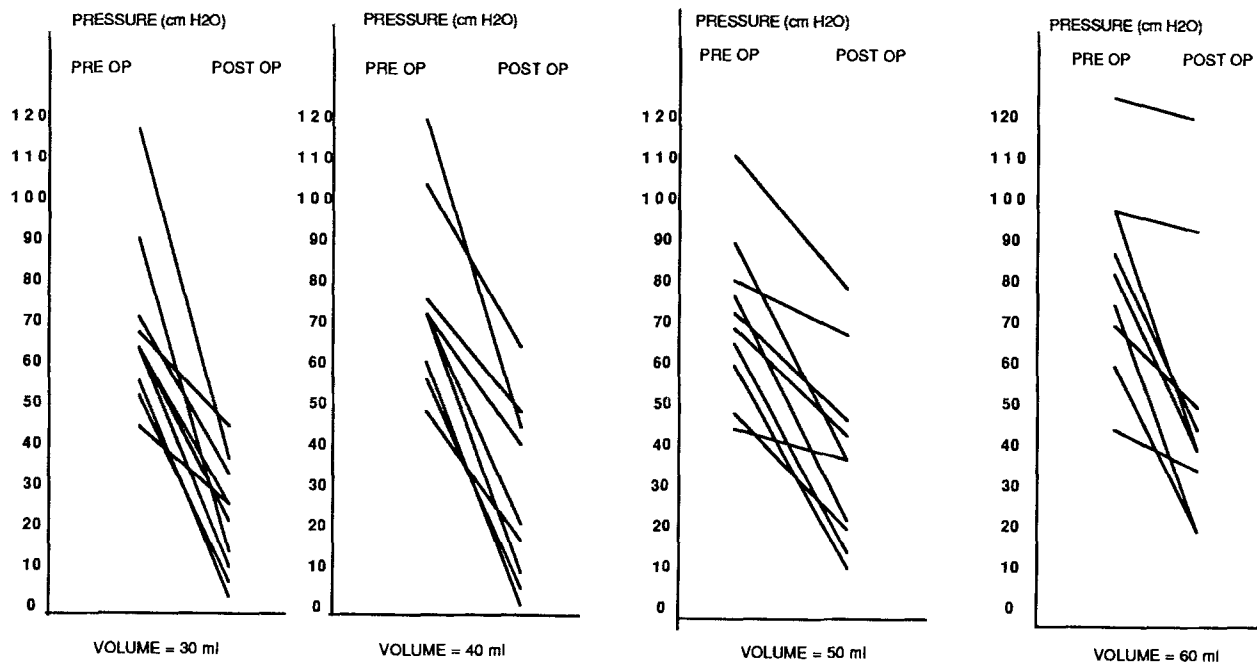


Fig. 4. Macroscopic aspect of the rectal reservoir: s, sigmoid colon; p, ileal patch; r, rectum

Fig. 5. Evolution of rectal pressure after 1 min of distension with different volumes (30, 40, 50 and 60 ml) of air 3 months after rectal augmentation ($P < 0.01$)



is linear, following the equation $T = Er + To$, where E is the slope of the line obtained and To its ordinate at the origin. The values of E and To , which were calculated for each component of tension (T^∞ and TA), were compared between the preoperative examination and that performed 3 months after the rectal augmentation by means of Fischer's t -test for paired values, each dog being its own control.

Frontal and transverse aspects of the rectum were studied radiologically after retrograde injection of sulfate of Barium via a transanal stent.

Results

No complications occurred in group I. Two dogs in group II died of postoperative complications, one of peritonitis due to failure of the patch sutures and the other pyelonephritis due to a stenosis of the ureteroileal anastomosis. The results for the remaining 10 dogs sacrificed 3 months postsurgery were evaluated.

The morphologic study of the rectum by radiography with opacification revealed a reservoir added to the rectum (Fig. 3). At autopsy, the maximum diameter of the rectum in a flaccid state at the level of the reservoir was 64.4; 14.1 mm (mean; SD), while the length of the reservoir was 57.2; 9.0 mm; the mean diameter of the rectum below the reservoir was 37.0; 9.9 mm and that of the sigmoid 32.3; 6.5 mm (Fig. 4).

The rectal asymptotic pressure was significantly lower for a given volume of distension following rectal augmentation ($P < 0.01$; Fig. 5). The slopes of the straight lines expressing tension T^∞ and TA as a function of the radius of the balloon were not statistically different before and after enhancement of the rectum. The ordinate at the origin of the straight line expressing T^∞ was significantly decreased ($P < 0.05$) (Fig. 6) but not changed for TA . These results indicate that elasticity of the rectum was not modified whereas its capacity was increased.

Histological examinations showed the particular structure of the canine small intestine, which is different from

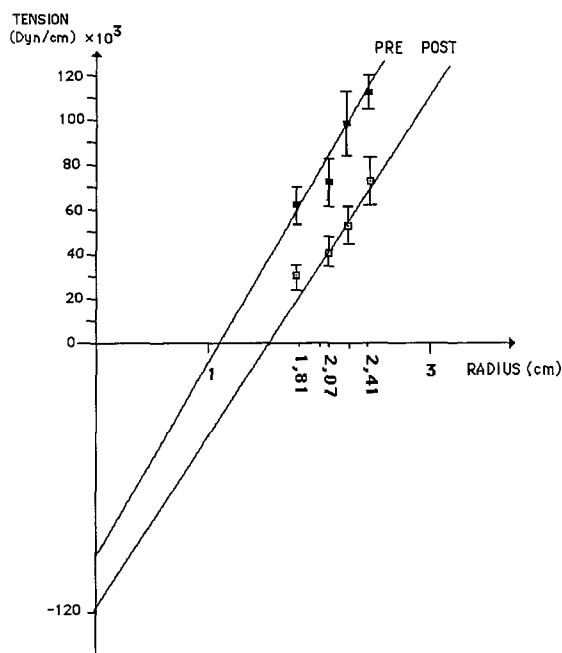


Fig. 6. Linear relationship between the wall tension T_{∞} and the radius of the balloon before (PRE) and 3 months after (POST) rectal augmentation. The slopes are not different, whereas the ordinates at origin are: T_{∞} preoperative = $84996r-95099$; T_{∞} postoperative = $72659r-117230$ ($P < 0.05$)

that in humans; in the dog, smooth muscle fibers of the intestinal wall reach the tip of the villus but stay in the muscularis mucosae in the man. The patch was very inflammatory and congestive but the wall of the rectum was normal.

The ureteroileal implantation was patent at 3 months in two of the five evaluable dogs out of seven implantations performed. In these two dogs, the ureters had been stented. Urography done 3 months postoperatively showed a normal right kidney function, with no rectoureteral reflux after contrast enhancement. However, histological examination showed the presence of ascending pyelonephritis in both cases. The ureteroileal implantation was stenosed in the remaining three cases and the right kidney was atrophic at autopsy.

Discussion

Rectal augmentation is aimed at increasing the capacity of the rectum, thereby reducing rectal pressure and improving urinary continence. Indeed, the classic ureterosigmoidostomy technique is associated with unsatisfactory continence, particularly when the patient breaks wind. Kock and Gonheim were the first to describe a model of ureterorectal diversion with the goal of limiting these complications. In addition to a rectal augmentation, their technique [9, 10] includes a colorectal invagination which forms an antireflux valve, with the aim of limiting contact between urines and the colon, which can engender metabolic disturbances [8, 14]. However, this latter compli-

cation is easily avoidable by the systemic prescription of bicarbonate [15] and this colorectal invagination appears to be complex [15]. For this reason, we chose not to do it. Although the prevention of colorectal reflux could contribute to the progressive expansion of the rectum [9], in our model the reservoir developed in satisfactory manner in the absence of such a valve, as shown by radiological examination and the aspect of the autopsy specimens. Furthermore, the manometric study showed that the rectal capacity was increased.

The comparison of pre- and postoperative asymptotic rectal pressures obtained by the balloon technique [1, 3] showed that there was a 50% decrease relative to the initial pressure for a given distension. The pressure in the upper urinary tract being low [5], the reduction of pressure in the intestine after ureterorectal diversion is a good factor to prevent the rectoureteral reflux. Daniel [6] demonstrated that the long-term results in the upper urinary tract in patients with ureterosigmoidostomy were related to the intracolonic pressure. He suggested making an incision of the colonic musculature to decrease the high bowel pressure, but this technique was abandoned because of the high postoperative fistula rate [7]. The effect of the rectal patch is the same as that of incision of the colonic musculature, as shown by the 50% reduction in pressure obtained in this study. The second effect of decreasing pressure could be improved anal continence. Physiologically, distension of the rectum by stool or artificially by a balloon causes relaxation of the internal anal sphincter. This reflex could be delayed by rectal augmentation, but monitoring of anal pressure and evaluation of this rectal inhibitory reflex is not feasible in the anesthetized dog. Further studies in man will be necessary to confirm the hypothesis suggested, i.e. that anal continence may be improved by this decrease in rectal pressure and increase in rectal capacity.

The use of the antireflux technique described by Le Duc and Camey is supported by the favorable clinical results obtained after ureteroileal implantations during substitution enteroplasties and transileal cutaneous ureterostomies in Le Duc's experience, stenoses occurred in only 1% of cases and reflux in 16% [11]. Classic ureterosigmoidostomy is almost always complicated by recurrent pyelonephritis due to the association of colorectal reflux and the high rate of stenosis (up to 40%) [2, 4, 15]. In our experimental series, only two of six evaluable implantations (out of a total seven procedures) were permeable, and in both cases ascending pyelonephritis occurred in the right kidney. The failures were mainly related to our experimental conditions: the maintenance of a ureteral probe intubating the anastomosis is difficult in the dog and, above all, the canine ileal mucosa is not of the same texture as that in man, since smooth muscle fibers extend through the underlying tissues to the tip of the villus. This leads to additional difficulties in preparing the mucosal groove. In this way, it is difficult to reach a conclusion on the quality of the reimplantation in this model. However, the good results obtained with ureteroileal implantation in man with the Le Duc and Camey technique in other types of deviation suggest that clinical trials of our approach are warranted.

Conclusion

This experimental study of rectal augmentation for urinary diversion in the dog shows that a high-quality reservoir can be obtained, leading to significantly lower pressure than preoperatively for a given volume of distension. These results suggest that the upper urinary tract could be better protected after augmentation of the rectum than after classic ureterosigmoidostomy and that continence may be favored by the augmentation of the rectal capacity with lower rectal pressure.

Acknowledgements. The authors wish to thank Dr. Landais (Department of Medical Statistics, Faculté de Médecine, Necker Enfants Malades, Paris) for statistical analysis.

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