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E. Sanford · J.L. Lockhart · D. Weinstein

Experimental investigation of an infolded bowel segment as an anti-incontinence mechanism without interposing the ileo-cecal valve

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Abstract A technique for using bowel segment as an anti-incontinence mechanism was developed in an animal model and evaluated urodynamically. Variously modified bowel segments were investigated alone and later attached to a colonic reservoir to establish their value in preventing urinary incontinence while allowing easy catheterization. Using careful surgical technique, intussuscepted, tapered and plicated bowel segments were constructed. The maximum segmental closure pressure and functional length were evaluated in all preparations. The three bowel segments remained continent during slow filling and up to reservoir capacity. The recordings demonstrated both highest maximal closure pressure and longest functional length in the plicated system when evaluated both alone and following reservoir attachment. These recording differences occurred both with the reservoir full and empty. These results demonstrate the value of a plicated bowel segment in the maintenance of urinary continence when attached to a compliant urinary reservoir without using the ileo-cecal valve in this model.

Key words Anti-incontinence · Infolded bowel · Ileo-cecal valve

Kock successfully applied the concept of stapling intussuscepted small bowel to construct a continence mechanism for a urinary reservoir [7]. This outstanding contribution, as well as that of others, revived interest in continent bowel reservoirs such as the abandoned Gilchrist-Merricks procedure [4]. The most common anti-incontinence system currently utilized is the stapled intussuscepted bowel segment as initially reported by Kock and modified by Skinner [7, 12]. Other authors and ourselves have utilized different techniques for distal ileum plication to preserve continence in urinary reservoirs [8, 9, 11]. Some investigators have also utilized other ingenious infolding or tapering bowel techniques for similar purposes [1, 2, 5]. However, the majority of these techniques are utilized to reinforce the anatomical resistance present at the ileo-cecal valve [4].

The most desirable continence mechanism would be the least complex to construct and the most effective in preserving continence. Since we have successfully utilized a plicated bowel segment clinically, we attempted to also establish its experimental effectiveness as an anti-incontinence mechanism alone and connected to a urinary reservoir. The parameters investigated included: the complexity of surgical technique; the facility for catheterization; success in preventing urinary incontinence; urodynamic recording of maximal closure pressure and functional length. Results were compared in intussuscepted and tapered bowel segments of equal anatomic length and connected to the same reservoir.

E. Sanford (✉) · J.L. Lockhart · D. Weinstein
Department of Surgery, Division of Urology,
University of South Florida College of Medicine,
Tampa, Florida 33612-4799, USA, Fax: 1(813)974-2669

Material and methods

Two New Zealand rabbits were placed under general anesthesia using Ketamine and Xylazine. In the first animal, the small bowel was approached and exteriorized from the abdominal cavity. A 2.5 cm small bowel segment was isolated as a control and a 7Fr Bard pediatric profilometry catheter (model 091434) was placed intraluminally. Using a four channel Life-Tech Urolab, we recorded the maximum closure pressure (MCP) and functional length (FL) of the segment. The onset of the segmental closure pressure occurs at the implantation in the reservoir and extends through its external opening. This is expressed as the "functional length". The maximal closure pressure represents the highest pressure exerted by apposition of the intestinal wall contributing to segment closure. These recordings were made using continuous manual withdrawal with the standard Brown-Wickham technique [3]. The resistance to the fluid egress through a lateral hole in the catheter is recorded while the catheter is manually pulled at equally measured time intervals.

A second 2.5 cm small bowel segment was then isolated from the exteriorized bowel and four 5–0 chromic sutures were placed at one end, one in each of four quadrants. The four sutures were then brought through intraluminally, thereby intussuscepting the bowel

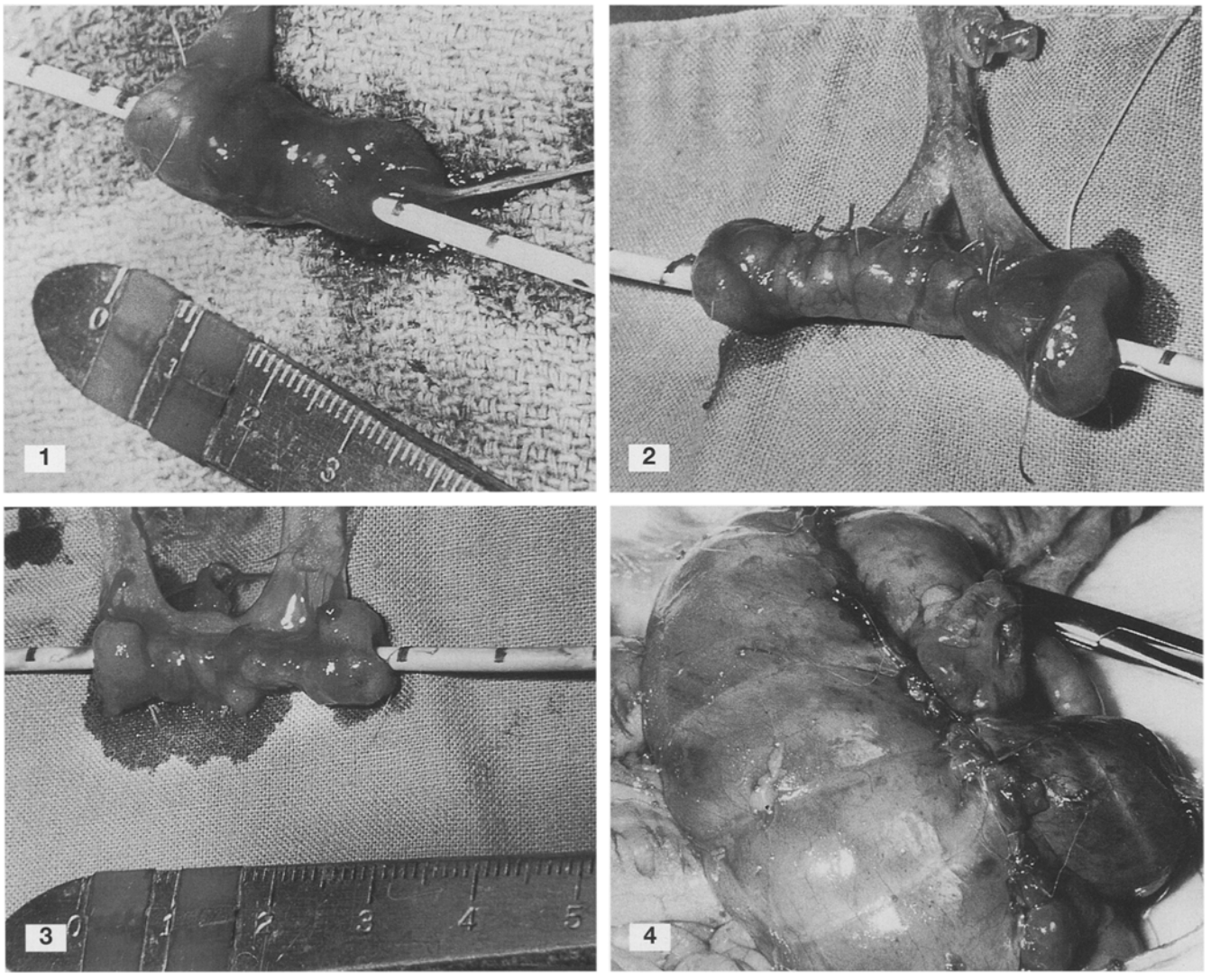

Fig. 1 Intussuscepted bowel segment

Fig. 2 Tapered bowel segment

Fig. 3 Plicated bowel segment

Fig. 4 Colonic reservoir

segment (Fig. 1). The same pediatric profilometry catheter was placed intraluminally and similar recordings were obtained. A third 2.5 cm bowel segment was then isolated and with the same 7Fr Bard catheter in its lumen, and a longitudinal strip of bowel was excised as is done in a mega-ureter tapering procedure (Fig. 2). The bowel was sutured snugly around the 7Fr catheter using a running 5–0 chromic continuous suture and was then reinforced with interrupted chromic sutures.

A fourth 2.5 cm bowel segment was isolated. Around the same 7Fr catheter a careful bowel infolding or plicating technique was applied to this segment using interrupted 5–0 chromic sutures (Fig. 3). Recording techniques identical to those used on the control segment were then applied to the other three experimental models.

A second animal was anesthetized and the large bowel isolated. An appropriate segment of colon (approximately 20 cm) was isolated and fashioned into a "U". As previously described, the bowel was opened and sutured together to achieve full detubularization [8, 9]. This latter procedure should allow better reservoir compliance and decreased segmental contractions as well as decreased intraluminal pressure (Fig. 4). A small opening was developed in the reservoir and the 7Fr Bard catheter was introduced and utilized for filling and pressure recording. Following reservoir construction, new segments of intussuscepted, tapered and plicated bowel were constructed in a manner similar to the previous models. Each segment measured 2.5 cm in length and all three were fit snugly around the 7Fr catheter. The three continence mechanisms were consecutively anastomosed to the reservoir which was then filled to the previously measured maximum capacity and statistical comparisons were made using students' *t*-test. MCP and FL were obtained with the reservoir full and empty on multiple trials. Complexity of surgical technique, facility for catheterization and dryness following observation during reservoir filling to its maximum capacity were determined in all segments.

Results

On the first animal, the control segment presented a MCP of 0 cm of H_2O and a FL of 0 cm. On successive recordings,

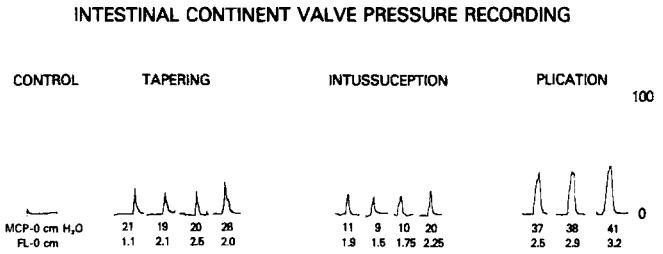

Fig. 5 Maximum closure pressures and functional lengths in bowel segments not attached to colonic reservoir

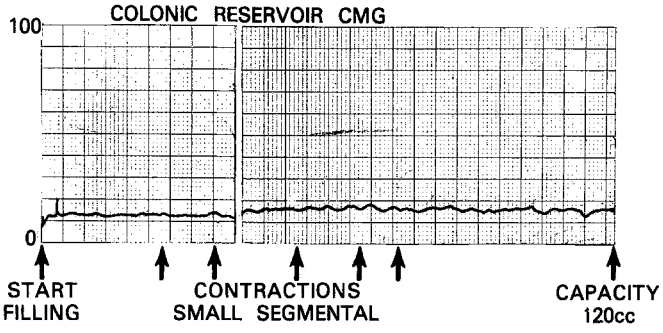

Fig. 6 Cystometrogram of colonic reservoir

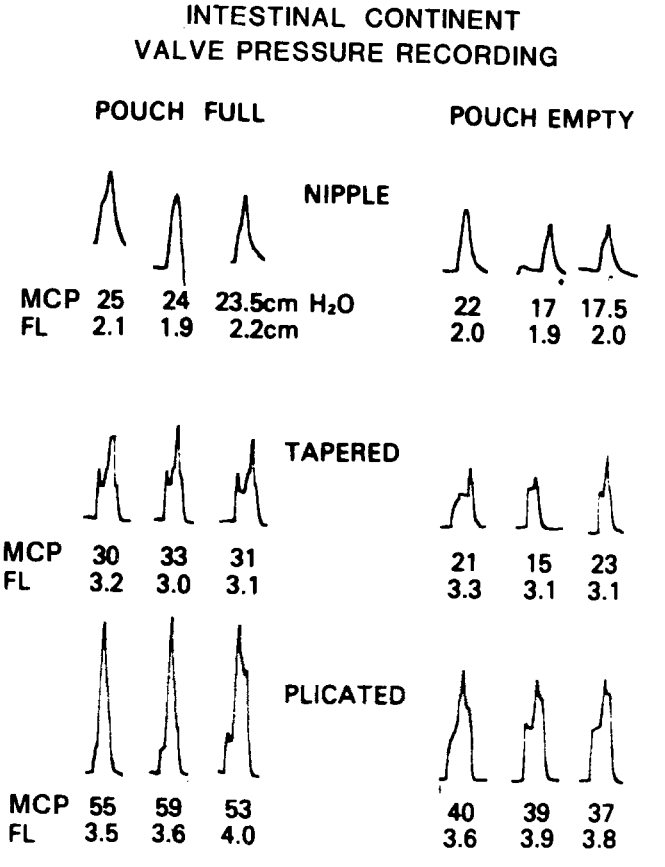

Fig. 7 Maximum closure pressures and functional lengths in bowel segments attached to both empty and full colonic reservoirs

the tapered segment presented MCPs of 21, 19, 10 and 28 cm of H_2O (average 19.5) and FLs of 1.1, 2.1, 2.5 and 2 cms (average 1.93). The intussuscepted segment presented MCPs of 11, 9, 10 and 20 cm of H_2O (average 12.5) and FLs of 1.9, 1.5, 1.75 and 2.25 cms (average 1.9). The plicated segment presented MCPs of 37, 38 and 41 cm of H_2O (average 39) and FLs of 2.5, 2.9 and 3.2 cm (average 2.9) (Fig. 5).

The colonic reservoir prepared from the second animal was tested by cystometry and found to have a maximal capacity of 120 ml. The maximum pressure recorded during filling was 6 cm of water (Fig. 6). When connected to the colonic reservoir, the intussuscepted, tapered and plicated segments were continent during filling and up to reservoir capacity. All three mechanisms were catheterizable: among them, the tapered segment presented the most difficulty for this manoeuver. MCP and FL recordings were different for three segments with the reservoir empty or full (Fig. 7).

The recording technique was reproducible and the variations measured were within an expected range in all intestinal segments in both animals. The differences recorded for MCP and FL for a full and empty reservoir between the plicated and other segments (tapered, intussuscepted) were statistically significant ($P < 0.0001$). All three mechanisms were catheterizable. Again, the tapered segment presented the most difficulty for this manoeuver. The catheter was occasionally held up by one of the sutures in the middle third of the reservoir. This difficulty did not occur with the intussuscepted and plicated segments. The required surgical technique was necessarily more meticulous and longer (approx. 45 min) with the tapered segment as compared to the intussuscepted and plicated segments (approx. 20 min).

Discussion

The outstanding contribution of Kock has revived interest in the use of a bowel reservoir attached to a continent stoma for bladder replacement [7]. The intussuscepted bowel segment, most commonly utilized in the past for prevention of both reflux and incontinence, presents a variety of drawbacks in many surgeons' hands. The main problems associated with this technique have been the complexity of its construction, the necessity to utilize non-absorbable staples and the requirement to devascularize a portion of bowel for the nipple construction. Possible long term complications include stone formation and the loss of the intussusception. Other authors have reported success utilizing plicating, tapering and infolding bowel techniques [1, 2, 5, 6, 8, 9, 11]. Complications inherent in these techniques include late failures resulting in urinary incontinence and possible difficulties in catheterization. Except for Benchenkroun's [2] and Guzman's [5] techniques, the others utilize a reinforced ileo-cecal valve as an anti-incontinence mechanism.

Our experimental use of the three described bowel segments demonstrated that all methods require a careful surgical technique, but this was more time consuming when performing intestinal tapering. Preliminary results were similar since all methods were successful in preventing urinary incontinence during a short observation period. All segments are catheterizable, but with much greater difficulty in the tapered bowel segment. Creation of an irregular inner bowel lumen seemed to impair catheter passage. This drawback might be minimized utilizing stapling techniques [1]. Plicating a bowel segment increases resistance, but at the same time allows easy catheterization. It seems that despite the presence of plicating sutures, there is still some bowel segment distensibility and a smooth inner lumen which allows catheterization. We have not encountered difficulty with catheterization among our patients undergoing an intestinal plication to prevent urinary incontinence [10].

The plicated bowel segment in our experimental animal presented higher closure pressures as compared to the intussuscepted and tapered preparations and all were continent. This varies from Yalla's model that showed plicated systems in dogs to be suboptimal in continence efficiency when compared with ileal intussusceptions [13]. Since we found statistically significant higher closure pressures with both the plicated and tapered segments than with the intussuscepted ones, we feel that the difference is related to a difference in surgical technique.

The plicated bowel technique presented in our experimental animal provides higher MCP and FL with a full and empty reservoir as compared to other segments. Closure pressures were higher with the reservoir full than when it was empty; this was also observed clinically [10]. The recording technique was reproducible and the variations measured were within an expected range in all intestinal segments and in both animals. In the plicated and tapered segments, we obtained longer FLs than the measured length of excised bowel. The explanation for this difference in length includes: a possible "stretching factor" in these segments, since they are closed longitudinally and are probably lengthened; it is also possible that the reservoir wall contributed to some of the pressure determinations. The above phenomenon was not observed with the intussuscepted segment, which was considerably shorter. As with Yallas' results, the efficiency of continence was not altered by the FL of the segment [13]. Despite their urodynamic differences, the three segments were demonstrated to be effective in preventing incontinence in our short term experimental observations.

The surgical technique for plicating the bowel wall to partially occlude its lumen causes minimal interference with its blood supply. Intestinal intussusception causes some venous impairment at the base of the nipple, while the bowel excision technique (tapering) requires extensive interruption of the intestines blood supply. The latter two techniques might result in fibrosis on a long term basis, thus interfering with the ease of reservoir catheterization.

The higher MCPs and FLs obtained in our model with the plicated bowel segment plus the simplicity of its construction and the relatively minor vascular compromise make it an attractive alternative for use in creating a continent urinary diversion. In clinical situations, continence may be enhanced by interposition of the ileo-cecal valve.

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