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The Results of Pouch Surgery after Ileo-Anal Anastomosis for Inflammatory Bowel Disease: The Manometric Assessment of Pouch Continence and its Reservoir Function

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Anal sphincter function after restorative proctocolectomy has mainly been investigated by anal manometry. A significant decrease of basal pressure up to 45%, has been recorded postoperatively, possibly due to sphincter stretch during endoanal mucosectomy. Both abdominal mucosectomy and anastomosis at the level of the anorectal ring have been reported to prevent anal sphincter damage and lead to better continence. The striated sphincter is not significantly affected by the surgical procedure. Pouch-anal inhibitory reflex is partly maintained in the presence of a rectal cuff which leaves the ganglionic plexus unaltered; a satisfactory continence is also retained in the absence of the reflex when the rectum is totally excised.

Pouch capacity, compliance and motility have been investigated by endoluminal balloon and probes. Pouch emptying has been studied by a "porridge" test, by a semi-solid medium labelled with technetium-99, and by other methods. A more effective storage function is achieved by large capacity reservoirs which lower the bowel frequency. The motor response to pouch distension, to a meal, and to pharmacological stimuli is usually counteracted by sphincter contraction. Ileal hypermotility may lead to fecal leakage mainly in the presence of weak sphincters. Poor pouch emptying may be related to an anal stricture.

An important aim of restorative proctocolectomy with an ileo-anal reservoir is to maintain anal continence. Anal manometry, alone or in combination with sphincter electromyography (EMG), has been used in many laboratories as the method of choice [1]. Preoperatively, such investigations permit better selection of the patients suitable for this operation, i.e., those with intact anal sphincters able to effectively counteract the peristaltic drive of the terminal ileum. After surgery anal manometry and pouch motility studies, including EMG of the terminal ileum, correlate with clinical outcome in terms of both fecal continence and bowel frequency [2]. Either microballoon and open-tip catheters or more sophisticated strain-gauge and microtransducers have been used for manometric purposes [3]. Video-proctography, scintigraphy, and simpler evacuation tests have been performed to evaluate the emptying of the ileal reservoir [4]. Its capacity and compliance has been investigated in different pouch designs.

The present article deals with studies carried out by the author during the last 10 years at St Mark's Hospital, London and at the Policlinico Gemelli of Rome and includes recent unpublished data on a modified S-pouch. It reports briefly the experience of the Italian Registry with ileo-reservoir. Several controversial points will be reviewed such as the factors affecting anal continence after restorative proctocolectomy and the surgical modifications of the original technique, most importantly their effects on postoperative bowel and sphincter function.

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Anal Sphincter Function

Anal sphincter function has mainly been investigated by means of anal manometry using simple fine probes carrying either small latex balloons or open-ended perfused catheters attached to a pressure transducer and connected to a polygraph via an amplifier system [1]. More complex rigid polyglass cylindrical probes with four peripheral perfusion channels 90° apart, each ending in a side port, allowing a simultaneous four quadrant measurement of anal sphincter pressure changes, have also been described [5]. This radial pressure measurement gave marked differences, both in resting tone (range 18–59 H_2O) and in voluntary contraction (range 63–126 H_2O) among the various quadrants of the anal canal, the lowest values being recorded anteriorly. Others [6] have used more sophisticated microtransducers, the advantages being the small diameter (1.67 mm) of the probe causes less dilatation of the sphincter, and the possibility of measuring not only the resting tone and squeeze pressure, but also the area of the high pressure one. Anal sphincter function decreases with age [7], thus explaining the risk of incontinence in pouch patients over 50 years of age.

Resting Tone

At rest when a 0.3 cm diameter pressure recording probe is used in subjects without anal pathology, 30% of the maximal anal basal pressure is made up by striated sphincter tonic activity, 45% of it is due to nerve-induced internal sphincter activity, 10% to purely myogenic internal sphincter activity, and 15%

Table 1. Soiling and anal manometry in 156 pts reported by the Italian Registry: Factors affecting continence after ileo-anal reservoir.

Factor	Soiling		Manometry (mm Hg)			
	No. of pts. (%)		RT		VC	
Length of follow-up						
<1 yr (n = 98)	33 (34)		41 ± 12	n.s.	100 ± 36	$p < 0.02$
>1 yr (n = 58)	12 (21)		43 ± 23		141 ± 60	
Bowel frequency						
<5/24 hr (n = 108)	22 (20)	$p < 0.01$	47 ± 19	n.s.	120 ± 57	n.s.
≥5/24 hr (n = 48)	23 (48)		42 ± 16		103 ± 36	
Pouchitis						
Present (n = 18)	9 (50)	$p < 0.05$	50 ± 19	n.s.	120 ± 20	n.s.
Absent (n = 138)	36 (26)		46 ± 19		116 ± 57	

RT: Resting tone; VC: Voluntary contraction; n.s.: Not significant.

can be attributed to the expansion of the hemorrhoidal plexuses [8].

Pre-operative resting tone (RT) was usually within the normal range, but most authors have recorded an early drop in basal pressure following restorative proctocolectomy [1, 9–13]. In some series RT decreased to 40–45% of the preoperative value [13–15]. The decrease in RT after restorative proctocolectomy has been attributed either to the stretching of the internal sphincter during endoanal mucosectomy [1, 16] or to the division of the intramural nerve plexus in the proximal anal canal, interfering with internal sphincter reflex function [17]. This decrease in RT has also been attributed by Sharp and coworkers [13] to stripping of the internal sphincter muscle fibers during mucosectomy and the fibrosis either of the rectal cuff or of the reservoir spout. According to Keighley [12], high RT is recorded after abdominal mucosectomy which eliminates any traction on the sphincter muscle. Lavery and associates [18] reported the same finding after stapled anastomosis at the level of the anorectal ring without mucosectomy. Both authors reported an improved postoperative continence by this technique; similar clinical findings are reported by Heald and Allen [19]. Miller and colleagues [20] demonstrated an improved sensation in those patients with a preserved anal transitional zone. Functional results were not significantly improved, although there was a trend towards improved continence and discrimination in those with the most anal transitional zone preserved. Different results were reported by others [21] assessing anal sensation using a constant current stimulator in two groups of patients; patients whose anal transition zone had been excised still retained the ability to discriminate and did not have an increased risk of impaired continence. Larger series and prospective randomized studies are needed to reach conclusive results on this point. The decrease was usually associated with a disordered continence and a recovery of RT with an improvement of function was recorded within a year by most authors. Lindquist [6] did not find any correlation between decreased RT and soiling; 62% of the patients with postoperative soiling investigated by the author at St Mark's Hospital [1] showed a good RT at manometry. An inflamed or strictured efferent limb of the S pouch might have caused the symptoms. Ileal hypermotility and low reservoir capacity may also be responsible for postoperative soiling in these patients [22]. An ultraslow wave activity in the anal canal, not related to continence, with a frequency of 1.04 ± 0.25 cpm was found by O'Connell [5].

Voluntary Contraction

Voluntary contraction (VC) is accomplished by the striated sphincter and is recorded as a "squeeze pressure" in the anal canal at manometry. VC is recorded less commonly by means of sphincter EMG as it is difficult to quantify precisely and requires insertion of a needle which causes anal discomfort. Moreover, the theoretical risk may exist of causing a perianal abscess in a patient with an ileo-anal anastomosis. VC is not usually affected by the pouch procedure and its postoperative decrease, when recorded [14], is not usually statistically significant and still gives values within the normal range [1]. A significant increase of VC 1 year following ileo-anal reservoir surgery has been reported by the Italian Registry [23]. The data are shown in Table 1.

Pezim [24] advocates Caesarian section for childbirth in patients with an ileo-anal reservoir to reduce the risk of sphincter stretching in vaginal delivery. Caesarian section is not advocated by Metcalf and coworkers [25] on the basis of the experience at the Mayo Clinic that ileo-anal pouch anastomosis is compatible with normal childbearing and that the route of delivery should be individualized.

Pouch-Anal Inhibitory Reflex

As shown in Table 2, the reflex inhibitory response of the internal sphincter to the distension of the pouch has been controversial. Some investigators could detect a relaxation in the internal anal sphincter in almost half of the patients [1, 13, 18], whereas many others recorded this event more rarely [6, 15, 26] or not at all [27, 28]. The reason for this discrepancy may be related either to the different interpretation of the baseline deflection on the manometry tracings or to different ways of stimulating the rectum when eliciting the reflex. But a more consistent reason is related to the surgical technique: the presence of a rectal cuff does not interrupt the ganglionic plexus, which is the anatomical basis of the reflex and this is the case in some series [29, 31]. On the other hand, the permanence of the inhibitory reflex does not seem to be associated with a better or worse degree or postoperative continence.

Pouch Capacity and Emptying

Pouch capacity has been recorded using a balloon mounted on a catheter inserted transanally into the pouch. By gradually

Table 2. Bowel frequency, anal continence and pouch-anal manometry after restorative proctocolectomy and ileo-anal reservoir as reported in the literature.

Author, year (reference)	No. of pts.	Follow-up (mos)	Diagnosis	Pouch type	Bowel frequency (24 hr)	Soiling (%)		Manometry			
						Minor	Major	RT	VC	PV	PAIR
Nicholls et al., 1981 (10)	14	>6	UC, FP	S	3.7	0	50	37/79	106	M 330	63
Neal et al., 1982 (47)	10	>4	UC, FP	J, S	5	0	20	56		M 423	25
Taylor et al., 1983 (22)	14	8	UC, FP	J	7	43	43	68	142	M 278	36
Pescatori and Parks, 1984 (1)	50	20	UC, FP	S	3.7	2	12	65	128	M 450	52
Becker, 1984 (31)	21	2	UC, FP	J	6.2	0	some	68[b]	100[b]		95
Grant et al., 1986 (27)	20	>6	UC	J, S	4.3	1	11	66[b]	173[b]		0
Stryker et al., 1986 (26)	20	4	UC	J		0	35	68[b]	176[a]	M 382	5
Smith and Sircus, 1987 (9)	10	12	UC	J, S	2–6	0	20	70	130	F 220	
Citone et al., 1987 (11)	6	12	UC, FP	J	2–4	0	0	60	192		50
Sharp et al., 1987 (13)	30	1	UC	S				43[b]	163[b]		41
Johnston et al., 1987 (17)[a]	12	3	UC	J, S		0	10	70	146		
Fiorentini et al., 1987 (28)	8	6	UC, FP	J	2–5	0	12	36[b]	87[b]	F 241	0
Keighley, 1987 (12)[a]	22	>5	UC, FP C	J	6.1	0	10	81	168	M 287	
O'Connell et al., 1988 (5)	38	22	UC, FP C	J, S		0	44	59[b]	114[b]		4
Oresland et al., 1988 (14)	40	1	UC	J	7.1	0	33	50[b]	170[b]	F 220	
Luukkonen, 1988 (15)	20	12	UC	J	5.1	0	60	46	96	M 338	15
Lavery et al., 1989 (18)[a]	15	>3	UC	J		0	0	81[b]			50
Hatakejama et al., 1989 (48)	16	6	UC, FP	W		0	12	57			
Chaussade et al., 1989 (44)	18	6	UC, FP	J	5.3	4	0	47	136	M 270	
Slors et al., 1989 (49)	20		UC, FP	B	6–8	7	7	60	192		50
Kock et al., 1989 (50)	6	12	UC	K	4	0	0	55	160	M 550	
Miller et al., 1990 (20)[a]	22	>9	UC		5.5	0	7	62			
Lindquist, 1990 (6)	55	12	UC	J			31	68		M 330	13
Italian Registry, 1990 (23)	156	12	UC, FP C	J, S, W	4.2	2	27	43[b]	141[b]		

[a]Anal transitional zone preserved

[b]mm Hg

UC = Ulcerative colitis; FP: Familial polyposis; C: Constipation; K: Kock's reservoir; RT: mean resting tone in the anal canal; VC: Voluntary contraction (cm H_2O); PV: Maximal (M) or functional (F) pouch volume (mean); PAIR: pouch-anal inhibitory reflex (% positive responses).

inflating the balloon with water in defined volume increments, a volume is reached which produces the onset of threshold sensation, i.e., functional volume and subsequently a volume which causes discomfort or painful urgency, i.e., maximal tolerable volume [1]. This phenomenon confirms that the receptors for normal rectal sensation do not lie in the rectal mucosa but in the levator ani on which the pouch invariably lies. Compliance is measured simultaneously by recording the intraluminal pressure of the reservoir at each volume increment. An inverse relationship between reservoir volume and frequency was found examining three different reservoir designs: S, J, and W [32]. Mean intra-operative reservoir volumes were 177 ± 64 ml, 172 ± 58 ml, and 325 ± 37 ml, and volumes after the ileostomy closure were 416 ± 176 ml, 197 ± 69 ml, and 322 ± 33 ml, respectively. J reservoir was significantly smaller and led to a bowel frequency of 5.5 ± 1.6/24 hr compared with S

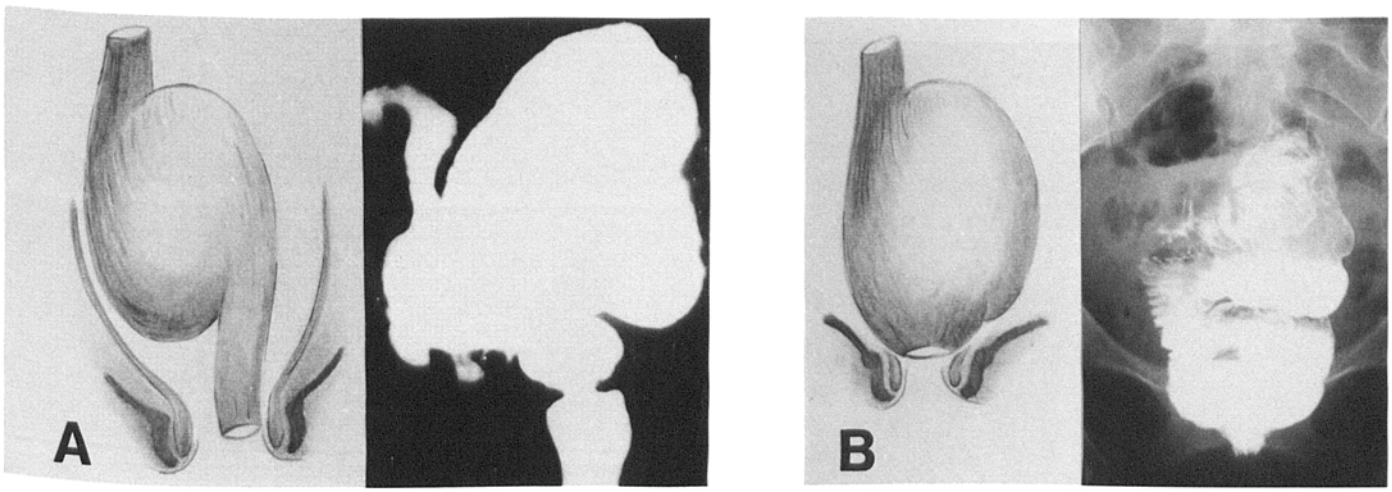

Fig. 1. Modifications of S pouch designs over the last decade. **A.** Illustration and pouchography of the original S pouch, with a long rectal cuff and a long efferent limb. A spasm of the efferent limb is clearly detectable at x-ray. Emptying is more difficult and the efferent loop may angulate, impairing anal continence. With a long rectal cuff a pelvic abscess is more likely to occur. The use of the anal retractor for a longer period of time is required to perform the extended mucosectomy, overstretching the sphincters, decreasing resting tone in the anal canal, and impairing continence. **B.** Current S pouch design, without efferent limb. A side-to-end suture between the reservoir and the anal canal is performed, as in the J and W pouch. Pouch capacity is still large and emptying is easier, as shown in the x-ray, because the pouch outlet is unlikely to be obstructed. Manometry data are listed in Table 3.

pouch bowel frequency of 3.7 ± 1.6/24 hr, and W pouch bowel frequency of 4.1 ± 1.3/24 hr. Functional and maximal pouch volumes, as recorded by different authors, are listed in Table 2.

Pouch emptying may be studied by different methods: defecating pouchography [16], video-"procto"graphy [4], evacuation of a porridge simulating stool [33], mathematical calculations [34], semi-solid radionuclide enema [35], and others [36]. Evacuating pouchography performed at St Mark's Hospital showed that an angulated long efferent loop was the main cause in delaying S-pouch emptying; therefore, a shorter loop was adopted to avoid the need for self-catheterization. More recently the authors of the present article reported a modification of the S pouch [37] in which the efferent limb was absent and a latero-terminal anastomosis was directly performed between the pouch and the anal canal, as in J and W pouches. The diagram of the modified S pouch is shown in Figure 1 and the early functional results are shown in Figure 2 and Table 3. The absence of the efferent limb allows better emptying, as assessed by video-"procto"graphy (unpublished observations).

Video-"procto"graphy studies, performed by others [4], showed that emptying did not influence either the frequency of defecation or patient soiling rate; the only factor that was consistently associated with poor pouch emptying was the presence of an anal stricture. Heppel and associates [35] measured emptying with instillation per anus of a semi-solid medium labelled with 1.0 mCi of technetium-99. Ileal pouch counts were measured using a scintillation camera before and after spontaneous evacuation via a computerized method. Emptying of the pouches was less efficient than a normal rectum. No correlation was established between age, sex, stool frequency, pouchitis, and the efficacy of emptying. Attempts have been made by Oresland and colleagues [14] to increase the pouch volume by inflating an intraluminal balloon in order to improve function. Both pouch inflations and anal sphincter did not improve bowel frequency and continence.

Pouch Motility

Myoelectric and motor patterns of both reservoir and efferent limb were analyzed by the author [2] under basal conditions during mechanical distension after feeding and pharmacological stimuli in a group of patients between 1 and 58 months after the construction of a Parks' S pouch (Fig. 1). The recordings were carried out using a probe with three sets of bipolar electrodes and three open-ended perfused catheters, as shown in Fig. 3. Ileal motility was recorded during fasting and Phase I, II, and III of the inter-digestive migrating complex clearly observed in some cases. The tracing showed periodic bursts of fast electrical activity with a frequency of 9 cycles per minute in most patients. The spikes were superimposed on electrical slow waves, as reported by Alwary and coworkers [38] in the continent ileostomy and preceded the onset of pressure waves. The volume necessary to produce a response in the reservoir was approximately 10 times than needed to produce the same effect in the ileostomies. In our experience, wide propulsive waves propagated from the pouch to its distal limb and causing urgency were observed in response to the intraluminal distention and instillation of a laxative, as shown in Figure 3. Neostigmine clearly enhanced both electrical and motor activity. The author and coworkers recently analyzed the motor pattern in the modified S pouch, i.e., without efferent limb (Table 3). Figure 2 shows a typical basal tracing from a panel and the response to a meal.

According to Rabau and coworkers [39], the reservoir behaves as a capacitance organ with the ability to distend without contraction before a reasonable volume has accumulated within it. When it does contract, it initiates a sensation of impending evacuation and the anal sphincter is voluntarily contracted until the pressure wave passes. This serves to avoid the discharge of pouch content until it is convenient to allow evacuation to occur.

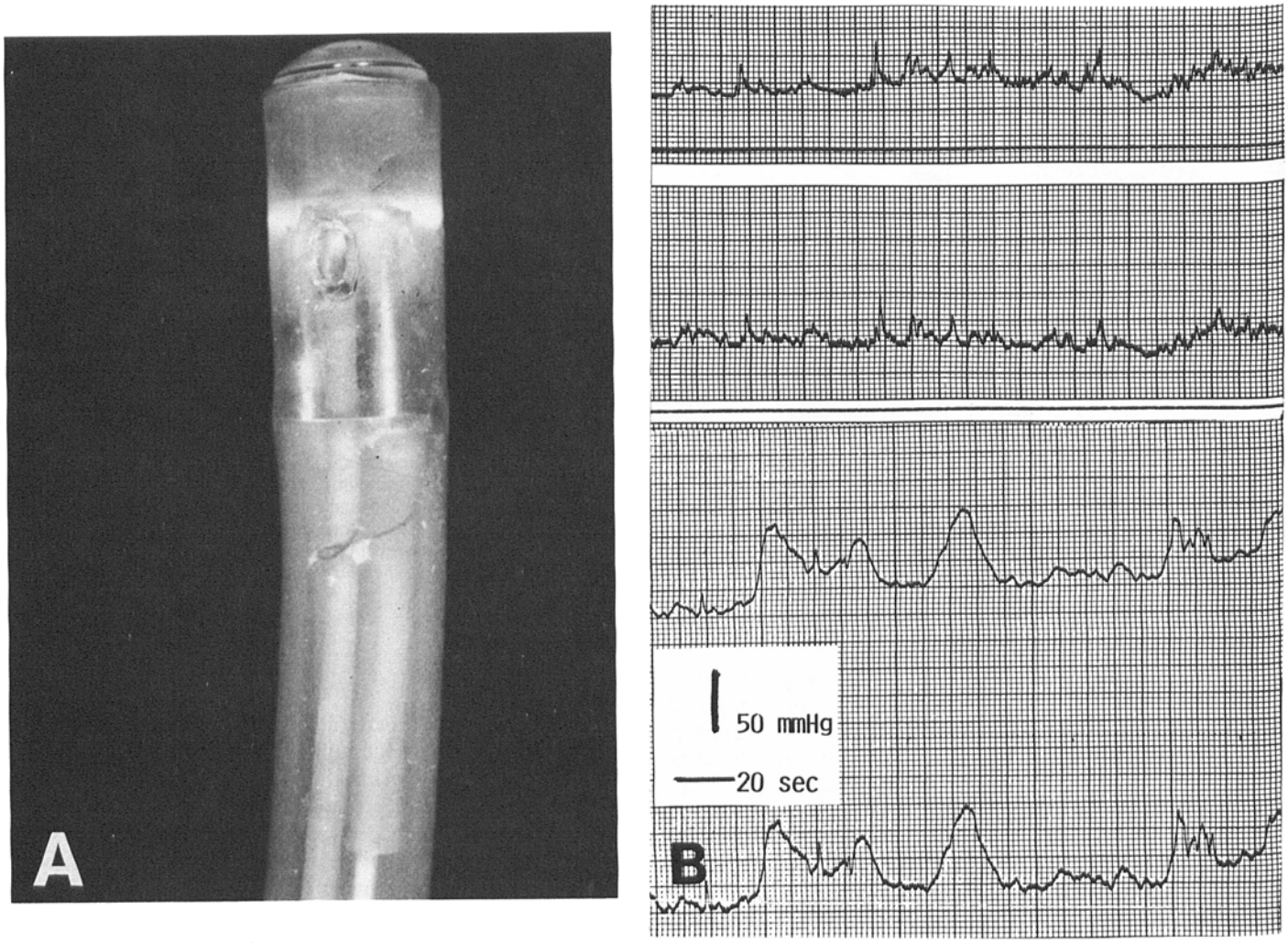

Fig. 2. Ileal manometry of the author's modified S pouch, without efferent limb. **A.** The top of the recording perspex and rubber probe showing the open-tip perfused catheter for the intraluminal pressure recording. **B.** Intraluminal pressures under basal conditions (top two tracings) and after a meal (bottom two tracings). The post-prandial motor response, i.e., gastro-ileal reflex, is clearly detectable.

Table 3. Postoperative soiling and S reservoir design following restorative proctocolectomy for ulcerative colitis.

Clinical characteristic	Standard S pouch[a] (n = 6)	Modified S pouch[b] (n = 4)
Age (range) (yrs)	42 (14–59)	25 (22–27)
Follow-up (range) (mos)	43 (20–67)	11 (5–15)
Bowel frequency/24 hrs	4.8 ± 2.7	3.5 ± 1.7
p.o. soiling (n)	2	1
Pouch volume (ml)	255 ± 72	268 ± 94
Sphincter tone (mm Hg)	29 ± 11	31 ± 5

[a]With a short efferent limb.
[b]Without efferent limb, as shown in Figure 1 B.

Motility of the jejunum was also analyzed in pelvic pouch patients [40]. The migrating motor complex remains unchanged and bacterial overgrowth is rare. In the post-prandial state, the occurrence of discrete ileal clustered contractions suggest that ileo-anal anastomosis may cause a partial obstruction of the small bowel.

Taylor and associates [22] correlated the motor pattern of the pouch, its capacity, and the results of anal sphincter manometry with the clinical outcome in terms of fecal continence. Each patient with a poor result had at least one, and sometimes more, motor abnormalities which could explain their problems, e.g., in one patient with effective sphincters and a large neorectum, a hypercontractile distal ileum appeared to be the anomaly responsible for a poor clinical result.

Pre-operative study of both small bowel motility (barium follow-through, breath tests, radiopaque markers, ileal EMG, and manometry) ascertains good sphincter function (anal manometry, sphincter EMG) together with the construction of a large capacity pouch (Kock S and W reservoirs or J pouch with long loops), seems advisable to minimize the risk of a disordered continence after restorative proctocolectomy. Stryker and colleagues [26] investigating reservoir and rectal filling in a group of pouch patients and in healthy volunteers, found that patients with poor results had rapid filling of their ileal pouches. Therefore, rapid pouch filling and impaired pouch evacuation

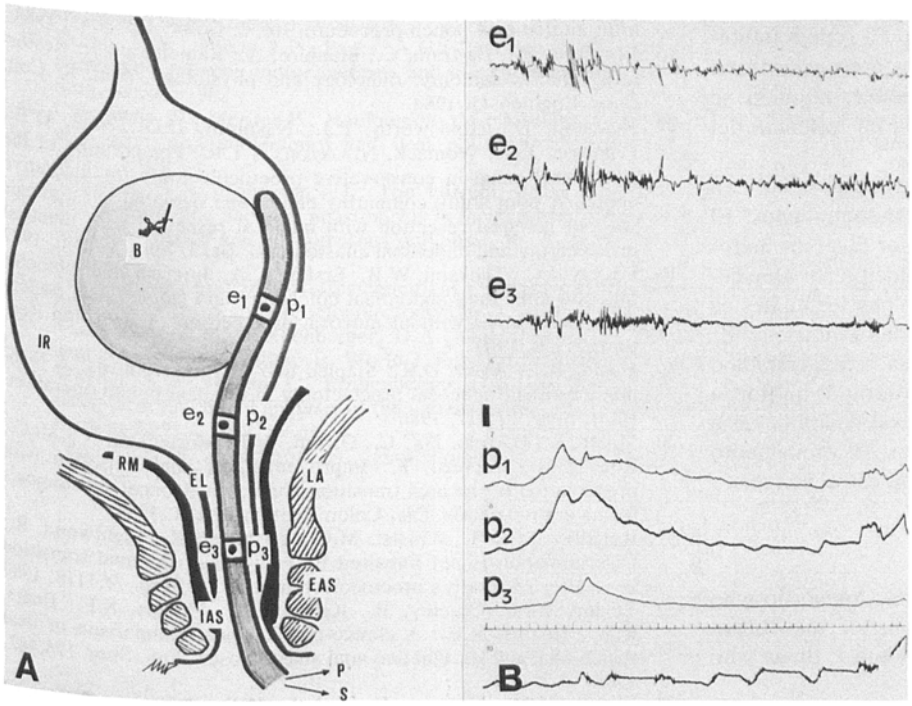

Fig. 3. Technique for pouch manometry and electromyography. **A.** Recording probe and anatomy after surgery. B: Stimulating balloon; IR: Ileal Reservoir; e_1, e_2, e_3: Bipolar ring electrodes; p_1, p_2, p_3: Pressure catheters; EL: Efferent limb; RM: Rectal muscle; IAS: Internal anal sphincter; EAS: External anal sphincter; LA: Levator ani; P and S: Polygraph and suction. **B.** Response to distension. e tracings: Electrical activity; p tracings: Motor activity; bottom line: Pneumogram. Vertical bar means 0.5 mV refer to electrical activity, 10 cm of water refer to intra luminal pressure. Time is expressed in seconds. Long electrical spike bursts propagate from reservoir to efferent limb when the pouch is maximally distended by an inflated balloon. The corresponding motor pattern is represented by a change from smaller segmental to large propulsive contractions not associated with urgency or leakage. Reprinted with permission of publisher [2].

can also promote increased stool frequency in patients after ileal pouch-anal anastomosis.

Conclusion

The function of ileo-anal reservoirs and of their adjacent sphincter apparatus has been widely investigated in the last 10 years by means of simple and sophisticated procedures. Anal continence, together with the complete excision of the diseased large bowel, is the goal of restorative proctocolectomy. This aim is often, but not always, achieved by surgeons [41–43]. The large amount of data obtained from physiological studies has helped to decrease the soiling rate by 9%, according to Wexner and coworkers [44], by modifying the operative technique, e.g., completely excising the rectum by the abdominal route in order to prevent prolonged sphincter stretch due to a long mucosectomy [45], constructing the anastomosis at the level of the ano-rectal ring using a stapling technique, and avoiding endo-anal sutures [18, 19, 46] to enlarge the capacity of the reservoir and to facilitate emptying by removing an angulated efferent limb in the S pouch [16, 37].

Moreover, a better knowledge of the causes related either to a disordered postoperative continence or to a high bowel frequency suggests adopting pre-operative physiology studies as a means of selecting the patients for whom this kind of operation is suitable, thus minimizing the risk of a functional failure.

Résumé

On a évalué par manométrie anale la fonction sphinctérienne après coloprotectomie avec rétablissement de continuité. En post-opératoire, on enregistre une baisse de la pression de base de 45%, probablement due à l'étirement du sphincter pendant la mucosectomie endoanale. La mucosectomie par voie abdominale et l'anastomose au niveau de la ligne pectinée sont deux gestes reputés pour éviter le traumatisme du sphincter et pour améliorer la continence post-opératoire. Le sphincter strié, par contre, n'est normalement pas beaucoup touché par cette opération. Le réflexe inhibitoire réservoir-anus est maintenu car le plexus ganglionnaire du manchon rectal reste intact. La continence est bonne malgré l'absence du circuit réflexe due à l'exérèse rectale. La capacité du réservoir, la compliance et la mobilité rectales ont été étudiées par ballonnets et sondes endocavitaires. La vidange du réservoir a été étudiée notamment par le test au "porridge" et par l'évacuation aux radionucléides semi-solides au Technetium 99. On améliore la fonction de réservoir en augmentant le volume du réservoir, ce qui diminue la fréquence des selles. La réponse motrice à la distension due réservoir, aux repas et aux stimulations pharmacologiques va souvent de pair avec une contraction sphinctérienne. L'hypercinétique iléale peut être responsable d'une incontinence, surtout lorsque le muscle sphinctérien est faible. La mauvaise vidange est parfois en rapport avec une sténose au niveau de l'anastomose anale.

Resumen

La función del esfínter anal luego de proctocolectomía restaurativa ha sido investigada mediante manometría anal principalmente. Una disminución significativa de la presión basal, hasta de 45%, ha sido registrado en el postoperatorio, posiblemente debido al estiramiento del esfínter durante la mucosectomía endoanal. Tanto la mucosectomía abdominal como la anastomosis al nivel del anillo ano-rectal han sido acreditados en la prevención del daño del esfínter, lo cual significa mejor conti-

nencia. El efínter "hiperstirado" no resulta afectado en forma significativa por el procedimiento quirúrgico. El reflejo inhibitorio bolsa-anal se mantiene parcialmente en presencia de un mango rectal que no altera el plejo ganglionar; también se retiene un grado satisfactorio de continencia en ausencia del reflejo cuando se reseca totalmente el recto.

La capacidad de la bolsa, su compliancia y su motilidad han sido estudiados mediante balones y sondas endoluminales. El vaciamiento de la bolsa ha sido investigado por diversos métodos. Es eviednte que se logra una mejor función de almacenamiento con reservorios de gran capacidad, con los cuales se observa una disminución de la frecuencia de las evacuaciones. La respuesta motora a la distensión de la bolsa, a una comida o a estímulos farmacológicos es usualmente contrapuesta por la contracción del esfínter. La hipermotilidad ileal puede llevar a escape fecal en presencia de esfínteres débiles. El vaciamiento pobre de la bolsa puede estar relacionado con estrechez anal.

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