Coordinated Activity of the New "Rectum" and Anal Sphincter After Sphincter-Saving Resection of the Rectum for Colitis or Carcinoma

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PURPOSE: The aim of this study was to determine whether coordinated activity exists across a stapled enteroanal anastomosis. METHODS: Twenty-nine patients were studied for a median of one year after complete excision of the rectum and stapled enteroanal anastomosis; 12 patients underwent low anterior resection with coloanal anastomosis for carcinoma, and 17 patients underwent restorative proctocolectomy with ileoanal anastomosis. RESULTS: Maximum anal resting pressures were slightly lower after coloanal anastomosis than after ileoanal anastomosis [median range, 56 (11-60) cm H_2O, cf 69 (40-107) cm H_2O, P = NS]. During distention of the neorectum, anal sphincter pressures at 2.5, 1.5, and 0.5 cm from the anal verge were significantly lower after coloanal anastomosis compared with after ileoanal anastomosis ($P < 0.01$ at each station). The volume of neorectal distention required to produce maximal inhibition of the anal sphincter was significantly less after coloanal anastomosis at 50 (range, 20-60) ml of air than after ileoanal anastomosis at 240 (range, 100-420) ml of air ($P < 0.01$). Minor fecal leakage and urgency of bowel action were significantly more common after coloanal anastomosis ($P < 0.01$). CONCLUSION: Alterations in the dynamic response of the anal sphincter to distention of the neorectum may explain why the clinical results were better after ileal pouch-anal anastomosis than after coloanal anastomosis. [Key words: Rectal carcinoma; Ulcerative colitis]

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Sphincter-preserving enteroanal surgery is based on the concept that the rectum is not necessary for anal continence provided that the internal anal sphincter, the external anal sphincter, and the skeletal musculature of the pelvic floor are intact and functioning adequately.[1] However, clinical reports that as many as 50 percent of patients suffer from imperfections of anal continence, such as frequent bowel actions, urgent defecation, and minor fecal leakage after rectal excision and coloanal or ileal pouch-anal anastomosis, call this assumption into question or at least suggest that it should be modified.[2, 3] The aim of this study was to investigate whether the activities of the "new" rectum and the anal sphincter are coordinated, by analyzing in detail the dynamic response of the anal sphincter to distention of the neorectum. Our hypothesis was that such coordination of activity between the neorectum and the anal sphincter does exist, in view of the fact that many patients experience an excellent functional result despite loss of the rectum; but that impairment or modification of this integrated activity between neorectum and sphincter may explain why some patients suffer from imperfections of continence after excision of the rectum.

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PATIENTS AND METHODS

Twenty-nine patients were studied. Twelve patients underwent complete excision of the rectum for rectal carcinoma, and 17 patients were studied after restorative proctocolectomy with ileal reservoir (16 quadruplicated[4] and 1 duplicated reservoir[5]) and ileal pouch-anal anastomosis mainly for ulcerative colitis (Table1). One patient who was initially thought to have ulcerative colitis was subsequently proven to have Crohn's disease on histologic examination of the entire colonic specimen. In each patient intestinal continuity was restored by means of a double-stapled anastomosis, using a TA®30 or TA®55 (United States Surgical Corp., Norwalk, CT) to cross-staple and a PREMIUM CEEA™ (U.S. Surgical Corp.) stapling device to fashion an end-to-end anastomosis. None of the patients who underwent rectal excision and coloanal anastomosis had evidence of recurrent carcinoma, and none had received radiotherapy. In the coloanal group, the level of the anastomosis above

Table 1.
Details of the Patients

Group of Patients	Coloanal	Ileoanal
Number of patients	12	17
Age	68 (58–81)	33 (19–62)*
Sex (male)	5	9
Diagnosis		
Carcinoma of rectum	12	0
Ulcerative colitis	0	14
FAP†	0	2
Crohn's disease	0	1
Follow up (mo)	14 (4–96)	12 (3–21)*

* Median (range).
† FAP, familial adenomatous polyposis.

the anal verge (in centimeters) was determined by means of the rigid sigmoidoscope (A cm), the length of the anal high-pressure zone (HPZ) (B cm) by anorectal manometry, and the length of residual rectum was calculated by subtracting B from A. The median height of the anastomosis above the anal canal HPZ in the coloanal group was zero (range, 0–2) cm; thus excision of the rectum seemed to be complete. In the ileoanal group, all patients underwent a double-stapled anastomosis without mucosal stripping, the anastomosis being situated 1.0 to 2.0 cm above the dentate line with the aid of anorectal eversion.[6]

Laboratory Studies

Each patient underwent laboratory studies of anal sphincteric function a median of 13 months after operation (range, 4–96 months). Anal pressure was measured by the station pull-through technique as we described previously.[7] The capacity of the neorectum was measured by gradually inflating a balloon, placed with its lower extremity at least 5 cm from the anal verge, with air, at a rate of 1 ml/sec, until the patient experienced either discomfort or a strong desire to defecate. The rectoanal inhibitory reflex was assessed by measuring the response of the entire length of the anal sphincter at multiple stations to rapid distention of the neorectum with a balloon with increasing volumes of air, beginning with 20 ml, then 50 ml, then 100 ml, and if necessary progressing to larger volumes until the anal sphincter demonstrated maximal inhibition. A 20 percent decrease in pressure was taken to denote a positive reflex.[8] Pressures were measured at the point of maximal inhibition of the anal sphincter (Fig. 1). Anal sensation was tested by measuring threshold electrosensitivity of the anal mucosa by means of a bipolar, constant-current stimulator probe, lubricated with a solution of KY jelly (Johnson and Johnson, Ascot, United Kingdom) and normal saline in equal quantities.[9]

Clinical Assessment of Outcome

The quality of anal continence was assessed clinically by two doctors who questioned each patient about bowel frequency, the ability to defer defecation, anal soreness, and fecal leakage. Significant leakage was defined arbitrarily as leakage that occurred at least once a week and urgency as the inability to defer defecation for more than fifteen minutes.

Statistical Analysis

All grouped data were expressed as median and range. The groups were compared by means of the Mann-Whitney *U* test for unpaired data, and nominal data were analyzed using Fisher's exact probability test.[10]

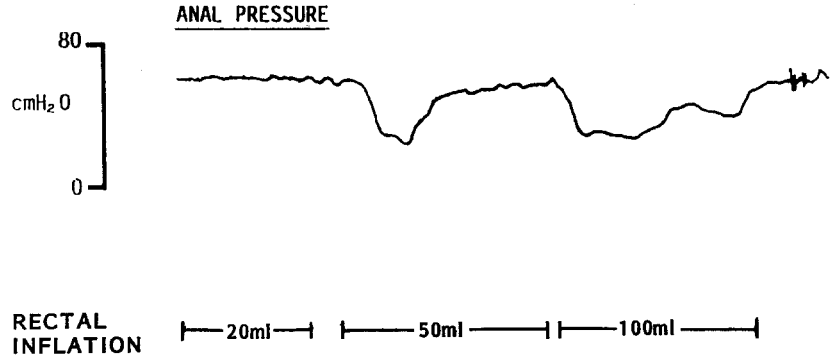

Figure 1. The normal rectoanal inhibitory reflex. Note the graduated response of the anal sphincter, with no decrease in pressure with small volumes of distention (20 ml), a transient drop in pressure with larger volumes of distention (50 ml), and then maximum inhibition of the sphincter, which does not recover until the (neo)rectal distention is released (approximately 100 ml).

RESULTS

Laboratory Tests

Anal Pressure. Median maximum anal resting pressure was 56 cm of water (range, 11–160) in the coloanal group and 69 cm of water (range, 40–107) in the ileal pouch-anal group (P = NS). The median maximum squeeze pressure was 109 cm of water (range, 55–240) in the coloanal group compared with 145 cm of water (range, 84–282) in the ileal pouch-anal group (P = NS; Fig. 2).

Pressure Profile of the Anal Sphincter. The pressure profiles of the anal sphincter in the two groups of patients are shown in Figure 3. The anal HPZ was shorter, with a lower peak pressure, in the coloanal group than in the ileal pouch-anal group, but the difference was statistically significant only in the lower 1 cm of the anal canal ($P < 0.05$).

Sensation in the Anal Canal. The thresholds for sensation did not differ significantly between the groups, as determined by threshold electrosensitivity in the upper, mid, and lower anal canal (Fig. 4).

Maximum Tolerated Volume (Capacity of the Neorectum). Median maximum tolerated volume was 55 ml of air (range, 28–208) in the coloanal group compared with 275 ml of air (range, 170–760) in the ileal pouch-anal group ($P < 0.01$) (Fig. 5).

"Rectoanal" Inhibitory Reflex. The reflex was found to be present in each of 29 patients. The change in pressure profile of the anal sphincter during distention of the neorectum is shown in Figures 6 and 7. During distention of the neorectum, at maximal inhibition the pressures in the lower 3 cm of the anal canal were significantly lower than the pressures measured in the ileal pouch-anal group ($P < 0.01$).

Volume of Distention in Neorectum Required to Produce Maximum Inhibition of the Anal Sphincter. The amount of distention of the neorectum that was required to produce maximal inhibition of the anal sphincter was significantly greater in patients with an ileal pouch-anal anastomosis than in the patients with a coloanal anastomosis ($P < 0.01$) (Fig. 8).

Clinical Results

The functional results were significantly better after ileal pouch-anal anastomosis than after coloanal anastomosis (Table 2). Although bowel frequency was similar in the two groups of patients, urgency of defecation and minor fecal leakage were significantly more common after coloanal anastomosis than after ileal pouch-anal anastomosis ($P < 0.01$).

DISCUSSION

Enteroanal anastomosis to restore intestinal continuity after rectal excision for carcinoma or ulcerative colitis is based on the finding that the presence of the rectum is not a prerequisite for anal continence, provided that the skeletal musculature of the pelvic floor and internal anal sphincter are intact and functioning adequately.[1, 11–14] However, as experience of both operative procedures has increased, it has become clear from the reported incidence of minor problems with continence, in particular frequency and urgency

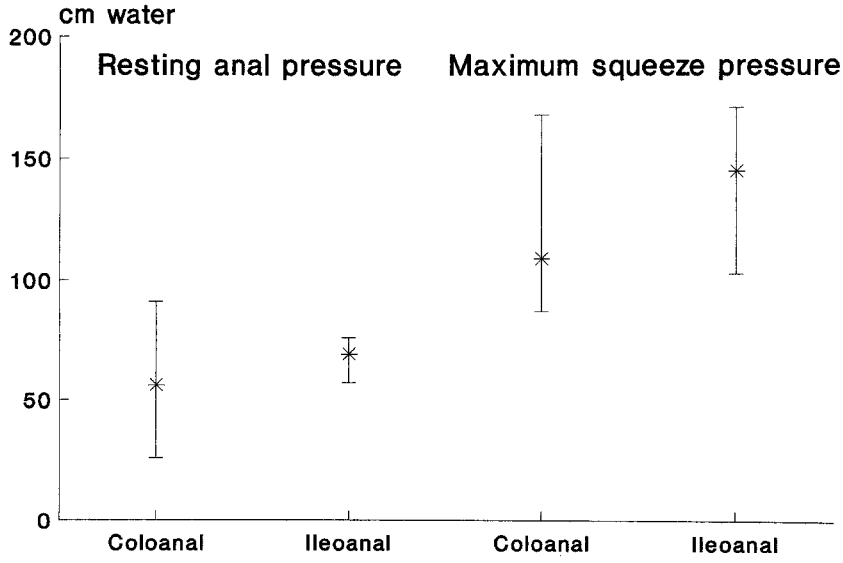

Figure 2. Median maximum anal resting pressures and median maximum squeeze pressures in the two groups of patients (P = NS).

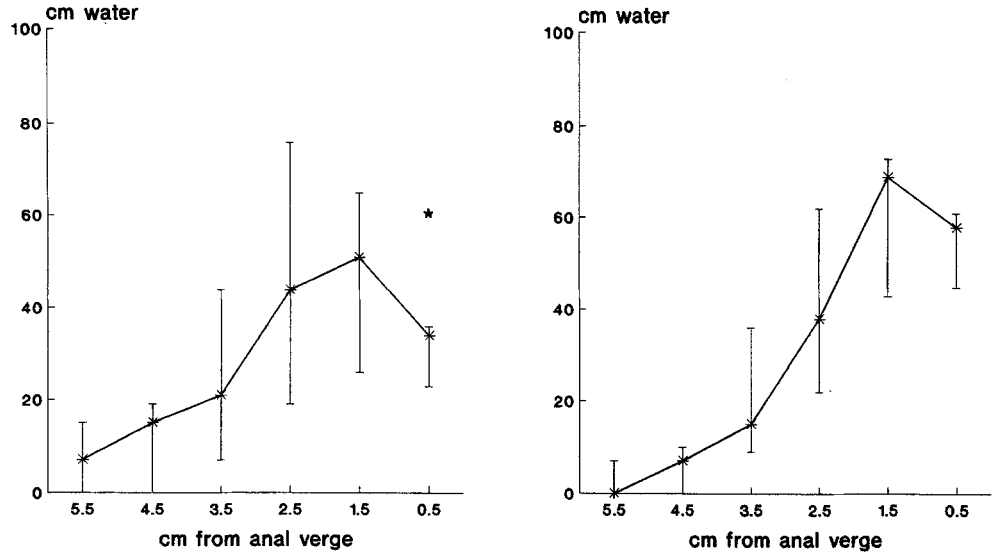

Figure 3. Pressure profiles of the anal sphincter by the pull-through technique in the two groups of patients (*, $P < 0.05$).

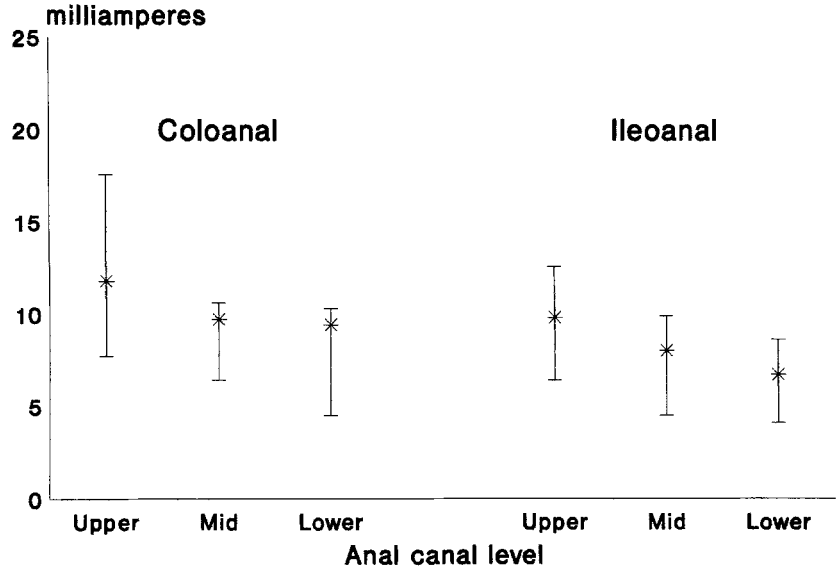

Figure 4. Sensation in the anal canal as determined by threshold electrosensitivity of the mucosa (P = NS).

of defecation and minor fecal leakage, that this assumption may need modification.[2, 3, 15]

Results of this study have again highlighted minor imperfections in anal continence that are suffered by many patients after surgical excision of the rectum. In this study, they were almost entirely confined to patients who had undergone coloanal anastomosis. It could be argued that this was only to be expected in an older group of patients in whom the normal rectal reservoir has been removed. However, each patient in this group enjoyed good anal continence before operation. Although the strength of their anal sphincters was not assessed by manometry before operation, our previous experience in assessing older patients with ulcerative colitis suggests that anal sphincter strength does not deteriorate significantly with age.[16] We would, therefore, expect the coloanal group to have had a normal pressure profile before operation. The type of dissection that is required in the performance of a potentially curative rectal excision for carcinoma is certainly very different from the perimuscular proctectomy that is performed in the course of restorative proctocolectomy for ulcerative colitis; the former may damage and compromise the pelvic autonomic nerves, but the latter seldom does.

Physiologic changes that occur after both low anterior resection and restorative proctocolectomy have been reported previously.[15, 17, 18] The rectoanal inhibitory reflex is a qualitative measure of coordination between the neorectum and anal sphincter. This phe-

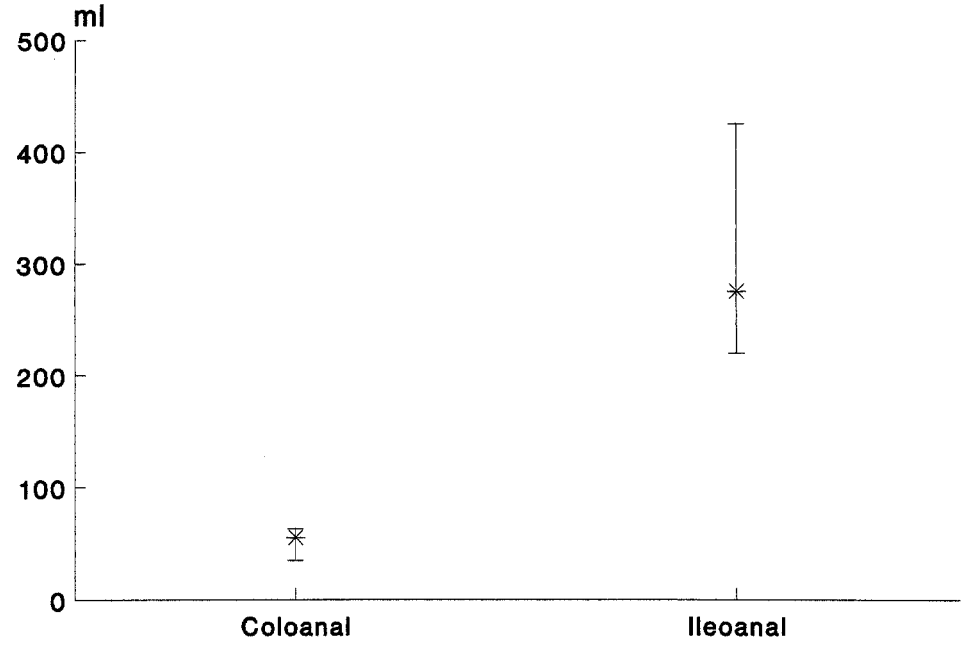

Figure 5. Maximum tolerated volume (capacity of the neorectum) (*, $P < 0.01$).

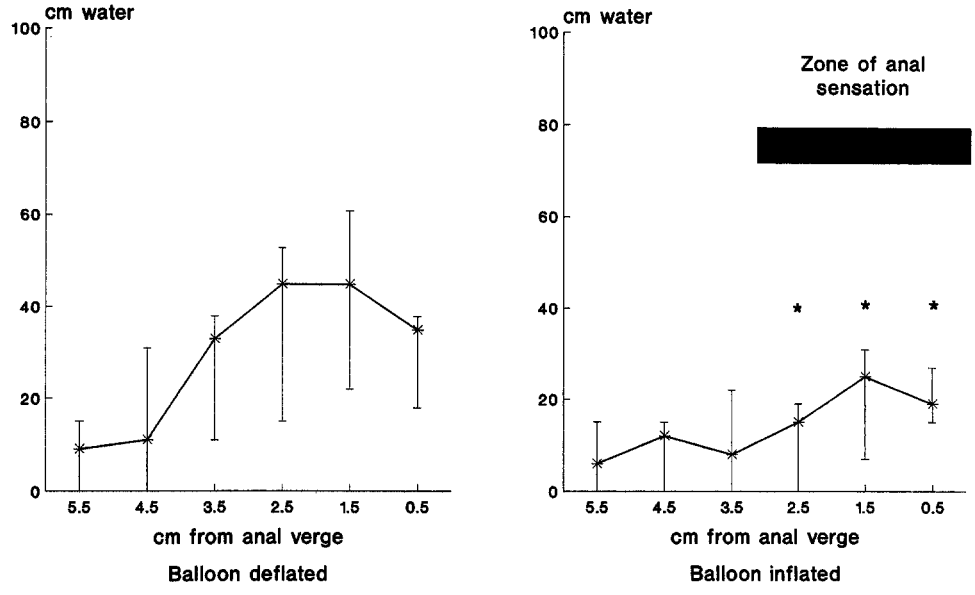

Figure 6. Maximal response of the anal sphincter to distention of the neorectum (colon) after coloanal anastomosis. Note the very low anal pressures in response to inflation of balloon in the neorectum, pressures that are slightly greater than "rectal" pressures. Also the pressures measured in the lower 3 cm of the anal canal were significantly lower than the pressures at the same sites in the ileal pouch-anal anastomosis group ($P < 0.01$) (Fig. 7).

nomenon was first described by Gowers[19] in 1877, and its significance in the fine control of anal continence was investigated further by Bennett and Duthie,[20] who suggested that this reflex may play an important role in enabling the sensitive upper anal canal to "sample" rectal contents when a fecal bolus enters the rectum. It was shown by Lane and Parks[11] that this reflex returns in some patients after surgical excision of the rectum, and we have reported previously on the reflex behavior of the whole anal sphincter to distention of the (neo)rectum after various levels of colorectal anastomosis.[21] However, the character of the response of the anal sphincter or "sampling" to distention of the neorectum after operative procedures in which the rectum is excised and replaced either with colon or an ileal reservoir is unclear. If graduated reflex inhibition of the anal sphincter is lost after such surgery, it is likely that the key to fine control of defecation is also lost.

In this study, both motor power and sensation in

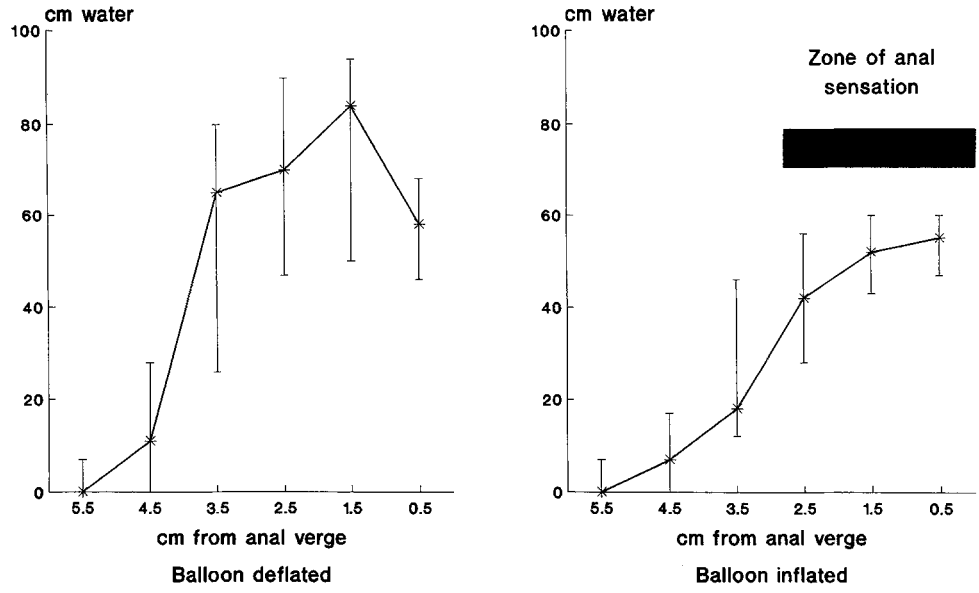

Figure 7. Maximal response of the anal sphincter to distention of the neorectum (the ileal reservoir) after restorative proctocolectomy.

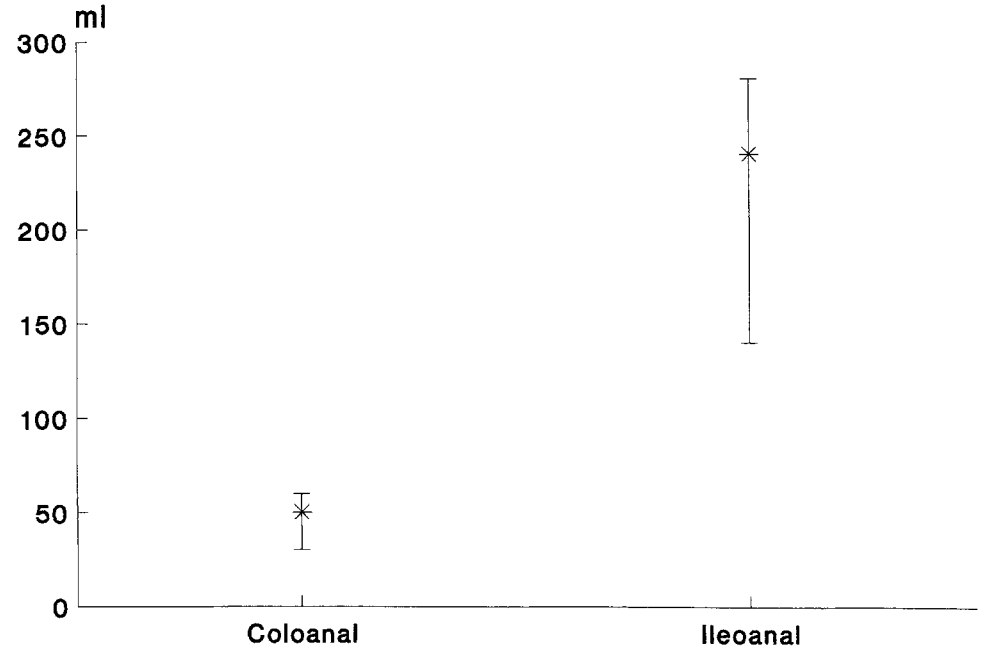

Figure 8. The amount of distention of the neorectum required to elicit maximal inhibition of the anal sphincter (*, $P < 0.01$).

the anal sphincter itself were found to be fairly similar in the two groups of patients. Capacity of the neorectal reservoir, in contrast, was markedly and significantly less in patients after straight coloanal anastomosis than in patients with an ileal reservoir and pouch-anal anastomosis. This finding would be expected from results published by ourselves and other investigators.[4, 15, 17] We showed previously that greater capacity of the neorectal reservoir correlates significantly with improved clinical function, bowel frequency in particular being less in patients with a capacious neorectum than in patients with a neorectum of small capacity.[22] From the findings of this study, however, we think that it is not simply increased reservoir capacity that results clinically in better bowel function but whether coordinated activity exists between a capacious neorectum and the anal sphincter. The unequivocal presence of a rectoanal inhibitory reflex in all of the patients studied here suggests that coordinated activity does exist between

Table 2.
Clinical Results

Group of Patients	Coloanal	Ileoanal
Bowel frequency/24 hr	4.5 (2–12)	5 (2–8)*
Urgency of defecation (X patients)	5	0†
Minor fecal leakage (X patients)	8	1†

* Median (range).
† $P < 0.01$.

neorectum and anal sphincter, but the mere presence of the reflex did not necessarily imply that good anal continence returned, as shown by the fact that no fewer than 8 out of 12 patients had problems with continence after coloanal anastomosis. The dynamic response of the anal sphincter to distention of the neorectum was markedly different in the two groups of patients. After restorative proctocolectomy, the upper part of the anal sphincter underwent more marked relaxation than the lower part of the sphincter, and so a graduated pressure differential was maintained along the length of the anal canal even during maximal reflex inhibition of the sphincter. After coloanal anastomosis, in contrast, the anal sphincter relaxed throughout its length, and the graduated pressure differential was lost almost completely, as illustrated in Figure 6. Moreover, the amount of distention of the neorectum that was required to produce maximal relaxation of the sphincter was significantly lower after coloanal anastomosis (50 ml) than after ileal pouch-anal anastomosis (240 ml).

The clinical, functional results in the two groups of patients were very much as would be expected from the above physiologic findings. Thus, urgency of bowel action and minor fecal leakage were found to be significantly more common after coloanal anastomosis than after ileal pouch-anal anastomosis. However, the degree of leakage was fairly minor in each case, and all of the patients were reasonably satisfied with the functional outcome.

CONCLUSIONS

The assumption that good anal continence can be preserved after complete excision of the rectum, provided the anal sphincter complex remains intact, requires some modification. Many factors act together to govern the quality of anal continence after rectal excision, and the functional outcome varies according to whether the neorectum is reconstructed with normal descending colon or with an ileal reservoir. Some factors militate against the return of normal continence after rectal excision; for example, after coloanal anastomosis, distention of a neorectum, that is colon, of small capacity, above the anal sphincter evokes such a marked degree of reflex inhibition of the whole anal sphincter, together with abolition of the pressure differential, that urgency of defecation and minor fecal leakage become almost inevitable. Because we studied patients one year after surgery, clinical and laboratory findings seem likely to be permanent. In contrast, after restorative proctocolectomy with a pelvic ileal reservoir, not only is the capacity of the rectal substitute greater than after coloanal anastomosis but distention of the neorectum elicits a more "normal" response in the anal sphincter, which may permit "sampling" of the contents of the reservoir. Thus, the reflex function of the anal sphincter appears to change after rectal excision, and the end result clinically may depend on the type of neorectal reservoir constructed. Hence, if a patient presents with low rectal cancer and is found preoperatively on laboratory testing to have a relatively low anal resting pressure, it is likely that this patient will suffer from a poor functional result after low anterior resection; reduced capacity of the neorectal reservoir will in turn influence anal sphincter proprioception, leading to a further decrease in anal sphincter pressure when the neorectum is distended. Such an undesirable sequence of events might be prevented by construction of some form of colonic reservoir[23–26] instead of a straight coloanal anastomosis, in an attempt to increase the capacity and compliance of the new "rectum" after surgery. If construction of such a colopouch is considered inadvisable, then at least the patient might be forewarned of the likelihood of a less-than-perfect functional result.

REFERENCES

1. Parks AG. Benign tumors of the rectum. In: Rob C, Smith R, Morgan CN, eds. Clinical Surgery. Vol 10. London: Butterworths, 1966:541.
2. Karanjia ND, Schache DJ, Heald RJ. Function of the distal rectum after low anterior resection for carcinoma. Br J Surg 1992;79:114–6.
3. Pemberton JH, Kelly KA, Beart RW, Dozois RR, Wolff BG, Ilstrup DM. Ileal pouch-anal anastomosis for chronic ulcerative colitis: long-term results. Ann Surg 1987;206:504–13.
4. Nicholls RJ, Pezim ME. Restorative proctocolectomy with ileal reservoir for ulcerative colitis and familial adenomatous polyposis: a comparison of three reservoir designs. Br J Surg 1985;72:470–4.

5. Utsunomiya J, Iwama T. The J ileal pouch-anal anastomosis: the Japanese experience. In: Dozois RR, ed. Alternatives to conventional ileostomies. Chicago: Year Book Medical Publishers, 1985:371–83.
6. Lewis WG, Holdsworth PJ, Sagar PM, Holmfield JH, Johnston D. Effect of anorectal eversion during restorative proctocolectomy on anal sphincter function. Br J Surg 1993;80:121–3.
7. Johnston D, Holdsworth PJ, Nasmyth DG, *et al.* Preservation of the entire anal canal in conservative proctocolectomy for ulcerative colitis: a pilot study comparing end-to-end ileo-anal anastomosis without mucosal resection with mucosal proctectomy and endo-anal anastomosis. Br J Surg 1987;74:940–4.
8. Keighley MR, Henry MM, Bartolo DC, Mortensen NJ. Anorectal physiology measurement: report of a working party. Br J Surg 1989;76:356–7.
9. Roe AM, Bartolo DC, Mortensen NJ. A new method for assessment of anal sensation in various anorectal disorders. Br J Surg 1986;73:310–2.
10. Cohen L, Holliday M. Statistics for social scientists. London: Harper and Row, 1982.
11. Lane RH, Parks AG. Function of the anal sphincters following colorectal anastomosis. Br J Surg 1977;64: 596–9.
12. Nissen R. Sitzungsberichte aus chirurgichen Gesellschaften Berliner Gesellschaft fur Chirurgie (Offizieller Bericht). Siitzung von 14 Nov. Zentralbl Chir 1932; 60:888.
13. Devine J, Webb R. Resection of the rectal mucosa, colectomy and anal ileostomy with normal continence. Surg Gynecol Obstet 1951;92:437–42.
14. Martin LW, Lecoultre C, Schubert WK. Total colectomy and mucosal proctectomy with preservation of continence in ulcerative colitis. Ann Surg 1977;186:477–80.
15. Nasmyth DG, Johnston D, Godwin PGR, Dixon MF, Smith A, Williams NS. Factors influencing bowel function after ileal pouch-anal anastomosis. Br J Surg 1986; 73:469–73.
16. Lewis WG, Sagar PM, Holdsworth PJ, Axon AT, Johnston D. Restorative proctocolectomy with end to end pouch-anal anastomosis in patients over the age of fifty. Gut 1993;34:948–52.
17. Horgan PG, O'Connell, Shinkwin CA, Kirwan WO. Effect of anterior resection on anal sphincter function. Br J Surg 1989;76:783–6.
18. Nicholls RJ, Belliveau P, Neill M, Wilks M, Tabaquali S. Restorative proctocolectomy with ileal reservoir: a pathophysiological assessment. Gut 1981;22:462–8.
19. Gowers WR. The automatic action of the sphincter ani. Proc R Soc Lond [Biol] 1877;26:77–84.
20. Bennett RC, Duthie HL. The functional importance of the internal anal sphincter. Br J Surg 1964;51:355–7.
21. Lewis WG, Holdsworth PJ, Stephenson BM, Finan PJ, Johnston D. Role of the rectum in the physiological and clinical results of coloanal and colorectal anastomosis after anterior resection for rectal carcinoma. Br J Surg 1992;79:1082–6.
22. Sagar PM, Holdsworth PJ, Johnston D. Correlation between laboratory findings and clinical outcome after restorative proctocolectomy: serial studies in 20 patients with end-to-end pouch-anal anastomosis. Br J Surg 1991;78:67–70.
23. Lazorthes F, Fages P, Chiotasso P, Lenozy J, Bloom E. Resection of the rectum with construction of a colonic reservoir and colo-anal anastomosis for carcinoma of the rectum. Br J Surg 1986;73:136–8.
24. Parc R, Tiret E, Frileux P, Moszowski E, Loygue J. Resection and colo-anal anastomosis with colonic reservoir for rectal carcinoma. Br J Surg 1986;73: 139–41.
25. Nicholls RJ, Lubowski DZ, Donaldson DR. Comparison of colonic reservoir and straight colo-anal reconstruction after rectal excision. Br J Surg 1988;75:318–20.
26. Kusunoki M, Shoji Y, Yanagi H, *et al.* Function after anoabdominal rectal resection and colonic J pouch-anal anastomosis. Br J Surg 1991;78:1434–8.