Factors Influencing Bowel Function Following Total Abdominal Colectomy

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PURPOSE: The purpose of this study was to determine which factors influenced bowel function following total abdominal colectomy. METHODS: Thirty-two patients who had undergone total abdominal colectomy were studied with regard to factors that are classically thought to influence bowel function, namely, residual stump length, transit time, and rectal stump manometry. In a limited subset of patients, anal manometry was done also. RESULTS: Transit time was the best predictor of bowel function following total abdominal colectomy. This was followed by stump length. If transit time was short, then stump length became important in predicting the occurrence of diarrhea following total abdominal colectomy. CONCLUSIONS: Two factors have an important influence on bowel function following total abdominal colectomy: transit time and rectal stump length. Rectal stump length is an anatomic factor that can be controlled by the surgeon. In total abdominal colectomy, rectal stump length of at least 20 cm is necessary if the patient is to have satisfactory postoperative bowel function. This may not always be possible. In these patients, modification of diet to influence transit time and methods to increase rectal compliance will be necessary. [Key words: Bowel function; Total abdominal colectomy; Diarrhea; Transit time; Rectal stump length]

Aranha GV, Walsh RM, Jacobs HK, Freeark RJ, Harford FJ, Keshavarzian A, Zarling EJ. Factors influencing bowel function following total abdominal colectomy. Dis Colon Rectum 1996;39:1418–1422.

Total abdominal colectomy can be associated with disabling diarrhea (greater than six bowel movements per day despite medication) in 5 to 16 percent of patients.[1–4] Ottinger[2] suggested that three factors were presumably responsible for altered bowel function after ileorectal or ileosigmoidal anastomosis. These were the absence of ileocecal valve, loss of absorptive capacity of the resected colon, and decrease in colon storage capacity. However, the true factors, intestinal or otherwise, responsible for diarrhea have not been determined. The aim of this study was to determine which factors were associated with bowel function following total abdominal colectomy. To this end, we studied factors classically held to be important in this regard, namely, residual stump length, transit time, and rectal stump manometry. In a limited subset of patients, anal manometry was done. Stool analysis was also accomplished with 48-hour collections. The study group included 32 patients who, from a search of our medical records, had been listed as having had a total abdominal colectomy as their operative procedure to treat primary colonic disease consisting of colon cancer or diverticular disease.

METHODS

Thirty-two patients, including 27 males and 5 females who had undergone total abdominal colectomy or subtotal colectomy as recorded from their operative summaries, with ileorectal or ileosigmoidal anastomosis were evaluated in the gastrointestinal clinic of Loyola University Medical Center. Indications for the operation were carcinoma of the colon in 24 patients, multiple polyps in 2, and diverticular disease in 6. All 32 patients had uneventful postoperative recoveries. They were operated on by six different surgeons; however, the majority of patients were attended by two of the authors (GVA, RJF).

Oral-anal transit time (TT) was measured *via* SITZMARKS™ capsules containing radiopaque markers (Lafayette Pharmacal Inc., Fort Worth, TX). Timed stool collections were radiographed for first appearance.

Patients were evaluated in the gastrointestinal laboratory in which parameters of intestinal function and bowel continence were measured. Rectal manometry was performed using a homemade catheter assembly consisting of a latex balloon attached to an endotracheal tube with airtight seals. In turn, the latex balloon was attached to a pressure gauge. The balloon was secured so elongation into the small bowel was pre-

Supported by a grant from the Department of Surgery, Loyola University, Maywood, Illinois.
Presented at the meeting of the Society for Surgery of the Alimentary Tract, San Francisco, California, May 12, 1992.
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vented. The rectal balloon, placed into the patient, was filled with distilled water by a constant flow Harvard peristaltic pump calibrated to give the desired flow rate (60 ml/minute). Pressures were measured by means of a Statham p 23 ID transducer (Statham, Madison, WI) and recorded on a Gould 2400 chart recorder (Gould Instrument Systems, Valley View, OH). Parameters recorded included resting pressure, first pressure sensation, volume, time, and compliance, *i.e.*, when the patient first had a sensation of the balloon distention in the rectum, colon. Constant pressure, volume, time, and compliance, *i.e.*, when the patient felt a constant pressure in the rectum and colon, maximum tolerable pressure, volume, time, and compliance, *i.e.*, when the patient could not hold the balloon any longer.

Anal manometry was performed using a three-lumen anorectal manometric catheter with a distal balloon and high-pressure, low-compliance infusion system (Arndorfer Medical Specialties, Greensdale, WI). Intraluminal pressures were transmitted by water-filled catheters to external transducers. Recording catheters were arranged to measure pressure through side orifices. Sensitivity of the system was 400 mmHg/second. Speed of the article was 2.5 cm/second. The catheter was advanced or drawn 1 cm at a time. Internal sphincter pressure and its response (relaxation) to intrarectal inflation of the balloon (60 ml) was measured nine times and reported as a mean of these multiple measurements. External sphincter pressure and voluntary contraction (squeeze pressure) were also recorded nine times and reported as a mean of these multiple readings.

Following this, rectal stump length (STLEN) was measured using rigid and flexible sigmoidoscopy. Procedures performed on patients were conducted after obtaining full informed consent following guidelines of the institutional review boards at both Loyola University Medical Center and Hines V.A. Hospital.

Operative outcome was assessed in each patient by questionnaire and personal interview. Patients were asked about their bowel function after surgery: 1) number of stools per day; 2) whether they took any medication to control bowel function; 3) whether they considered their quality of life after surgery as satisfactory or unsatisfactory; 4) whether they had been admitted to the hospital since their surgery for uncontrolled diarrhea dehydration; and 5) whether they had been physically stable since the operation.

Statistical evaluation of the data was aided by the Systat 4.1™ (SPSS, Inc., Chicago, IL) statistical package. Rigorous analyses were used including automatic and manual, multiple linear regression protected for collinearity univariate linear regression and analysis of variance with Student-Newman-Keuls test. Specific tests used are delineated with the results.

RESULTS

Rectal Stump Data

For convenience, the entire data set for patients with diarrhea (>0.6 bowel movements/day) and those without diarrhea (≤3 bowel movements/day) is presented in Table 1. Although this arbitrary classification was not used for multiple regression analysis below, it is interesting to note the trend for patients with diarrhea to hold lesser volumes at the three points used in this study.

The principal analytic tool for this study was a multiple linear regression model protected for collinearity and used in both automatic (stepwise) and manual selection routines to ascertain which of the rectal manometry parameters were important in predicting patient outcome (bowel movements/day). All measured parameters were entered into the regression analysis except for the anal manometric data because of the low "n." All rectal manometric data were shown to be basically noncontributory to the outcome of patients, either in the overall or any of the subset analysis. Only STLEN and TT were shown to be contributory to patient outcome. The equation describing this effect is number of bowel movements per day = 6.729 to 0.112TT minus 0.071STLEN, with a correlation coefficient (r) of 0.587 and $P = 0.005$. Transit time and STLEN were also subjected to linear regression analyses, independently, to determine the goodness or fit of each factor to the overall outcome. Univariate equations found were number of bowel movements per day = 5.132 minus 0.116TT; $r = 0.526$; $P = 0.003$ and number of bowel movements per day = 5.441 minus 0.096STLEN; $r = 0.302$; $P = 0.104$ (not significant). Obviously, TT is a more significant predictor of outcome than is STLEN.

Nevertheless, closer examination of individual data (*e.g.*, Fig. 1) reveals three somewhat distinct groupings among our patients. As predicted from the multivariate analysis above, there was a group of patients with short TT and diarrhea (n = 9) and a group of long TT and no-diarrhea patients (n = 16; one patient included in this group reported 3.5 bowel movements/day). There was, however, a third group with short TT but no diarrhea (n = 7). Subdividing the data

Table 1.
Physical, Rectal, Manometric, Fecal, and Anal Manometric Data for All Patients Classified by Absence (≤3 Bowel Movements/day) or Presence (≥3 Bowel Movements/day) of Diarrhea

	No diarrhea	Diarrhea	
Bowel movements per day	1.8 ± 0.1 (21)	6.0 ± 0.5 (11)**	
TT (hr)	20.4 ± 2.3 (20)	10.1 ± 1.9 (11)**	
STLEN (cm)	22.6 ± 1.7 (21)	18.8 ± 1.8 (11)	
RPRE (cm H_2O)	14.4 ± 1.6 (21)	13.0 ± 2.2 (11)	
FPS (cm H_2O)	24.1 ± 3.1 (21)	24.0 ± 4.1 (11)	
FPV (ml)	151.4 ± 20.2 (21)	92.3 ± 16.6 (11)	$P = 0.062$
FPT (min)	2.24 ± 0.34 (21)	1.22 ± 0.28 (11)	$P = 0.056$
FPC (ml/cm H_2O)	8.2 ± 1.6 (21)	6.6 ± 3.0 (11)	
CPS (cm H_2O)	31.1 ± 3.7 (21)	31.3 ± 5.2 (11)	
CPV (ml)	224.0 ± 24.4 (21)	138.6 ± 18.2 (11)†	
CPT (min)	3.44 ± 0.41 (21)	2.00 ± 0.30 (11)*	
CPC (ml/cm H_2O)	8.5 ± 1.2 (21)	7.1 ± 2.4 (11)	
MTS (cm H_2O)	52.6 ± 4.2 (21)	54.9 ± 5.5 (11)	
MTV (ml)	394.9 ± 24.0 (21)	313.3 ± 44.3 (11)	$P < 0.086$
MTT (min)	6.25 ± 0.41 (21)	4.93 ± 0.73 (11)	$P < 0.090$
MTC (ml/cm H_2O)	8.4 ± 1.0 (21)	6.0 ± 0.9 (11)	
Internal anal pressure (mm Hg)	61 ± 7 (7)	51 ± 7 (9)	
Squeeze pressure (mm Hg)	128 ± 18 (7)	124 ± 17 (9)	
% Relax	48 ± 4.5 (7)	36 ± 8 (9)	

TT = transit time; STLEN = stump length; RPRE = resting pressure; FPS = first pressure sensation; FPV = volume; FPT = time; FPC = compliance; CPS = constant pressure; CPV = volume; CPT = time; CPC = compliance; MTS = maximum tolerable pressure; MTV = volume; MTT = time; MTC = compliance.

Means ± standard error of the mean (number of observations).

* $P < 0.005$ *via* analysis of variance and Student-Newman-Keuls test.

† $P < 0.05$ *via* analysis of variance and Student-Newman-Keuls test.

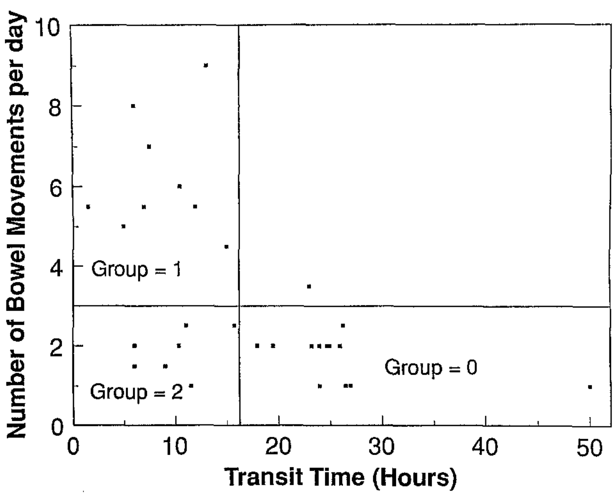

Figure 1. Individual data.

set into these groupings by the somewhat arbitrary classifications of TT ≤ 16 hours as short and number of bowel movements per day ≤ 3 as no diarrhea (Table 2) revealed that the only difference between the groups with short TT was in STLEN. The group with diarrhea had STLEN of 17.8 ± 1.7 cm, whereas the group without diarrhea had STLEN of 27.1 ± 3.6 cm. An analysis of variance with Student-Newman-Keuls test reveals this to be significant at $P < 0.05$. It would seem, therefore, that the combination of short transit time and short rectal stump length contribute to the presence of diarrhea following total abdominal colectomy.

Rectal Compliance

The data of Table 2 again suggest that the toleration of larger volumes is beneficial for control of the number of bowel movements per day. We, therefore, subjected the data of Table 2 to independent multiple linear regression in an attempt to ascertain those variables important in predicting into which group the patients will be placed. Again, both automated and manual analyses were performed. Parameters selected by both analyses were, again, TT and STELN. In this analysis, these two parameters were of near equal importance. The predictive equation for this analysis is patient Group = 1.012 minus 0.058TT plus 0.033 STLEN, with $r = 0.773$ and $P < 0.001$.

Anal Manometry

Table 1 presents results of the anal manometry performed on 16 patients, 7 of whom were in the

Table 2.
Physical, Rectal, Manometric, and Fecal Data for All Patients Classified by Groups as Indicated

	Group 0 Long TT No Diarrhea	Group I Short TT Diarrhea	Group 2 Short TT No Diarrhea
Bowel movements per day	1.9 ± 0.2 (16)*	6.2 ± 0.5 (9)	1.9 ± 0.2 (7)*
TT (hr)	25.9 ± 2.0 (16)	8.6 ± 1.4 (9)†	9.9 ± 1.3 (7)†
STLEN (cm)	21.2 ± 1.7 (16)	17.8 ± 1.7 (9)	27.1 ± 3.6 (7)‡
RPRE (cm H_2O)	15.9 ± 2.0 (16)	11.4 ± 2.1 (9)	12.5 ± 3.0 (7)
FPS (cm H_2O)	28.9 ± 4.1 (16)	21.0 ± 3.4 (9)	18.3 ± 4.8 (7)
FPV (ml)	176.0 ± 24.9 (16)‡	81.9 ± 16.4 (9)	104.4 ± 20.9 (7)
FPT (min)	2.64 ± 0.41 (16)‡	1.05 ± 0.27 (9)	1.45 ± 0.35 (7)
FPC (ml/cm H_2O)	7.9 ± 2.1 (16)	7.3 ± 3.6 (9)	8.1 ± 1.9 (7)
CPS (cm H_2O)	37.3 ± 5.1 (16)	28.0 ± 4.5 (9)	23.1 ± 4.5 (7)
CPV (ml)	251 ± 31 (16)‡	129.9 ± 19.6 (9)	167.1 ± 20.9 (7)
CPT (min)	3.89 ± 0.51 (16)‡	1.86 ± 0.33 (9)	2.49 ± 0.35 (7)
CPC (ml/cm H_2O)	8.3 ± 1.7 (16)	7.7 ± 3.0 (9)	8.3 ± 1.2 (7)
MTS (cm H_2O)	57.0 ± 5.1 (16)	53.7 ± 6.6 (9)	45.0 ± 5.9 (7)
MTV (ml)	404 ± 34 (16)	324 ± 54 (9)	355 ± 14.8 (7)
MTT (min)	6.39 ± 0.57 (16)	5.13 ± 0.89 (9)	5.62 ± 0.25 (7)
MTC (ml/cm H_2O)	8.2 ± 1.5 (16)	6.3 ± 1.0 (9)	8.4 ± 0.8 (7)

Means ± standard error of the mean.

TT = transit time; STLEN = stump length; RPRE = resting pressure; FPS = first pressure sensation; FPV = volume; FPT = time; FPC = compliance; CPS = constant pressure; CPV = volume; CPT = time; CPC = compliance; MTS = maximum tolerable pressure; MTV = volume; MTT = time; MTC = compliance.

* $P < 0.001$ from Group 2 *via* analysis of variance and Student-Newman-Keuls test.

† $P < 0.001$ from Group 1 *via* analysis of variance and Student-Newman-Keuls test.

‡ $P < 0.05$ from Group 2 *via* analysis of variance and Student-Newman-Keuls test.

no-diarrhea group and 9 of whom were in the diarrhea group. Measurements of internal anal sphincter (resting pressure), external sphincter pressure (squeeze pressure), and present relaxation of the internal sphincter to rectal dilation show no significant differences (*via* analysis of variance and Student-Newman-Keuls test), suggesting that anal parameters were not contributory to diarrhea.

DISCUSSION

Removal of the abdominal colon can result in alteration of bowel function for several reasons. These include abnormalities in motility, loss of absorptive surface of the colon, and loss of storage capacity of the colon.[2, 5] In addition, diarrhea after abdominal colectomy may be caused by abnormalities in the continence mechanism.[5–8] Actual studies to document the physiology of bowel function after total abdominal colectomy with ileorectal and ileosigmoidal anastomosis, until now, are nonexistent. We studied parameters associated with these suggestions to delineate which factors have an important influence on patient outcome and satisfaction (*i.e.*, bowel movements per day) following total abdominal colectomy and ileorectal anastomosis.

Although removal of the abdominal colon could contribute to a decrease in oral anal transit time and lead to diarrhea, proving that abnormal motility is the cause for diarrhea is difficult.[5] Of note, TT was the most important overall predictor of bowel function in our patients. A long TT appears to signal normal bowel movements. A short TT, on the other hand, does not imply the presence of diarrhea. If a long rectal stump is present, there is an accommodation for the short TT, and patients have normal bowel movements. However, combination of a short TT and short STLEN are highly predictive of a poor outcome. It would be interesting to see whether modulation of transit time by diet in patients with short stumps would increase transit time and decrease diarrhea.

The important factors in achieving anorectal continence are thought to be 1) a normal anal sphincter mechanism and anorectal angle; 2) a distensible and compliant rectum; and 3) stool that is firm and bulky.[9] Our data tend to discount the importance of the anal sphincter mechanism as contributory to diarrhea. All functions of the anal sphincter tested in our patients showed no difference in the groups who had diarrhea *vs.* those patients who had no diarrhea. We conclude, therefore, that anal manometry has no significant role in prediction of diarrhea following total abdominal colectomy. This leaves the physical factors of rectal distensibility and compliance. Studies of rectal compliance have been previously performed by the continuous distention of a balloon inserted into the rectum. Volume and pressure at first sensation, constant sensation, and maximum tolerable limits have been measured and related to compliance.[10–12] Maximum tolerable rectal volume in healthy persons approximates 400 ml.[9] Such studies suggest the importance of a compliant rectal stump. In our study, it was noted that patients with short rectal stumps and diarrhea had first pressure sensation at a significantly lower volume (81.9 ± 16.4 ml) compared with those who had no diarrhea (176 ± 24.9 ml). This seems intuitive. However, it was also noted that maximum tolerable volumes were not different across groups. It, thus, appears that once patients with diarrhea get beyond the first sensation stage, their maximum tolerable volume is close to those who have normal bowel movements. This suggests that if patients could be taught to overcome the urge to evacuate the rectum at first pressure sensation by, for example, biofeedback, control of diarrhea might be possible.

Our study has several implications for the surgeon. The rectal stump length being an anatomic factor can be controlled by the surgeon. Therefore, in the total abdominal colectomy, the surgeon would need to fashion the rectal stump length of at least 20 cm if the patient is to have satisfactory postoperative bowel function. However, this may not always be possible because, in some instances, removal of the diseased bowel may result in a shorter rectal stump. In these patients, modification of diet to influence transit time and methods to increase rectal compliance will be necessary.

CONCLUSIONS

Our study is the first of its kind to investigate bowel physiology in patients who have undergone abdominal colectomy with ileosigmoidal or ileorectal anastomosis. We found that transit time was the best predictor of bowel function after an operation followed by stump length. If TT is short, then STLEN becomes important in predicting the occurrence of diarrhea. Further studies are needed to see if modulation of transit time by control of diet and modulation of first pressure sensation and volume by the use of biofeedback could decrease the incidence of diarrhea in certain patients following total abdominal colectomy.

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