Modulation of abnormal defecation dynamics by biofeedback treatment in chronically constipated children with encopresis

V. Loening-Baucke, MD

From the Department of Pediatrics, University of Iowa Hospitals and Clinics, Iowa City

To determine whether outcome in chronically constipated and encopretic children with abnormal defecation dynamics could be improved with biofeedback training, we randomly assigned patients, 5 to 16 years of age, to receive conventional treatment alone (n = 19) or conventional plus biofeedback treatment (n = 22) and evaluated physiologic outcome at 7 months and clinical outcome at 7 and 12 months. Eighty-six percent of patients learned normal defecation dynamics with up to six biofeedback sessions. At 7 months, 13% of conventionally treated and 77% of biofeedback-treated patients had normal defecation dynamics (p <0.01); one conventionally treated (5%) and 12 biofeedback-treated patients (55%) had recovered (p <0.01). Learning normal defecation dynamics was correlated with clinical recovery (p <0.01). At 7 months, 11% of patients with normal defecation dynamics after biofeedback treatment had abnormal defecation dynamics, and 71% of the biofeedback-treated patients with normal defecation dynamics recovered. At 12 months, 16% of conventionally treated and 50% of biofeedback-treated patients had recovered (p <0.05). Balloon defecation did not improve significantly in those who learned normal defecation dynamics. Therefore the ability to defecate balloons is apparently not dependent on the normal function of the external and sphincter and pelvic floor muscles alone. Biofeedback treatment is complementary to a good conventional therapeutic regimen in patients with abnormal defecation dynamics. (J Pediatr 1990;116:214-22)

Several anorectal abnormalities, including impaired rectal and sigmoid sensations, have been detected by us and other investigators in children with chronic constipation and encoporesis.[1-4] Impaired rectal sensation, higher maximal rectal compliance, or both were found in 97% of constipated children and were independent of rectal size.[3] Impairment of rectal sensation leads to fecal impaction, which can impede the defecation process. This impairment can persist up to 3 years despite therapy and clinical improvement of symptoms.[2] We have demonstrated that approximately 50% of children with chronic constipation and encopresis have abnormal defecation dynamics; they close the anal canal by contracting rather than relaxing the external anal

EAS	External anal sphincter
EMG	Electromyography

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Reprint requests: Vera Loening-Baucke, MD, University of Iowa Hospital, 2555 JCP, Iowa City, IA 52242.

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sphincter, as well as the puborectalis and pelvic floor muscles, during defecation attempts.[5] These abnormal defecation dynamics may persist after 12 months of laxative treatment,[4] and patients with abnormal defecation dynamics are significantly less likely to have recovered after 1 year of conventional laxative treatment than constipated children with normal defecation dynamics (13% vs 70%; $p < 0.01$).[4]

Because the EAS is a striated muscle, it should be amenable to modulation by the use of biofeedback training. The aims of our study were to evaluate (1) what proportion of patients with abnormal contraction of the EAS during defecation attempts could learn relaxation of the EAS with biofeedback training, (2) whether relaxation of the EAS would persist for 5 to 6 months after the children successfully learned it, and (3) whether learning relaxation of the EAS with biofeedback training would influence outcome.

METHODS

Study population. The study population consisted of 43 children (33 boys) with chronic constipation and encopresis and with abnormal defecation dynamics. (See methods for biofeedback training and for the study of the anal sphincters during the act of bearing down for defecation, below.) Abnormal defecation dynamics was defined as an abnormal contraction of the EAS and pelvic floor during defecation attempts.

Children with abnormal defecation dynamics (5 to 16 years of age) and their parents were approached to enter our study if they had ≥2 soiling episodes per week and evidence of a huge amount of fecal material in the rectal ampulla at rectal examination. In many patients, stool evacuation was incomplete as evidenced by periodic passage of very large amounts of stool (every 7 to 30 days), often clogging the toilet. Stooling could occur with normal or increased frequency, but then the stool volume was small. All children had fecal soiling for more than 1 year. Children with Hirschsprung disease, hypothyroidism, mental deficiency, chronic debilitating diseases, or neurologic abnormalities and children who had had previous surgery of the colon were not approached.

We had calculated that 22 pairs of subjects would be needed per group to allow a power of approximately 0.9 to detect a difference of 0.7 versus 0.2 in achieving normal bowel habits (recovery from chronic constipation and encopresis). Recruitment for the study took place in the University of Iowa Encopresis Clinic from March 1985 to March 1988.

Sixteen healthy children (11 boys) aged 6.5 to 12.8 years (mean age 10.3 years) who had been studied previously served as control subjects.[5] The parents of these control children were University of Iowa staff members who volunteered for this study. The children had from two bowel movements per day to one every other day. They had no history of previous gastrointestinal tract disease, and their physical examination findings were normal.

The study was approved by the institutional human research review committee. Written informed consent was obtained from the parents and children studied.

Study protocol. Sealed envelopes with 4 × 4-inch cards indicating either conventional therapy alone or conventional therapy with biofeedback trainnig were used for randomization. Patients in both treatment groups returned to the clinic for evaluation and for adjustment of medication at 30 ± 7 days, 60 ± 14 days, and 4 ± 0.5 months after random assignment. In addition, patients in both treatment groups were contacted every week during the first month after random assignment, to ensure that patients were receiving adequate doses of medication and complying with treatment, and that the same frequency of contacts between patients and therapists was maintained in both treatment groups. Patients in the biofeedback group received up to six sessions of biofeedback therapy spaced 7 ± 2 days apart. Patients were instructed to discontinue laxative therapy at 6 ± 0.5 months after initiation of therapy.

Reevaluation of patients occurred 4 weeks ± 5 days after discontinuation of laxative therapy. The evaluation included review of the last month's stool, soiling, and medication diary; an interview about abdominal pain and day or night urinary incontinence; an abdominal and rectal examination; and anorectal manometry and studies of defecation dynamics. Patients were considered to have recovered from chronic constipation and encopresis if they met the following criteria: ≥3 bowel movements per week and ≤2 soiling episodes per month while not receiving laxatives for 4 weeks.[2, 4-8] Patients were considered not to have recovered if they had <3 bowel movements per week or were soiling >2 times per month or had been started on a regimen of laxatives again. Follow-up interview by questionnaire was conducted at 12 months.

Treatment protocol. All patients received conventional laxative treatment for encopresis and constipation similar to that used for the previous 10 years in our encopresis clinic. Twenty patients were randomly assigned to receive conventional treatment alone. After disimpaction with enemas, the treatment was aimed at relieving social and psychologic problems faced by these children through education about the underlying constipation, at prevention of accumulation of fecal material in the colon with the help of daily use of laxatives (milk of magnesia) and increase in dietary fiber, and at scheduling of toileting. Enough milk of magnesia (approximately 2 ml/kg body weight) was given daily to induce at least one bowel movement daily and prevent fecal retention. The milk of magnesia dosage was decreased

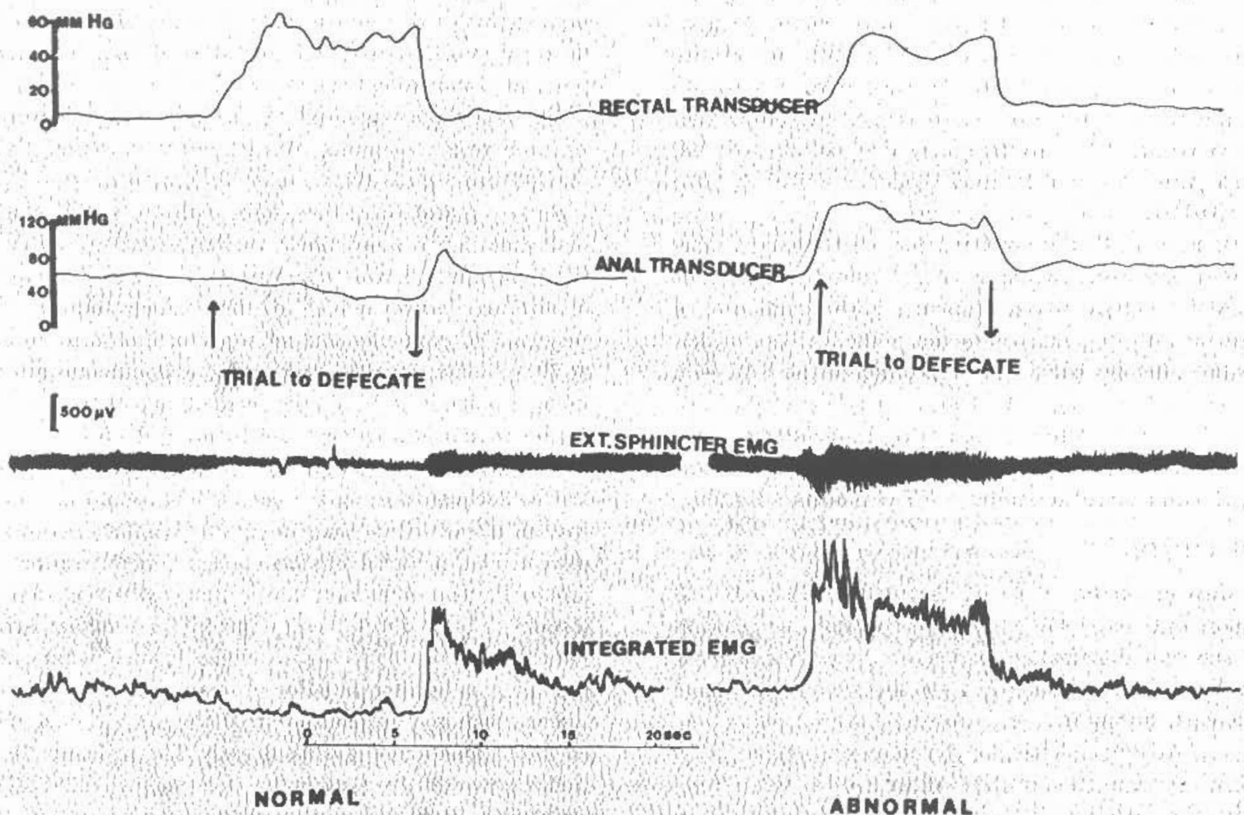

Figure. Tracings depict pressure changes in rectum and anal canal, and EMG changes from EAS during trial to defecate. Duration of defecation trial is indicated by *arrows* (↑↓). Normal defecation consists of increased rectal (intraabdominal) pressure, decreased anal pressure, and decreased direct and integrated EMG activity. Abnormal defecation dynamics consists of increased rectal (intraabdominal) pressure, anal pressure, and direct and integrated EMG activity.

gradually to maintain a daily bowel movement and prevent fecal retention and soiling. Concomitantly with the administration of milk of magnesia, the child was instructed to try to defecate for 5 minutes after each meal and after returning from school for the initial month, and then to try to defecate at least once daily for the remaining months of the study. Parents and children kept a diary of bowel movements, fecal soiling, and medication used during the study. Although it is unusual to request parents and patients to keep records for such an extended period, our previous experiences showed that record keeping motivates parents and patients to comply with the therapy; it also supplies a guide for adjustment of therapy. Parents and children learn from daily record keeping because they recognize stool retention and are able to adjust the medication and to use cleansing enemas if necessary.

Biofeedback training. Twenty-three patients were randomly assigned to receive additional biofeedback training. We recorded myoelectric activity from the external sphincter at a recording speed of 10 mm/sec with three surface electrodes (Abco Dealers, Inc., Milwaukee, Wis.). Two electrodes were placed over the external sphincter and a third on the buttock. The area under the wave form of the action potentials, an index of total activity, was obtained by integrating the primary signal with an EMG averaging coupler (type 9852A, SensorMedics Corp., Anaheim, Calif.). Simultaneously, we used a motility probe (model P31-D3, Sandhill Scientific Inc., Littleton, Colo.) to evaluate the combined function of the external and internal anal sphincters and rectal pressure changes, as described previously.[2,7] One of the transducers was placed into the rectum (6 cm) and a second into the anal canal (1 cm above the anal verge). A latex balloon (2.5 × 3 cm) tied to the end of a polyethylene tube was used for rectal distension and placed with its base 11 cm above the anal verge. The outputs of all transducers and surface electrodes were fed into amplifiers of an eight-channel dynograph recorder (Beckman R-611, SensorMedics) and graphed on paper. The patients were shown a manometric and an EMG tracing from a normal child (Figure). The differences in the patient's EAS contraction and the healthy child's EAS relaxation during defecation trials were pointed out. Initially the rectal balloon was inflated with 50 ml air and the patients were instructed to increase intraabdominal pressure, to push as if defecating, and to inhibit contraction of the EAS in attempts to produce relaxations (or tracings) similar to the normal EAS relaxations that he or she was shown. Constant verbal reinforcement, visual reinforcement (recording), and sound reinforcement (the EMG recording stylus produced less noise) were given when correct responses were made. The patient experimented and tried to modify the responses to make them appear more normal until he or she finally accomplished relaxations of the EAS. After the patient was able to produce relaxation of the EAS, he or she was encouraged to increase the duration of the EAS relaxation and to do so without rectal balloon distension. After relaxation of the EAS was accomplished, the visual feedback and later the verbal feedback were withdrawn.

A biofeedback training session included approximately 30 to 35 defecation trials and lasted approximately 45 minutes. At least two and up to six training sessions 7 ± 2 days apart were given. The number of training sessions given depended on how soon the child learned to relax the EAS. Biofeedback training sessions were stopped after 10 relaxations of the EAS without visual feedback could be accomplished in each of two successive biofeedback training sessions.

Defecation studies and anorectal manometry

Studies of the EAS and pelvic floor during the act of bearing down for defecation. These studies were performed at least 1 hour after disimpaction with one or two phosphate enemas. In children with enormous fecal retention, disimpaction was done over several days and the child returned after disimpaction for testing. Myoelectric activity from the EAS and pressures in the anal canal and rectum were recorded with the anal surface electrodes and the anorectal motility probe. Instruments and their position were the same as those described during biofeedback training.

While lying in the left lateral position, the child was asked to bear down five times as if defecating and to squeeze (tighten up) five times in random order. We defined defecation dynamics as normal if the integrated EMG decreased during intraabdominal pressure increase (rectal pressure recording ≥30 mm Hg) during at least two of five defecation trials. We defined defecation dynamics as abnormal if there was a persistent increase in the integrated EMG during bearing down (with intraabdominal pressure increase of ≥30 mm Hg) in at least four of the five defecation trials.[6] In three recordings, no change in the integrated EMG could be detected during intraabdominal pressure increase; this result was counted as normal. In the first few patients, we had no coupler for EMG integration, so an increase in frequency and amplitude of the action potentials of the raw EMG was used.

Studies of balloon defecation. To simulate defecation of a stool from the rectum, we asked children to defecate rectal balloons filled with 30, 50, and then 100 ml water, allowing 5 minutes for each balloon, while sitting on a toilet chair. Defecation of a balloon of each size was evaluated during the first minute and during 5 minutes. The intraabdominal pressure exerted on the rectal balloon during attempts to defecate was transmitted via a polyethylene tube to a pressure transducer (type 4-327-0, Beckman Instruments Inc., Fullerton, Calif.) and recorded.

Studies of the effects of rectal distension. Because it is possible that children with chronic constipation who do not recover have significantly more impairment in anorectal function than children who recover, we evaluated the response of the rectum and anus to rectal distension. These tests have been described previously; significantly higher balloon volumes are required in the constipated children compared with control subjects.[2,7,8] With the base of the balloon 11 cm above the anal verge, we determined (1) the minimal amounts of air (measured in milliliters) required to elicit a transient sensation of rectal balloon distension and the threshold of the rectosphincteric reflex (≥5 mm Hg relaxation of anal tone) by inflating the balloon two or three times transiently with volumes of air between 60 and 5 ml in random order, starting each time at 0 ml,[7] and (2) the minimal amount of air required to produce a lasting (30 seconds) urge to defecate (critical volume), a sustained complete relaxation of the internal and external sphincters (constant relaxation), and a rectal contraction of ≥10 mm Hg (recorded 6 cm above the anal verge) by stepwise addition of 10 ml air increments, up to 60 ml, and then 30 ml increments each 10 to 15 seconds into the rectal balloon.[2] When the critical volume was reached, but constant relaxation or a rectal contraction of ≥10 mm Hg had not yet occurred, the next higher volume was used as the volumes of constant relaxation and rectal contraction.

Statistical methods. Statistical methods included the Wilcoxon nonpaired rank sum test and signed rank sum test and the Fisher exact probability test, with significance accepted at 5% level. Results were expressed as mean ± SD.

RESULTS

Of the 20 patients randomly assigned to receive conventional therapy alone, one boy was lost to follow-up 1 month after treatment began. At that visit he was taking milk of magnesia daily and his soiling had resolved. Therefore the

Table I. Findings in initial history and physical examination

	Conventional treatment alone (n = 19)	Biofeedback + conventional treatment (n = 22)	p*
Age (yr) (range 5-16 yr)†	8.6 ± 2.2	9.2 ± 2.6	NS
Gender (M/F)	18/1	13/9	<0.02
Bowel movements (No./wk)†	4 ± 5	4 ± 7	NS
Soiling episodes (No./wk)†	14 ± 16	19 ± 19	NS
Never toilet trained (%)	53	50	NS
Abdominal pain (%)	53	41	NS
Presence of abdominal fecal mass (%)	58	59	NS
Daytime urinary incontinence (%)	21	45	NS
Nighttime urinary incontinence (%)	21	36	NS
Previous urinary tract infection (%)	11	27	NS
Previous unsuccessful treatment (%)	55	53	NS

NS, Not significant.
*Fisher Exact Test or Wilcoxon nonpaired rank sum test.
†Values are expressed as mean ± SD.

Table II. Number of biofeedback training sessions given, number to learn EAS relaxation during act of bearing down for defecation, persistence of EAS relaxation, and clinical outcome at 7 months

	Learned to relax EAS*			No. of patients at 7-mo follow-up	
Biofeedback sessions given	During session relaxation	No. of patients	Cumulative percent	Relaxed EAS	Clinical recovered
2	1	4	18	3	1
3	2	4	36	4	2
4	3	3	50	3	3
5	4	3	64	3	2
6	5	2	73	2	2
6	6	3	86	2	2

*Three patients could not learn EAS relaxation.

results for 19 patients who received conventional treatment were analyzed.

Of the 23 patients randomly assigned to receive biofeedback therapy in addition to conventional therapy, one boy was lost to follow-up after the first biofeedback session. Therefore the results for 22 patients who received additional biofeedback treatment were analyzed. As can be seen in Table I, the patients in both treatment groups had similar age and frequency of gastrointestinal tract and urinary symptoms, but there were significantly more girls in the biofeedback-treated group (41%) than in the conventionally treated group (5%) (p <0.02). During the initial evaluation, the following were significantly more frequent in girls than in boys: severe constipation (an abdominal fecal mass present) (90% vs 48%; p <0.03), daytime urinary incontinence (70% vs 23%; p <0.02), and a history of previous urinary tract infection (60% vs 6%; p <0.001).

Biofeedback training. Eighty-six percent of patients (92% of the boys, 78% of the girls) learned to relax the EAS during defecation attempts in 3.2 ± 1.8 biofeedback training sessions (Table II). Fourteen percent were not able to learn relaxation of EAS in six biofeedback training sessions.

Clinical outcome at 7 months. Of 19 patients in the conventional treatment group, one (5%) recovered; 12 (55%) of 22 patients in the biofeedback-treated group recovered (p <0.001) (Table II). Soiling frequency per week decreased significantly in the conventional treatment group (14 ± 16 to 3 ± 6; p <0.01) and in the biofeedback treatment group (19 ± 19 to 1 ± 1; p <0.01). Soiling frequency might have been higher in some of the nonrecovered patients in both treatment groups because often the parents did not let the children stay off their medication regimen for 4 weeks when soiling recurred.

Recovery rates did not differ between boys and girls (29% vs 40%; not significant). Recovery rates of biofeedback-treated boys and girls did not differ (62% vs 44%; not significant). Prior unsuccessful treatment was not related to treatment outcome in the conventionally treated and bio-

Table III. Ability to defecate water-filled ballons

Balloon volume	% Control subjects (n = 16)	Conventional treatment		Conventional + biofeedback treatment	
		% Initial (n = 19)	% Follow-up (n = 16)	% Initial (n = 22)	% Follow-up (n = 22)
30 ml					
≤1 min	88	0*	6*	5*	14*
≤5 min	88	16*	13*	14*	32*
50 ml					
≤1 min	88	11*	13*	18*	32*
≤5 min	88	11*	13*	23*	45*†
100 ml					
≤1 min	100	11*	25*	18*	50*
≤5 min	100	11*	25*	36*	55*

Control data from Loening-Baucke VA, Cruikshank BM, J PEDIATR 1986;108:562-6.
*p <0.05 from control subjects (Fisher Exact Test).
†p <0.05 from conventionally treated patients (Fisher Exact Test).

feedback-treated groups (p = 1). Patients with an initial abdominal fecal mass (severe constipation) were significantly more likely to recover with biofeedback training than with conventional treatment alone (46% vs 0%; p <0.02).

Clinical outcome at 12 months. Recovery was achieved at 12 months by 3 (16%) of 19 patients in the conventional treatment group and 11 (50%) of 22 patients in the biofeedback group (p <0.05). One patient in the biofeedback treatment group, a 14-year old boy, had a relapse. He had had severe fecal impaction with enormous abdominal distension initially. Fecal impaction recurred 4 months after successful discontinuation of milk of magnesia. He has no soiling but requires intermittent treatment for constipation.

Defecation studies and anorectal manometry

Studies of the EAS and pelvic floor during the act of bearing down for defecation. At the 7-month follow-up evaluation, 2 (13%) of 16 patients in the conventional treatment group and 17 (77%) of 22 patients in the biofeedback treatment group were able to relax the EAS (p <0.01). Three patients in the conventional group had no follow-up anorectal manometry and defecation studies. Of 19 patients who had learned to relax the EAS with biofeedback training, one boy and one girl could not do so during the 7-month follow-up evaluation. Of the patients who could relax the EAS at follow-up, neither of the two patients in the conventional group had recovered but 12 of 17 patients in the biofeedback group had done so (p <0.001). Recovery in the biofeedback group was significantly related to the ability to relax the EAS during the act of bearing down for defecation (p <0.01).

Studies of balloon defecation. As can be seen in Table III, patients in both treatment groups, in comparison with control children, were significantly less likely to pass the 30 ml, 50 ml, and 100 ml water-filled balloons in 1 minute or 5 minutes (p <0.02). Neither treatment group showed significantly improved ability to defecate balloons at the 7-month follow-up evaluation. The ability to defecate balloons did not increase significantly in biofeedback-treated patients who could relax the EAS at 7 months (Table IV). Recovered biofeedback-treated patients were able to defecate the 100 ml balloon in 1 minute significantly more often at follow-up than initially (p <0.03), but not the 30 ml or 50 ml balloons (not significant). Girls did not differ from boys in their ability to defecate balloons (p >0.1). Patients with severe forms of constipation did not differ from patients with mild constipation (no abdominal fecal mass) in their ability to defecate balloons.

Table IV. Ability of biofeedbeck-treated patients to defecate water-filled ballons

Balloon volume	Patients who relaxed EAS at follow-up		Patients recovered at 7 mo	
	% Initial (n = 17)	% Follow-up (n = 17)	% Initial (n = 12)	% Follow-up (n = 12)
30 ml				
≤1 min	0*	6*	0*	8*
≤5 min	6*	29*	0*	33
50 ml				
≤1 min	12*	29*	8*	33
≤5 min	18*	47*	17*	58
100 ml				
≤1 min	12*	47*	8*	58*†
≤5 min	35*	53*	42*	67*

For control data, see Table III.
*p <0.05 from control subjects (Fisher Exact Test).
†p <0.05 from initial study (Fisher Exact Test).

Table V. Anorectal function test results

Balloon volume (ml air)	Control subjects (n = 16)	Conventional treatment Initial (n = 19	Conventional treatment Follow-up (n = 16)	Conventional + biofeedback treatment Initial (n = 22)	Conventional + biofeedback treatment Follow-up (n = 22)
Threshold of rectal sensation	14 ± 7	24 ± 18*	22 ± 7*	30 ± 19*	21 ± 10*†
Critical volume	101 ± 39	212 ± 107*	234 ± 62*	203 ± 92*	213 ± 110*
Threshold of rectosphincteric reflex	11 ± 5	23 ± 12*	23 ± 9*	21 ± 9*	18 ± 7*
Volume for constant relaxation	104 ± 49	196 ± 95*	240 ± 58*	220 ± 99*	207 ± 88*
Threshold for rectal contraction	54 ± 28	147 ± 103*	170 ± 105*	118 ± 87*	132 ± 110*

Values are expressed as mean ± SD. Control data are from Loening-Baucke V, Cruikshank BM. J PEDIATR 1986;108:562-6.
*p <0.05 from control subjects (Wilcoxon nonpaired rank sum test).
†p <0.05 from initial study (Wilcoxon nonsigned rank sum test).

Table VI. Anorectal function test results

Balloon volume (ml air)	Biofeedback treatment: Recovered at at 7 mo Initial (n = 12)	Recovered at at 7 mo Follow-up (n = 12)	Not recovered at 7 mo Initial (n = 10)	Not recovered at 7 mo Follow-up (n = 10)
Threshold of rectal sensation	32 ± 22*	18 ± 9†	29 ± 15*	24 ± 12*
Critical volume	165 ± 67*	198 ± 116*	249 ± 99*‡	231 ± 105*
Threshold of rectosphincteric reflex	16 ± 7	15 ± 5	26 ± 8*‡	22 ± 8*
Volume for constant relaxation	173 ± 67*	188 ± 79*	276 ± 105*‡	231 ± 97*
Threshold for rectal contraction	84 ± 36*	103 ± 106	159 ± 113*	167 ± 108*

Values are expressed as mean ± SD.
*p <0.05 from control subjects (Wilcoxon nonpaired rank sum test); for control data, see Table V.
†p <0.05 from initial study (Wilcoxon signed rank sum test).
‡p <0.05 from recovered patients (Wilcoxon nonpaired rank sum test).

Studies of the effects of rectal distension. As can be seen in Table V, conventionally treated patients and biofeedback-treated patients initially required significantly larger balloon volumes to produce a rectal sensation, an urge to defecate, a rectosphincteric reflex, constant relaxation of both the external and internal anal sphincters, and a rectal contraction ≥10 mm Hg than control children required (p <0.05). These balloon volumes did not differ significantly between conventionally treated and biofeedback-treated patients.

Repeated studies at 7 months revealed an improvement only in the rectal sensation in the biofeedback-treated group (p <0.01); the mean volume for rectal sensation did not differ significantly from that of conventionally treated patients but was nevertheless significantly larger than that of control children (p <0.01).

As can be seen in Table VI, recovered and nonrecovered biofeedback-treated patients initially required significantly larger balloon volumes for rectal sensation, an urge to defecate, constant relaxation, and a rectal contraction than control children required (see Table V for data on control subjects) (p <0.05). The follow-up study at 7 months revealed a significant improvement only in rectal sensation for the 12 recovered biofeedback-treated patients (p <0.05). Rectal sensation of the recovered patients at follow-up was similar to that of control children (p >0.1).

The 10 patients who did not recover with biofeedback treatment initially required significantly higher balloon volumes than recovered biofeedback-treated patients for the urge to defecate, threshold of rectosphincteric reflex, and volume required for constant relaxation (p <0.05). On follow-up, these rectal distension volumes did not differ from initial means, nor did they differ between nonrecovered and recovered patients (p >0.05).

Girls did not differ from boys in their anorectal manometric measurements (p >0.1). Patients with severe constipation required a significantly larger air volume to produce an urge to defecate than patients with mild constipation required (238 ± 97 ml air vs 164 ± 79; p <0.03), but volumes to produce a rectal sensation, a rectosphincteric reflex, constant relaxation, and a rectal contraction were similar in patients with severe and mild constipation ($p > 0.1$).

DISCUSSION

Abnormal defecation dynamics and severity of constipation are factors responsible for the persistence of chronic constipation and encopresis.[4, 6] This study shows that the external anal sphincter, a striated muscle, is amenable to modulation by biofeedback training. Eighty-six percent of chronically constipated and encopretic children learned to relax the EAS with biofeedback treatment. The follow-up evaluation revealed that significantly more patients in the biofeedback group could relax the EAS than in the conventionally treated group, and that learning to relax the EAS was significantly related to recovery from mild and severe chronic constipation and encopresis.

Healthy children can expel fecal material from the rectum by voluntary actions: an increase in intraabdominal pressure produced by closure of the glottis, fixation of the diaphragm, and contractions of the abdominal, perineal, and hamstring muscles. Seconds after the intraabdominal pressure has increased, relaxation of the internal and external anal sphincters occurs. In our constipated children, the anal canal pressure did not decrease; rather, it increased because the EAS and the pelvic floor muscles were contracted during defecation attempts. This paradoxic closure of the anal canal created pressures that exceeded the pressure in the rectum and appeared to be responsible for the difficulties in defecating stool or rectal balloons.

Our study extended a controlled study by Wald et al.,[9] who treated 18 chronically constipated and encopretic children with abnormal defecation dynamics and found that 67% of biofeedback-treated patients had markedly improved or recovered by 12 months, whereas only 33% of patients treated with mineral oil had improved or recovered. In addition, four uncontrolled biofeedback studies of constipated children have been reported.[10-13] With biofeedback training, all 12 constipated and encopretic children in whom prior treatment had failed had recovered 7 to 22 months later,[10] all seven constipated children (2 to 14 years of age) had achieved regular bowel habits,[11] 58% of 12 had recovered 2 to 18 months later,[12] and 80% of 65 severely constipated patients (aged 5 to 77 years) had normalization of defecation dynamics and relief from symptoms of constipation.[13]

It appears that the ability to defecate balloons is not dependent on normal defecation dynamics alone, because patients who learned normal defecation dynamics and recovered did not significantly improve their ability to defecate the 30 ml of 50 ml balloons, although they were able to defecate the 100 ml balloon significantly more often in ≤ 1 minute than initially. In this study, many patients had additional anorectal function abnormalities, but our sample size does not allow further analysis of anorectal function in nonrecovered biofeedback-treated patients who could and could not relax EAS during follow-up.

How can chronic constipation with encopresis be avoided? Many parents gave a history of a transition from simple constipation to fecal impaction with soiling, most often describing large, painful bowel movements, often followed by stool withholding, in the first 2 years of life. Allowing the child's bowel to remain distended for months or even years can produce encopresis. It appears that early recognition and treatment of constipation, together with dietary changes, increased fluid intake, and the use of stool softeners or laxatives, may help prevent progression from simple constipation to chronic constipation with encopresis.

Our results show that biofeedback training is a promising mode of treatment for a subgroup of patients with abnormal defecation dynamics. It is complementary to a good conventional therapeutic regimen. Anorectal function studies and biofeedback training are labor intensive and should be offered to children who have been compliant but have failed to respond to conventional treatment.

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Available fellowships in pediatric subspecialties and those for general academic pediatric training are listed once a year, in May, in THE JOURNAL OF PEDIATRICS. Each October, forms for listing such fellowships are sent to the Chairman of the Department of Pediatrics at most major hospitals in the United States and Canada. Should you desire to list fellowships, a separate application must be made each year for each position. All applications must be returned to The C.V. Mosby Company by February 15 of the listing year to ensure publication. Additional forms will be supplied on request from the Journal Editing Department, The C.V. Mosby Company, 11830 Westline Industrial Drive, St. Louis, MO 63146-3318/314-872-8370.