A Nordic multicenter survey of long-term bowel function after transanal endorectal pull-through in 200 patients with rectosigmoid Hirschsprung disease ☆,☆☆,★,★★

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ABSTRACT

Objective: Transanal endorectal pull-through (ERPT) is the most popular technique to treat Hirschsprung disease (HD). Still, there is limited knowledge on long-term bowel function. This cross-sectional, multicenter study assessed long-term bowel function in a large HD population and examined predictors of poor outcome.
Methods: Patients older than four years or their parents filled out a validated questionnaire on bowel function. Clinical details were recorded retrospectively from medical records.
Results: 73/200 (37%) patients reported absolutely no impaired bowel function, meaning no constipation, fecal accidents, stoma, appendicostomy or need for enemas. Seven (4%) had a stoma, and 33 (17%) used antegrade or rectal colonic enemas. Most disarrangements of fecal control and constipation were significantly less common in older age group, but abnormal defecation frequency and social problems remained unchanged. Syndromic patients (n = 31) experienced frequent fecal accidents (46%) more often than nonsyndromic (14%, $P < 0.001$). Having a syndrome (adjusted OR 5.6, 95% CI 2.1–15, $P = 0.001$) or a complete transanal ERPT (adjusted OR 2.4, 95% CI 1.1–5.7, $P = 0.038$) was significantly associated with poor outcome defined as having a stoma, an appendicostomy, daily fecal accidents or need of regular rectal wash outs.
Conclusion: A significant number of HD patients experience bowel problems many years after definite surgery. Fecal control was significantly better in older than younger HD patients, but some continued to have considerable bowel problems also as adults. A total transanal ERPT was associated with poorer outcome. Long-term follow-up of HD patients is warranted.
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Hirschsprung disease (HD) is the most common congenital motility disorder in children affecting 1 in 5000 live births [1,2]. Lack of ganglion cells in a variable length of the distal gut causes functional bowel obstruction. 80% of HD patients have aganglionosis restricted to the rectosigmoid colon. There is a strong male preponderance, and other developmental disorders occur in 4%–30% of patients, Down syndrome being the most common [3]. Affected patients usually present shortly after birth with clinical signs of distal intestinal obstruction. In older children, severe constipation is the predominant symptom.

Surgical treatment of HD includes resection of the aganglionic bowel segment and anastomosing ganglionic bowel to the anus. Traditionally, treatment of HD required a colostomy at diagnosis followed by a pull-through procedure when the child reached 8–12 months. With advances in surgical techniques, neonatal anesthesia and critical care, most children are now operated shortly after diagnosis with a single-stage repair. Different pull-through operations have been described, and minimally invasive techniques have recently become popular. Today the most

common operations are the Duhamel procedure and the endorectal pull-through, performed either completely transanally (TERPT) or in combination with laparotomy or laparoscopy (LERPT) [4]. TERPT may be considered the least invasive technique because it does not include any transabdominal dissection and leaves no visible scars.

During recent years it has become apparent that long-term morbidity and functional bowel problems after surgical treatment of HD are significant [5,6]. Previous follow-up studies have revealed occurrence of both fecal incontinence and constipation in patients operated with the traditional Duhamel, Soave and Swenson techniques. Obstructive symptoms may be caused by residual aganglionic segment, stricture, or congenital dysmotility, whereas fecal incontinence may be caused of anal sphincter damage, inappropriately low coloanal anastomosis or overflow soiling. So far, there is very limited knowledge concerning the long-term outcome after transanal endorectal pull-through, and in particular, reports where validated questionnaires are used, are few. Most previous studies have included limited number of patients, and duration of follow-up is relatively short. Furthermore, results have mostly been based on retrospective reviews of medical charts. Therefore, we undertook this multicenter study to assess long-term bowel function using validated questionnaires in a large number of HD patients operated with transanal endorectal pull-through with or without transabdominal colonic mobilization. We also analyzed potential predictors of long-term functional outcome.

1. Methods

1.1. Patients

All HD patients above four years of age with aganglionosis not extending oral to the sigmoid colon operated with primary endorectal pull-through at four Nordic tertiary pediatric surgical centers, were eligible for inclusion. The only exclusion criterion was severe language problems precluding reliable assessment of bowel function.

1.2. Surgical management

All patients had the diagnosis verified preoperatively by a rectal biopsy, and a contrast enema, indicating the location of the transition zone, was performed in all patients prior to the pull-through.

The operation was performed either completely transanally (TERPT) or in combination with laparoscopic or laparotomy assisted colonic mobilization (LERPT). A senior consultant either operated or assisted at all operations at all institutions. In some patients a biopsy was taken through a small umbilical incision for exclusion of long-segment HD, and the rest of the operation was performed completely transanally as a TERPT. In patients having a stoma closed simultaneously with the endorectal pull-through, colon was mobilized together with the stoma closure. In all patients a transanal mucosectomy leaving a short muscle cuff was performed. The mucosectomy started approximately 5 mm above the dentate line and continued for 2–4 cm [7]. Then, the muscle cuff could be pulled downwards and incised circumferentially. Further dissection of the bowel was continued strictly on the bowel wall. During TERPT, colonic mobilization was performed until the transition zone. If an umbilical biopsy had not been taken at the start of the operation, a frozen section biopsy was obtained to confirm that ganglionic bowel was pulled down to the anal canal. Any dilated bowel above the transition zone was resected together with the aganglionic bowel. For those who underwent LERPT, the transanal mobilization was continued to the level where the colon or rectum had been mobilized from above. A hand-sewn coloanal anastomosis with interrupted sutures was performed in all patients, and no incision in the muscle cuff was performed. The coloanal anastomosis was calibrated in the outpatient clinic during the first postoperative weeks. If the anastomosis felt tight, either the parents continued daily dilatations at home for some weeks, or dilatations were performed regularly in the outpatient clinic.

1.3. Acquisition of data

Demographic and clinical details were recorded retrospectively from medical record and included birth weight, associated syndromes and anomalies, family history, presenting symptoms, various surgical details including postoperative complications and reoperations, and occurrence of Hirschsprung associated enterocolitis (HAEC).

Present bowel function was assessed using a bowel function score (BFS) questionnaire developed for assessment of bowel function in pediatric anorectal disorders and validated in patients and in the general population [5,8–10] (Table 1). Soiling refers to fecal staining of underwear, fecal accidents to leakage of fecal contents needing change of underwear or use of protective aids, and constipation was defined as need of a special diet, laxatives or enemas. Patients with a stoma or an appendicostomy for antegrade colonic enemas did not fill out the BFS questionnaire. In addition, there was also a questionnaire for registration of HAEC episodes and milk intolerance. The questionnaires were sent by post and filled out by the patients or the parents, given to the patients or parents at outpatient clinics or filled out by a specialized nurse during a telephone interview. Those who did not return the questionnaires or could not be reached by phone, were sent a reminder. None of the surgeons that had treated the patients were involved in collection of the postoperative functional outcome data.

1.4. Definitions

For comparison of results after TERPT and LERPT, those who had an umbilical biopsy, were grouped as having TERPT because no colonic mobilization was done through the umbilical incision. TERPT converted to LERPT were also classified as TERPT. If a stoma was closed simultaneously as the pull-through, the patient was excluded for this particular

Table 1
Bowel function score questionnaire.

Factor	Score
Ability to hold back defecation	
Always	3
Problems <1/week	2
Weekly problems	1
No voluntary control	0
Feels the urge to defecate	
Always	3
Most of the time	2
Uncertain	1
Absent	0
Frequency of defecation	
Every other day to twice a day	2
More often	1
Less often	1
Soiling	
Never	3
Staining <1/week, no change of underwear required	2
Frequent staining, change of underwear often required	1
Daily soiling, requires protective aids	0
Fecal accidents	
Never	3
Fewer 1/week	2
Weekly, requires protective aids	1
Daily, requires protective aids day and night	0
Constipation	
No constipation	3
Manageable with diet	2
Manageable with laxatives	1
Manageable with enemas	0
Social problems	
No social problems	3
Sometimes	2
Problems restricting social life	1
Severe social/psychosocial problems	0

The Bowel Function Score questionnaire was used to assess postoperative bowel function in Hirschsprung patients without a stoma or an appendicostomy.

subanalysis because it was impossible in retrospect to assess the extent of transabdominal colonic mobilization.

The need for anal dilatations for more than three postoperative months was defined as a postoperative stricture. To assess predictors of functional outcome, the patients were divided into two groups based on functional outcome. Poor functional outcome was defined as having a stoma, an appendicostomy, needing regular rectal enemas, or having at least daily fecal accidents as recorded on the BFS questionnaire.

The number of postoperative HAEC episodes was based on review of medical journals and information from patients and parents. When HAEC was recorded from medical records, the diagnosis was based on the presence of abdominal distension, diarrhea, and/or vomiting and/or bloody stools with or without fever.

1.5. Statistics

The data are presented as median (range), mean (standard deviation) or frequencies (percentage). IBM SPSS software for Windows version 21.0 (Armonk, NY: IBM Corp.) was used. Categorical variables were compared with a chi-square test. The Gamma coefficient was used as a measure of association of two ordinal variables. Continuous variables were compared between groups with independent samples t-test or Mann–Whitney U-test as appropriate. Predictors for outcome were analyzed using simple and multivariable logistic regression analysis. A P value <0.05 was considered statistically significant.

1.6. Ethics

The regional ethical review boards at each hospital approved the study.

2. Results

2.1. Patients

A total of 258 patients with rectosigmoid HD were operated with a primary transanal endorectal pull-through at the four hospitals until 2010. The technique was introduced in the departments in Helsinki, Oslo, Stockholm, and Lund in 1987, 1999, 2001, and 2005, respectively. 55/258 patients/parents did not respond, and three were excluded owing to language problems. Consequently, 200 patients (169 males) were enrolled. 75, 68, 30 and 27 patients were recruited from the hospitals in Helsinki, Oslo, Stockholm, and Lund, respectively. Down syndrome was the most common syndrome (16/31); others were Mowat–Wilson syndrome, congenital central hypoventilation syndrome, Currarino syndrome, hypoplastic left heart syndrome, and others.

A dropout analysis comparing included and nonincluded patients showed that nonincluded patients were older. Median age in included patients was 9.5 years (3.9–32) as compared to 14 years (5.2–31) in those that did not take part in the study (p < 0.001). The frequencies of patients with syndromes (15% in included patients and 24% in nonincluded patients; p = 0.14) and operated with TERPT (34% in included patients and 41% in nonincluded; p = 0.1) were similar.

2.2. Operative details

Median age at transanal endorectal pull-through was three months (0.4–133). The various operative approaches are outlined in Table 2. Four of the five patients who had TERPT converted to LERPT, were operated in the early period after TERPT introduction, and the last patient had multiple adhesions after a previous laparotomy

2.3. Surgical complications

Three patients (1.5%) developed anastomotic leakage which was treated with a decompressive proximal enterostomy, antibiotics and drainage. One of them also had a fistula to the seminal vesicle. The

Table 2

	Included patients (n = 200)	Not-included patients (n = 58)	P
Age (years)	9.5 (3.9–32)	14 (5.2–31)	<0.001
Syndrome	31 (15%)	4 (24%)	0.14
TERPT	67 (34%)	7 (41%)	0.17

Operative details for Hirschsprung patients with rectosigmoid aganglionosis. Numbers and frequencies (%) are given.

enterostomies were closed in all three some months later. Anastomotic stricture occurred in 19 patients (10%), and all were successfully treated by anal dilatations. A redo endorectal pull-through was performed in three patients (1.5%) owing to twisted pulled-through colon, fistula to the urethra or transition zone pull-through. The initial operative approaches were LERPT in two and TERPT in one patient. Other recorded complications were adhesive bowel obstruction (n = 4), stoma needing revision (n = 2), wound infection and/or dehiscence (n = 4). In addition, a myectomy or one or more intersphincteric injections of botulinum toxin were performed in five and 22 patients, respectively, to relieve bowel outlet obstruction.

2.4. Postoperative HAEC

HAEC was the initial symptom of HD in 14 children (7%). Information on postoperative HAEC was achieved in 195 patients. Among these, 69 (35%) reported to have had median 2 (range 1–8) HAEC episodes. The HAEC rate was similar in males (58/153, 38%) and females (11/42, 26%; $P = 0.159$). The frequency of HAEC was significantly higher in patients who reported often/always compared to those with rare/never soiling (47% versus 20%, $P = 0.006$). Fecal accidents, constipation or diarrhea was not associated with the number of HAEC episodes (results not shown). Interestingly, patients who got abdominal discomfort of cow's milk had significantly more often experienced HAEC as compared to those who did not get any abdominal symptoms from milk (51% versus 23%, $P < 0.001$). Altogether 73 patients reported some form of discomfort related to milk, but only 22 of these had documented lactose intolerance.

2.5. Long-term bowel function

73/200 (37%) patients reported absolutely no impaired bowel function, meaning that there were no need for bowel management, no constipation, no fecal accidents, and no stoma or appendicostomy. Seven (3.5%) patients had a stoma, and 33 (17%) needed bowel management (appendicostomy (n = 16)) or regular rectal wash-outs (n = 17).

Only patients (n = 177) without a colostomy or an appendicostomy filled out the BFS questionnaire. The majority had more than two bowel movements per day (Table 3), and age was not associated with frequency of bowel movements (gamma = 0.18). Constipation was reported in 44 patients (25%) and was more common in the youngest patients ($P = 0.008$). Also the ability to hold back defecation and recognition of need to defecate were significantly better in the older age groups (gamma = 0.54 and 0.35, respectively).

Soiling and fecal accidents were common and reported in cross-section by 77% and 47% of the patients without a stoma or an appendicostomy, respectively (Table 3). Both soiling and fecal accidents were less common among the older patients (gamma = 0.44 and gamma = 0.34 respectively). Among the teenagers and adults, 93% experienced no fecal accidents or fecal accidents less than once a week as opposed to 76% in those below 13 years ($P = 0.006$).

The majority of patients that filled out the BFS questionnaire reported no social problems related to bowel function. Still, bowel problems caused restrictions in social life or severe social/psychosocial difficulties in 11%. Soiling ($P = 0.001$), fecal accidents ($P = 0.001$), impaired

Table 3

Factor	Overall (%)	4–7 years (%)	8–12 years (%)	13–17 years (%)	>18 years (%)	Gamma/CI/P
Ability to hold back						
Always	51	31	45	78	77	0.54
Problems <1 per wk	22	21	30	7	18	(0.4–0.7)
Problems >1 per wk	24	43	21	3	5	P < 0.001
No control	6	5	4	3	0	
Reports urge to defecate						
Always	44	32	40	53	76	0.35
Mostly	31	30	36	28	24	(0.2–0.5)
Uncertain	17	33	9	8	0	P < 0.001
Absent	8	5	15	11	0	
Frequency of defecation						
< every other day	2	6	0	0	0	0.18
2/day to < other day	45	49	40	40	48	(0.04–0.4)
>2/day	53	45	60	60	52	P = 0.186
Soiling						
Never	23	15	10	42	48	0.44
<1/wk	37	27	48	42	39	(0.3–0.6)
> 1/wk	27	44	25	11	9	P < 0.001
Daily	12	15	17	6	4	
Fecal accidents						
Never	53	44	45	71	74	0.34
< 1/wk	28	30	35	20	22	(0.2–0.5)
>1/wk	19	15	8	6	0	P = 0.072
Daily	9	12	12	3	4	
Constipation						
No constipation	75	62	78	81	100	0.49
Diet	3	1	2	8	0	(0.3–0.7)
Laxatives	13	20	12	8	0	P = 0.008
Enemas	9	16	8	3	0	
Social problems						
No problems	76	72	79	81	74	0.08
Sometimes	13	16	10	11	9	(−0.2–0.3)
Restricted social life	10	10	8	8	17	P = 0.906
Severe problems	1	2	2	0	0	
Total BFS scores	16 (4–20)	13 (5–20)	16 (4–20)	18 (8–20)	19(13–20)	P < 0.001

Long-term bowel function in Hirschsprung patients without any stoma or appendicostomy. Patients are divided into four age groups. Frequencies, 95% confidence intervals (CI) and Gamma values are given. For total BFS scores median, minimum and maximum scores are reported.

sensation (p = 0.001), and impaired ability to hold back defecation (P = 0.006) were significantly correlated to social problems. In contrast, constipation was not related to social problems (P = 0.7).

2.6. Functional outcome in syndromic patients

Bowel problems were significantly more common in the syndromic patients (Table 4). The operative approach was similar in syndromic and nonsyndromic patients as TERPT was performed in 46% and 42% respectively (P = 0.8). As for the total patient population, BFS scores were higher among older than younger syndromic patients (P = 0.04).

2.7. Gender and center related functional outcome

BFS score was comparable in males and females (15.0 ± 3.8 versus 15.2 ± 3.7, respectively), as was poor outcome (27% in males, 30% in females; P = 0.7). 15% of the males were syndromic and 16% of the

females. Mean age at follow-up was 11.9 and 11.7 years in males and females, respectively. LERPT was performed in 54% of males and 58% in females.

The frequency of patients with poor outcome did not differ significantly between the four centers (23%, 23%, 31%, 37%; P = 0.4).

2.8. Predictors of poor functional outcome

Having a syndrome and undergoing TERPT were significantly associated with poor outcome, whereas age at endorectal pull-through and at follow-up did not influence the frequency of poor outcome in the multivariate model (Table 5).

3. Discussion

This multicenter study on a large population of HD patients with rectosigmoid aganglionosis operated with transanal endorectal pull-

Table 4

	No syndrome n = 169	Syndrome n = 31		P
Age at follow-up (years)	9.3 (3.0–32)	10.6 (4–22)		0.475
Age at operation (months)	3 (0.4–133)	3.6 (0.4–59)		0.904
BFS score	15.7 (15.1–16.2)	10.5 (8.6–12.4)	MD:5.2	<0.001
Fecal accidents, daily or >1/week	14%	46%	OR: 5.3 (2.1–13.3)	<0.001
Constipation Laxatives or enemas	19%	40%	OR: 2.8 (1.2–6.9)	0.023
Stoma or appendicostomy	10%	19%	OR: 2.1 (0.8–5.9)	0.143

Bowel function in syndromic and nonsyndromic Hirschsprung patients operated with transanal endorectal pull-through. Median and range are given for age at follow-up and operation, whereas 95% confidence intervals (CI) are presented for BFS scores and Odds Ratio (OR) values. MD refers to mean difference.

Table 5

Parameter	Poor outcome n (%)	Not poor outcome n (%)	Nonadjusted OR (CI)	P	Adjusted OR (CI)	P
Syndrome						
Syndrome	13 (57)	10 (43)	4 (1.9–11.7)	0.001	5.64 (2.1–15.0)	0.001
No syndrome	34 (21)	123 (79)	ref		ref	
Operation						
LERPT	19 (20)	78 (80)	ref		ref	
TERPT	28 (34)	55 (66)	2 (1.1–4.1)	0.03	2.4 (1.1–5.7)	0.038
Age at operation[a]						
Q1 (0.7; 0.4–1)	11 (23)	36 (77)	ref		ref	
Q2 (1.8; 1.0–2.9)	9 (20)	34 (79)	0.9 (0.3–2.3)	0.8	1.4 (0.5–4.2)	0.51
Q3 (4.5; 3–7.5)	14 (31)	31 (69)	1.5 (0.6–3.7)	0.4	2.3 (0.8–6.6)	0.11
Q4 (35.5; 7.9–133)	13 (29)	32 (71)	1.2 (0.5–3.4)	0.6	2.4 (0.8–7.0)	0.10
Age at follow-up (years)	10.0 (SD4.6)	11.6 (SD6.2)	0.09		0.97 (0.9–1.1)	0.47

Logistic regression analysis of predictors for poor outcome in Hirschsprung patients operated with transanal endorectal pull-through. N = Numbers. OR = Odds ratio. 95% confidence intervals (CI) are given for OR.

[a] Patients are grouped in quartiles (Q) according to age. Mean age in months is given along with minimum and maximum age in each group. Poor outcome was defined as having a stoma, an appendicostomy, daily fecal accidents or use of regular enemas.

through shows that a significant number of patients continue to have long-term problems, mainly related to fecal incontinence. We have also shown that syndromic patients have less favorable functional outcome. Our results also suggest that a completely transanal procedure may predispose to long-term bowel functional defects. Importantly, for the majority of the patients overall bowel function and fecal control seem to improve with increasing age.

Fecal incontinence was the most common problem. Twelve percent of the patients had a stoma or an appendicostomy, mainly because of problems related to fecal incontinence. In addition, 39% and 18% of the remaining patients reported soiling or fecal accidents happening more than once a week, respectively. The frequency of fecal incontinence after endorectal pull-through varies considerably in the literature. In a recent retrospective population-based study of 103 patients with rectosigmoid aganglionosis operated with transanal endorectal pull-through, 29% reported fecal incontinence episodes of variable degree more than once a week after a median follow-up time of 15 years [11]. High rates of fecal incontinence are also reported in other recent smaller series [6,12]. On the other hand, fecal incontinence was reported in only 12% in a study of 281 patients operated with endorectal pull-through after a mean follow-up time of 36 months [13], and in another study of patients undergoing endorectal pull-through, none reported fecal incontinence [14]. There are several plausible explanations for the different outcomes in these studies. First of all, most studies are based on retrospective chart reviews of follow-up visits to the operating surgeon, and not by an independent investigator. There is probably a bias in the surgeon's subjective assessment of postoperative fecal continence. Secondly, in studies assessing outcome after HD surgery, there is no uniform definition of fecal incontinence. When fecal incontinence is examined in adults, it is usual to divide into incontinence for either solid or loose stools, soiling, or urgency, and validated questionnaires are used. In the pediatric literature, several different questionnaires are used, and only the BFS questionnaire has data from the normal population. Furthermore, terms like soiling, staining or fecal accidents have different meanings. In some papers soiling refers to staining of underwear, whereas in other reports soiling includes all grades of fecal incontinence. Thus, a consensus on how to define fecal incontinence after surgical treatment for HD would be helpful. Lastly, HD is a rare disease, and very few hospitals treat a large number of patients. Comparison of outcomes obtained from small patient populations is hampered by the lack of statistical power.

Constipation was reported in 25% of patients not having a stoma or an ACE. Of these, 9% needed enemas to manage their constipation and 13% laxatives. Interestingly, among those over 18 years, no one had constipation. Compared to previous studies these numbers are within the range usually reported after endorectal pull-through [11].

When TERPT was introduced, it rapidly gained wide popularity because TERPT does not require any transabdominal or laparoscopic dissection, minimal postoperative pain enables fast recovery, and TERPT leaves no visible scars. Initially, there were concerns about possible damage to the anal sphincters since the bowel is mobilized solely through the anus and therefore the dilatation of the anal sphincters occurs for a longer period than if most of the colon and rectum is mobilized via laparotomy or laparoscopy. Similar manipulation of the anal canal has been shown to be associated with significant problems in adult patients [15]. One of the first studies that aimed at examining possible damage to the anal sphincters after TERPT, found no significant difference in manometric findings or stooling patterns in 26 patients 23 and 14 months after LERTP and TERPT respectively [16]. In another study of 42 patients, continence scores were two-fold better in those with a transabdominal procedure than in those that had undergone TERPT [17], and among 39 patients beyond three years of age, there was an obvious trend towards more soiling in the TERPT group although this did not reach statistical significance [18]. Stensrud et al. performed anal endosonography in 50 patients after endorectal pull-through and found that scar tissue in the internal anal sphincter was significantly more common in those operated with TERPT compared to those operated with LERPT [6]. In these patients scarring of the internal anal sphincter was significantly associated with daily incidents of fecal incontinence. Although some reports indicate more incontinence after TERPT as compared to LERPT, there are other studies showing no significant difference between the two operative approaches. A recent meta-analysis including 405 patients from five studies compared functional results after LERPT and TERPT and did not find any statistical significant difference in postoperative bowel function [19]. All the included studies in the meta-analysis were retrospective, there was treatment selection prior to inclusion, and follow-up times were short. Furthermore, lack of statistical power may also have influenced results. Data from some of the patients in this series were recently published, and the operative approach did not seem to influence outcome in the 57 patients who answered the BFS questionnaire [20]. Our finding of inferior result after TERPT is worrying since TERPT probably is the most popular operation to treat rectosigmoid aganglionosis. However, our study was not designed to compare the two different operative approaches, and we strongly encourage that further studies are performed to specifically compare bowel function after LERPT and TERPT. To efficiently do so, a prospective, randomized, multicenter design should be employed.

Several reports have shown that having a syndrome associates with poor functional prognosis. Our data are in line with these findings as fecal accidents and constipation were significantly more frequent among syndromic than nonsyndromic patients. For this reason, some

authors choose to exclude syndromic patients from their reports of functional outcome [21]. Since functional outcome in syndromic and nonsyndromic patients is so different, this must be taken into consideration when parents are informed about prognosis for their particular child.

Many of those who care for HD patients have an impression that bowel function improves with time [12,22–24]. Older patients not having a stoma or an ACE did better than the younger ones as illustrated by higher BFS scores and better individual parameters of fecal control among the oldest patients. It has previously been shown that minor problems related to fecal staining or constipation are not uncommon in the general population, but that these problems resolve after puberty [10]. For other congenital anorectal conditions it has also been demonstrated that bowel function improves as the patients get older [25]. It is reasonable to presume that patients learn to adapt, contributing to improving fecal control as they get older. Interestingly, contrary to improved BFS scores in the older patients, the percentage of patients reporting socially restrictive bowel problems did not decline with increasing age. This is not surprising since older patients probably are more affected by even minor incontinence problems than younger ones. It is important to take this into consideration in the follow-up of adolescents with anorectal disorders. Lastly, even though most patients experience fewer functional problems at older age, others may not improve with increasing age. In the present series, age at follow-up was not a significant predictor for poor outcome. It is likely that age-related adaption is insufficient in those with the most serious functional problems owing to a technically failed operation causing permanent sphincter damage and/or loss of anal sensation.

When neonatal repair of HD was introduced, it was a concern that particularly incontinence might be a problem. Several studies have shown good short-term results of neonatal repair [26]. Our results support that primary pull-through in babies is safe and that age at operation is not a predictor of poor outcome at long-term follow-up.

Postoperative HAEC was reported in one third of the patients. The frequency of postoperative HAEC varies considerably in the literature, and the use of different definitions of HAEC is probably an important explanation for this variety [27,28]. An interesting finding from our study is that soiling at follow-up was more frequent in those who had experienced postoperative HAEC. Similar findings have been reported from a subgroup of this patient population, and the results from this larger patient population support that there is an increased risk in patients with postoperative HAEC to have problems with fecal incontinence [20]. It has not been reported earlier that those who experience abdominal discomfort from milk, have an increased frequency of postoperative HAEC. We have no apparent explanation for this surprising observation. However, it seems reasonable to inform parents that some form of milk hypersensitivity is common among HD patients, and that those who get HAEC may refrain from cow's milk to test if that affects symptoms.

In addition to the large number of patients, the main strength of this study is that patient-reported functional outcome has been examined by independent staff using an extensively validated questionnaire [5,8,10]. To the best of our knowledge, this is the largest study where long-term functional outcome after transanal endorectal pull-through has been investigated according to these principles. The fact that centers with relatively few patients were included, may also be viewed as an advantage. Many centers in both Europe and the US treat less than ten new HD patients per year, and it is important to report results from such institutions as well, not only series where one surgeon has operated a high number of patients. There are, however, some limitations of this study. Despite the low dropout rate of 20%, it remains unknown whether the functional outcome is different in those who responded and those who did not. The operations at the four centers have been performed according to the same principles. Still, there may have been small variations in the surgical technique. Lastly, the number of postoperative HAEC episodes was based on parents' reports as well as medical records, and it is not unlikely that HAEC episodes may have been missed as well as viral infections may have been interpreted as HAEC.

To conclude, this multicenter study of a large cohort of HD patients with rectosigmoid aganglionosis shows that a significant number of patients continue to have bowel problems for many years after definite surgery, and some have significant problems when they reach adulthood. Although most aspects of fecal control significantly improved with increasing patient age, these findings imply that HD patients need long term follow-up extending into adulthood. Further clinical trials are warranted to clarify whether TERPT is associated with inferior functional outcomes.

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