

Figure Legends

Figure 1 Schematic diagram of the broomstick colonic irrigator

The lateral view of the broomstick colonic irrigator (A), front view of the head (B) and the tail (C) are shown. A colonic irrigation set (Coloclean PC, ALCARE, JAPAN) composed of a cone tip (1), water clamp (2) and irrigation bag was utilized. The silicone tip (1), connected to the irrigation bag via a plastic connector (4) and a vinyl tube (3), is fixed to the head of the handle by a bronze connector (9). The right angle head (6) and the body (5) are separable, which makes the infusion tube (3) pass easily through the handle at the assemblage. A slit and the claws (9) on the tail (7) allow the water clamp (2) to fit in place securely, so that the patient can control the infusion rate and handle position with one hand.

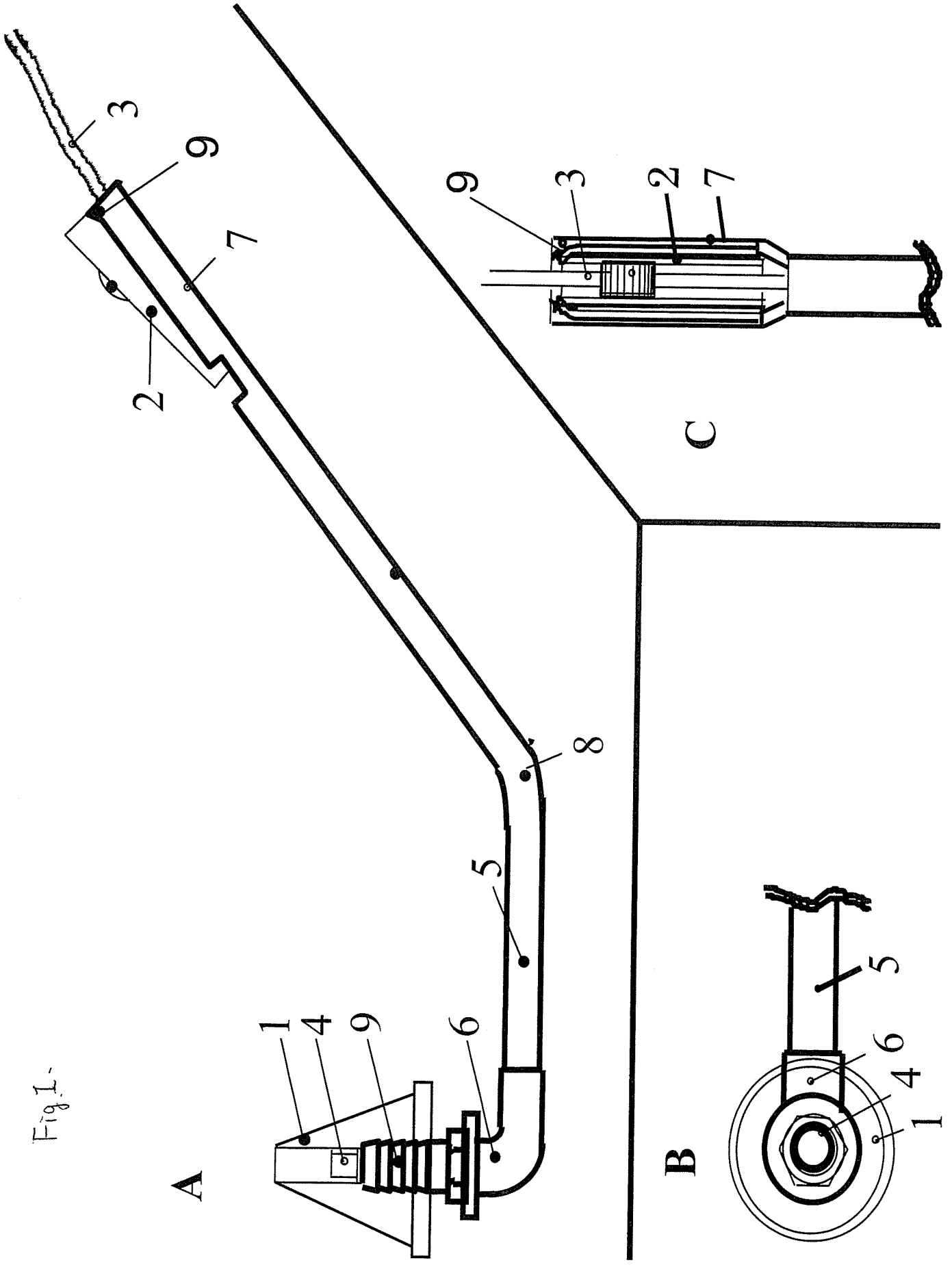
Figure 2 Schematic drawing of retrograde colonic irrigation using the broomstick

First, the cone tip (a) is placed on the anus, and the angular portion of the stick is on the anterior edge of toilet seat (b). Then the tail of the stick is pushed forward (c) to fix the cone tip securely in the anal canal. Irrigation fluid can be infused into the rectum (e) without backflow. When the patient feels abdominal discomfort or the urge to defecate, the stick is pulled to release the cone tip from the anus. At the release of the cone tip, the irrigation fluid and colonic content are evacuated into the commode. The volume of the irrigation fluid for one wash ranges from 200 - 500 ml. The total volume ranges from 2,000 - 6,000 ml.

No.	Age (years)	Sex	Diagnosis	Cord Tethering	Neurological level (The most caudal segment with normal function)		Brace	Use of wheel chair for community mobility	Anorectal functions
					Sensory	Motor			
1	8	Male	Lumbosacral meningocele	yes	S4-5	S1	none	no	Hyperactive rectum, Flaccid anus
2	12	Male	Lumbosacral meningocele	yes	S2	L3	ankle foot	yes	Hyperactive rectum, Flaccid anus
3	16	Male	Lumbosacral meningocele	yes	L5	L3	ankle foot	yes	Hyperactive rectum, Flaccid anus
4	18	Female	Lumbosacral meningocele	yes	S3	L4	none	no	Hyperactive rectum, Flaccid anus

Table 1, Clinical characteristics of the patients

Fig. 1.-



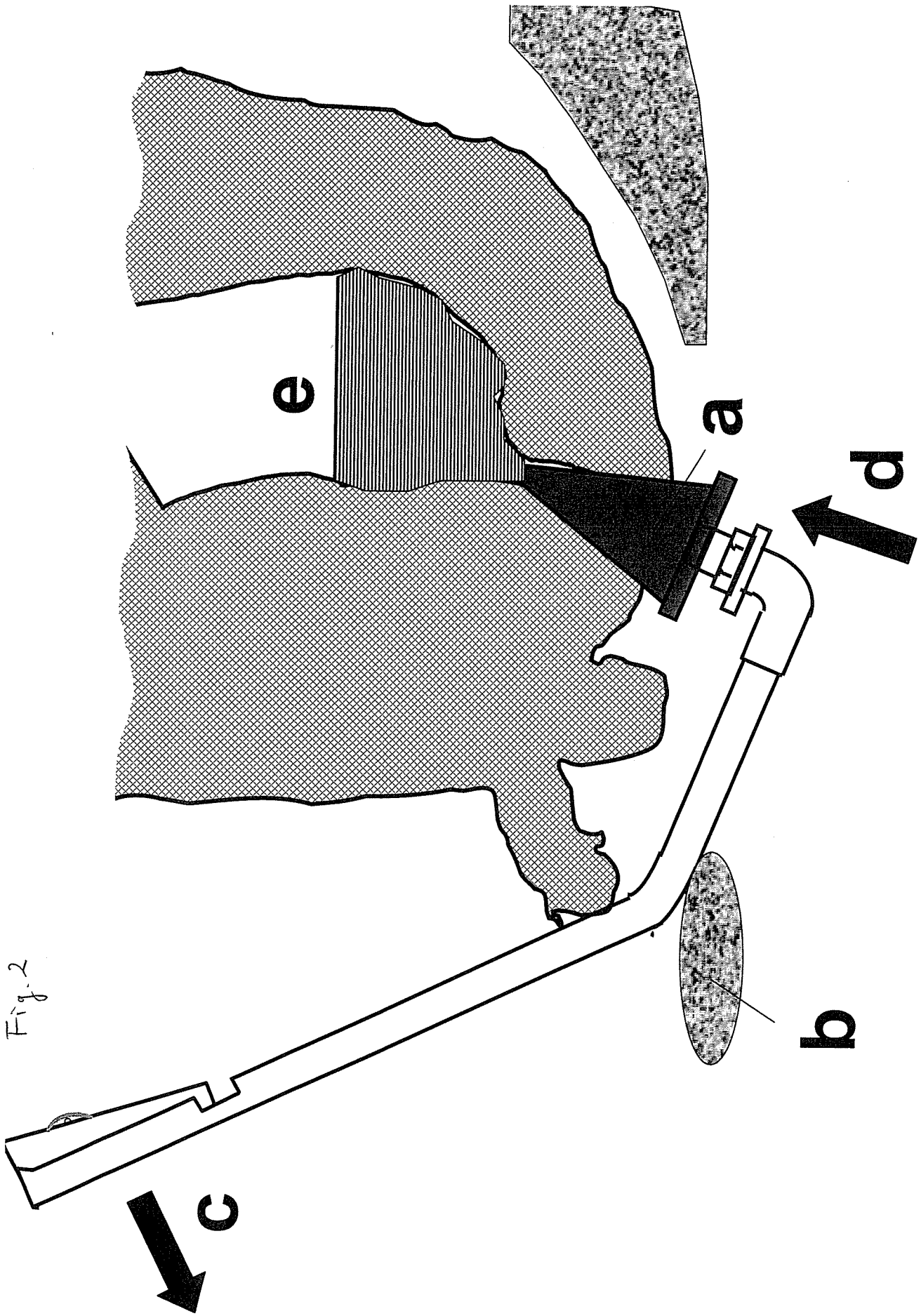


Fig. 2

THE TOHOKU JOURNAL OF EXPERIMENTAL MEDICINE

Vol. 211, No. 2, February 2007

TJEM 211 (2) 99-200 (2007)
PRINT ISSN 0040-8727
ONLINE ISSN 1349-3329

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Published by

TOHOKU UNIVERSITY MEDICAL PRESS, SENDAI, JAPAN

<http://journal.med.tohoku.ac.jp/>

Multiple Clinical Presentations of Anal Ultra Slow Waves and High Anal Pressure: Megacolon, Hemorrhoids and Constipation

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YOSHINO, H., KAYABA, H., HEBIGUCHI, T., MORII, M., HEBIGUCHI, T., ITO, W., CHIHARA, J. and KATO, T. *Multiple Clinical Presentations of Anal Ultra Slow Waves and High Anal Pressure: Megacolon, Hemorrhoids and Constipation*. Tohoku J. Exp. Med., 2007, 211 (2), 127-132 — The physiopathology of idiopathic chronic constipation is complex and yet to be investigated. In the manometric studies of the patients with severe chronic constipation, we noticed that some patients with megacolon show very slow periodical (< 2/min) pressure change in the anal canal, namely ultra slow waves (USWs). USWs are considered to represent the hyperactivity of the internal anal sphincter; however, USW-related clinical presentations have yet to be investigated. We retrospectively re-evaluated the patient records and manometric studies of 85 cases, 51 subjects without defecatory problems and 34 patients with constipation, to elucidate USW-related clinical presentations. USWs were seen in 10 patients, including eight patients with chronic constipation and two subjects without defecatory problems. Out of the eight patients with constipation, one had no organic change in the anorectum, three had hemorrhoids and four exhibited megacolon. Manometric and pathological studies proved that none of the four patients with magacolon was suffering from Hirschsprung's disease. Among the 51 subjects without defecatory problems, only two had USWs. Anal pressure in the USW-positive group (106.0 ± 37.0 cmH₂O) was significantly higher than that in the group without defecatory problems (56.0 ± 27.0 cmH₂O) or constipated patients without USWs (55.0 ± 26.0 cmH₂O). Megacolon and high anal pressure, as well as chronic constipation and hemorrhoids, were the clinical presentations related to USWs. This is the first report to show the clinical relevance of USWs to megacolon. USWs should be recognized as an important manometric finding indicating a possible new clinical entity in chronic constipation.

————— ultra slow wave; manometry; constipation; megacolon; high anal pressure

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Received August 21, 2006; revision accepted for publication December 19, 2006.

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Since anorectal function tests are very common and important diagnostic tools in pediatric surgery, the pediatric surgeons in our hospital are skilled at these tests, and as a result, undertake anorectal manometry of adult patients as well as children. In adult cases, we pay special attention to the verified physiopathology of severe chronic constipation. High anal pressure, hypoactive rectum, diminished rectal sensation, atypical recto-anal reflex and difficulty in straining are pointed out as contributing factors in the physiopathology of idiopathic chronic constipation. Besides anal pressure and recto-anal reflex elicited by balloon inflation in the rectum, we monitor static pressure of the anal canal. The anal canal usually exhibits periodic contractions with a frequency of 10-20/min, which are called anal slow waves. We occasionally encounter very slow but big pressure fluctuations with a frequency of less than 2/min, which are called anal ultra slow waves (USWs).

USWs are considered to represent hyperactivity of the internal anal sphincter because they usually accompany high anal pressure and difficulty in defecation. USWs have been observed in hemorrhoids (Roe et al. 1987; Schouten et al. 1992), anal fissure (Farouk et al. 1994; Bhardwaj et al. 2000), dyschezia (Eckardt et al. 1997) and, infrequently, in normal subjects with high anal pressure (Schouten et al. 1992).

To elucidate multiple facets of USW-related

clinical symptoms, we re-evaluated accumulated manometric recordings and selected USW-positive patients. We propose megacolon as one of the dominant clinical presentations of patients with USWs.

MATERIALS AND METHODS

We retrospectively re-evaluated patient records containing manometric studies of 85 cases: 51 subjects without defecatory problems and 34 patients with constipation. Eight out of the 51 subjects without defecatory problems, and 9 out of the 34 patients with chronic constipation, were diagnosed with central nervous system (CNS) diseases. Computed tomography or magnet resonance imaging was taken in all of the symptomatic patients suspected of having CNS diseases. Poor activities of daily living, such as leg weakness and cognitive disturbance secondary to brain attack or other causes, were recognized in eight subjects without defecatory problems and six patients with chronic constipation. The clinical backgrounds of the 85 cases are summarized in Table 1. The manometric recordings were obtained at Akita University Hospital and Fujiwara Memorial Hospital. All the recordings were of good quality for at least 15 min, allowing anal resting pressure profile for more than five minutes, which allowed us to make a correct judgment regarding the presence or absence of USWs. As a consensus definition of constipation, Rome II criteria for constipation (Lembo and Cam 2003) were applied to all the cases. The ethical committee of Akita University School of Medicine approved the methods

TABLE 1. Clinical backgrounds of the cases.

	<i>n</i>	Age (year)	Sex (Female/Male)	CNS diseases	Poor ADL	
No defecatory problems	51	71.6 ± 12.3	35/16	Cerebral bleeding	3	
				Cerebral infarction	3	8
				Epilepsy	1	
				Parkinson's syndrome	1	
Chronic constipation	34	68.0 ± 17.1	21/13	Cerebral bleeding	3	
				Cerebral infarction	2	
				Subarachnoid hemorrhage	1	6
				Epilepsy	1	
Parkinson's syndrome	2					

CNS, Central nervous system; ADL, Activities of daily living.

and design of this study.

Manometric study

After emptying the rectum by glycerine enema, patients lay with the left side down. One pressure-monitor-probe was positioned in the rectum and another in the anal canal. The transducers (DTS DX-360, Nihon Kohden Co., Tokyo) were connected via an amplifier (AD100F, Nihon Kohden Co.) to a chart recorder (RTA-1100M, Nihon Kohden Co.). Anal resting pressure was measured using the pull-through method. Then, the probe was positioned at the point of maximal pressure in the anal canal to determine the presence (or absence) of USWs and recto-anal inhibitory reflex elicited by balloon inflation in the rectum.

Criteria for USWs

There still remains confusion regarding the criteria for USWs. Based on previously reported criteria, we proposed the criteria described below to exclude some USW-like conditions.

- 1) Rhythmical pressure fluctuations with a frequency less than 2/min
- 2) Amplitude greater than 25 cmH₂O
- 3) Lack of synchronicity with rectal contractions
- 4) Lack of complete disappearance of anal slow waves at the nadir of the wave

The first two criteria for USWs were proposed by Hancock (1976). The second criterion is required to exclude the weaning and waxing of slow waves which may cause periodic change in the shape of the waves without prominent fluctuations of the basic pressure (Fig. 1C). Furthermore, we added the last two criteria to exclude a series of recto-anal reflexes characterized by synchronous rectal contractions and anal relaxations accompanying inhibited slow wave activities (Fig. 1B).

Statistical analysis

All measured values were presented as the means \pm s.d.s. When comparing three or more groups of data, the Scheffe F-test was used as a post hoc test, and significance was set at a value less than 0.05 after analysis of

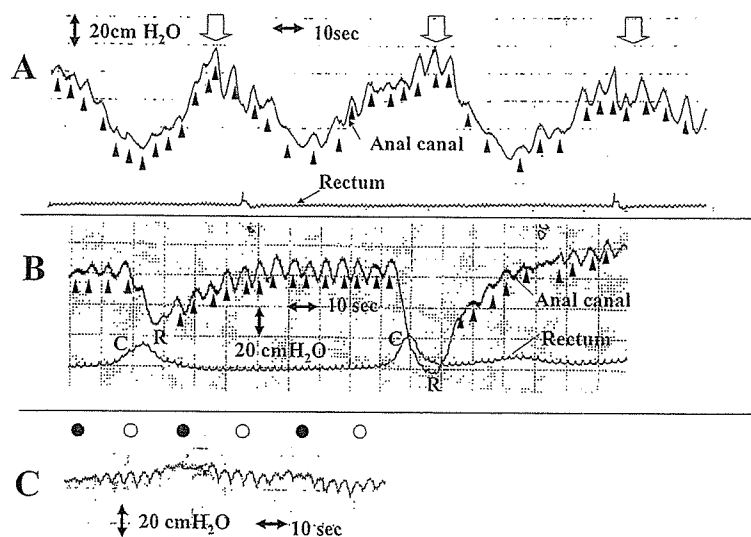


Fig. 1. USWs and USW-like tracings to be distinguished.

A: Low frequency (< 2 /min) and high amplitude are the characteristic features of USWs (open arrows). Slow waves are also well recorded (arrow heads) in this tracing. Note the presence of slow waves at the nadir of USWs.

B: A series of recto-anal reflexes (R) evoked by repeated rectal contractions (C) causes periodical pressure fluctuations with a low frequency and a high amplitude mimicking USWs. Note that slow wave activities are inhibited during anal canal relaxations.

C: Weaning (●) and waxing (○) of slow wave may cause periodic changes in the shape of the pressure curve. It looks like a train of spindles. The spindles have pressure fluctuations within the amplitude of slow waves but lack dynamic change in the basic pressure.

variance. In retrospective analysis of the 85 cases, five clinical variables, namely, chronic constipation, hemorrhoids, megacolon, high anal pressure (defined as a resting pressure $< \text{or} = 100 \text{ cmH}_2\text{O}$) and sex, were tested for the evaluation of attributing factors for the presence of USWs using the odds ratio (OR \pm 95% Confidence Intervals) and chi-square test of significance for categorical data.

RESULTS

USWs were seen in 10 patients for an overall prevalence rate of 11.9%. The frequency and amplitude of USWs were $1.16 \pm 0.43/\text{min}$ (range 0.55-2.0) and $59.8 \pm 33.2 \text{ cmH}_2\text{O}$ (range 30-140), respectively. The clinical characteristics of the 10 patients are summarized in Table 2. Out of the 10 patients with USWs, eight patients were suffering from chronic constipation (prevalence rate in

TABLE 2. Characteristics of the cases with USWs.

Case	Age (y)	Sex	Symptoms				Manometric findings	
			Chronic constipation	Hemorrhoids	Megacolon	Others	RAR	Anal pressure (cmH ₂ O)
1	27	f	no	no	no	Lumbar disk hernia	(+)	90
2	29	m	yes	no	yes		(+)	100
3	46	m	yes	no	yes	Epilepsy	(+)	120
4	53	m	yes	no	no		(+)	80
5	69	m	yes	yes	no		(+)	140
6	74	f	yes	no	yes	Dementia	(-)*	183
7	77	f	no	no	no		(+)	75
8	78	m	yes	yes	no		(+)	130
9	79	m	yes	no	yes	Parkinsonism	(+)	80
10	85	f	yes	yes	no		(+)	60

* Ganglion cells were seen in the rectal wall.

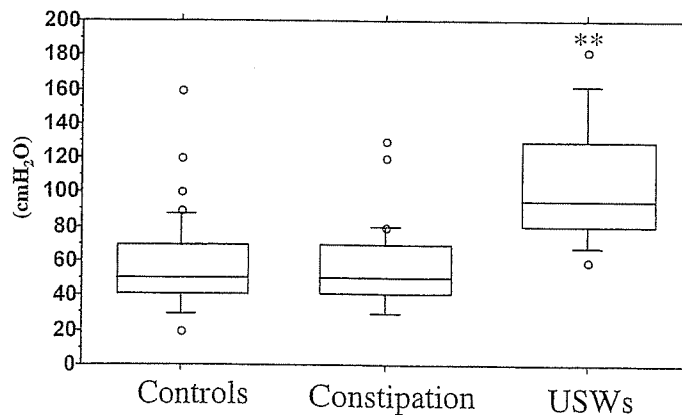


Fig. 2. Diagram illustrating high anal resting pressure in patients with USWs.

The anal resting pressure of patients with USWs was significantly higher compared with other groups. The top, bottom and line through the middle of the box correspond to the 75th percentile, 25th percentile and 50th percentile, respectively. The whiskers extend from the 10th percentile and to the 90th percentile.

** $p < 0.0001$.

TABLE 3. Odds ratios for USWs with selected clinical characteristics.

Factors	USWs (+)		USWs (-)		OR	95% CI
	Factor (+)	Factor (-)	Factor (+)	Factor (-)		
Constipation	8	2	26	49	6.00	1.36 to 26.56
Hemorrhoids	3	7	0	75	11.71	5.77 to 23.79
Megacolon	4	6	1	74	10.67	4.40 to 25.86
Anal pressure >100 cmH ₂ O	5	5	5	70	7.50	2.63 to 21.42
Male	6	4	23	52	2.90	0.89 to 9.46
CNS disorders	4	6	13	62	2.67	0.85 to 8.41

OR, odds ratio; CI, confidence interval.

constipated patients = 23.5%). Out of the eight patients, three had hemorrhoids, four exhibited megacolon and one had no organic change in the anorectum. Out of the four patients with megacolon, three had central nervous system disorders. Among the 51 subjects without defecatory problems, only two (3.9%) had USWs. Recto-anal reflex was absent in one patient with megacolon (case 6) who showed hyper-plastic ganglion cells in the rectal wall. Anal pressure in the USW-positive group (106.0 ± 37.0 cmH₂O) was significantly higher than that in the groups without USWs (subjects without defecatory problems: 56.0 ± 27.0 cmH₂O and constipated patients: 55.0 ± 26.0 cmH₂O) (Fig. 2). Based on the clinical characteristics of the 10 patients, chronic constipation, hemorrhoids, megacolon, high anal pressure (resting pressure of 100 cmH₂O or more) and sex were tested as possible attributing factors for the presence of USWs. Among these factors tested, chronic constipation, hemorrhoids, megacolon and high anal pressure had high odds ratios with statistical significance (Table 3).

DISCUSSION

After the report by Wankling et al. (1968), USWs have been described in several clinical conditions closely related to chronic constipation such as hemorrhoids (Roe et al. 1987; Schouten and Blankensteijn 1992) and anal fissures (Farouk et al. 1994; Bhardwaj et al. 2000). The prevalence rate of USWs in normal subjects varies in each report (Caplan et al. 1964; Wankling et al. 1968). Among these published reports, the first

one, by Wankling et al. (1968) has an exceptionally high prevalence rate (70%) in normal subjects. The large diameter (1 cm) of the pressure sensor inserted in the rectum utilized by Wankling et al. (1968) might have affected the prevalence rate. The average rate of USWs in normal subjects calculated from recently reported studies (Schouten and Blankensteijn 1992; Farouk et al. 1994; Eckardt et al. 1997) is 5.13% (4/78), which is compatible with our results.

USWs are considered to be smooth muscle activity because the induction of anesthesia or the complete paralysis of the external anal sphincter has no effect on them (Wankling et al. 1968). Interestingly, USWs are accompanied by high anal pressure; therefore, they are considered to represent hyperactivity of the internal anal sphincter. The underlying mechanism of the high anal pressure and the emergence of USWs has yet to be investigated; however, USWs have multiple clinical presentations such as hemorrhoids, chronic constipation, anal fissure and megacolon. Furthermore, as shown in this study, three patients with megacolon had central nervous system disorders. The association between megacolon and disorders of the central nervous system such as Parkinson's disease (Caplan et al. 1964; Kupsky et al. 1987) and depression under medical treatment (Ross et al. 1998) is known, but the association of USWs in such conditions has yet to be reported. The multiple presentations that have been reported may share a common physiopathology caused by hyperactivity of the internal anal sphincter presenting as high anal pressure and

USWs on manometric study. Long-standing constipation caused by high anal pressure may be an attributing factor for the formation of hemorrhoids and, in some cases, megacolon, as presented in this study.

Lateral sphincterotomy, forceful anal dilatation and Lynn's myectomy (Ohashi et al. 1985), which has also been utilized in the treatment for selected cases of Hirschsprung's disease (Suzuki et al. 1970), are reported to be effective for the management of clinical symptoms of high anal pressure. Recently, topical use of cream containing nitrogen oxide has been recognized as a non-invasive and effective medical treatment for the symptoms associated with anal high pressure (Bhardwaj et al. 2000; Singh et al. 2004).

In conclusion, USWs should be recognized as an important manometric finding in patients with high anal pressure and internal anal sphincter hyperactivity.

Acknowledgments

This research was funded through a Health Labour Science Grant for Comprehensive Research on Aging and Health (H16-Chozyu-026) supported by the Ministry of Health, Labour and Welfare, Japan.

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Anal ultra slow waves and high anal pressure in childhood: A clinical condition mimicking Hirschsprung's disease

Running head: Anal ultra slow waves in children

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Abstract

Purpose: Anal ultra slow waves (USWs) have been described in several clinical conditions closely related to chronic constipation associated with high anal pressure; however, USW-related clinical manifestations in childhood are poorly understood. The purpose of this study is to elucidate the clinical relevance of USWs in childhood.

Methods: Manometric recordings of 118 cases including 70 children with constipation and 16 patients with Hirschsprung's disease were analyzed.

Results: USWs were seen in 4 of 70 children with constipation. None of the controls or patients with Hirschsprung's disease exhibited USWs. The four infants were two infants with marked abdominal distension mimicking Hirschsprung's disease and two children aged 4 and 8 years with intractable constipation accompanying hemorrhoid or anal fissure. The manometric findings of the USW-positive patients showed a markedly high anal resting pressure and high frequency of slow waves compared with controls, patients with constipation not accompanied by USWs or patients with Hirschsprung's disease.

Conclusion: Children with USWs exhibit symptoms mimicking Hirschsprung's disease in infants and chronic intractable constipation in older children. In manometric studies of children, more attention should be paid not only to RAR but also USWs.

Key Words

Ultra slow wave, manometry, constipation, children, high anal pressure

Introduction

Anal ultra slow waves (USWs), a series of spontaneous pressure fluctuations of the anal canal with a frequency of less than 2/min, were introduced in clinical medicine as a smooth muscle activity in 1968 by Wankling et al¹. Since then, USWs have been described in several clinical conditions closely related to chronic constipation such as hemorrhoids^{2,3}, anal fissure³⁻⁵ and dischezia⁶. Interestingly, USWs are usually associated with high anal pressure, and they are considered to represent hyperactivity of the internal anal sphincter; however, USW-related clinical manifestations in childhood and their physiopathology are not fully understood yet. To elucidate these issues, we evaluated the manometric recordings of 118 cases and found 4 cases positive for USWs including two infants with marked abdominal distension mimicking Hirschsprung's disease and two children with intractable constipation accompanying hemorrhoid or anal fissure. Analysis of their clinical characteristics and anorectal functions is presented. The clinical relevance to "high anal pressure syndrome"⁷ is also discussed.

Material and Method

Patients

One hundred and eighteen manometric recordings of children were analyzed. Eighty-six of these recordings were obtained from children suffering from constipation, including 16 patients with Hirschsprung's disease, a major population suffering from severe constipation in infancy, and 70 patients with idiopathic chronic constipation. None of the patients with Hirschsprung's disease had undergone surgical treatment. Thirty-two children without defecatory problems participated as controls. Other congenital disorders such as spinal dysraphism and anorectal malformations affecting anorectal functions were excluded from the present study. Characteristics of each group are summarized in Table 1. The manometric recordings were obtained at Akita University Hospital and Fujiwara Memorial Hospital during the period from 1979 to 2005. All the recordings were of good quality for at least 15 minutes, allowing anal resting pressure profile for more than five minutes. As a consensus definition of constipation in infants and children, Rome II criteria for constipation⁸ were applied to all the cases except those in the early infantile period when their stool is usually soft even if the patient has defecatory problems. Rome II criteria for constipation in infants and children are 1) pebble-like, hard stools for a majority of bowel movements for at least 2 weeks, 2) firm stools <2 times per week for at least 2 weeks and 3) no evidence of structural, endocrine, or metabolic disease.

Anorectal function tests

The series of anorectal function tests utilized in this study are described below. The

details of the procedures and the classifications of these test-results have been described elsewhere⁹. Informed consent was obtained from all participants.

Anal canal pressure and recto-anal reflex (RAR)

In brief, after emptying the rectum by glycerine enema, patients lay with the left side down. One pressure-monitor-probe was positioned in the rectum and another in the anal canal. The transducers (DTS DX-360, Nihon Kohden Co., Tokyo, Japan) were connected via an amplifier (AD100F, Tokyo, Nihon Kohden Co., Japan) to a chart recorder (RTA-1100M, Nihon Kohden Co., Tokyo, Japan). Anal resting pressure was measured using the pull-through method. Then, the probe was positioned at the point of maximal pressure in the anal canal to determine the presence (or absence) of recto-anal inhibitory reflex elicited by balloon inflation in the rectum.

Saline enema test

After the rectal balloon was removed, pressure fluctuations of the rectum and anal canal were simultaneously recorded before and during saline infusion in the rectum. Saline (150-500 ml) was infused in the rectum at a rate of 5-10 ml/min in infants and 30-50 ml/min in children.

Fecoflowmetry

After the pressure fluctuation curves were recorded, the patient was freed from the pressure monitor apparatus and instructed to sit on the commode to evacuate the saline in the same manner as usual defecation. The saline evacuation curve was recorded with a uroflowmeter (UROFLO-MET SUF200, Sakura Co., Tokyo, Japan). The shape of the evacuation curve, maximum flow rate (ml/sec) and total evacuation time (sec) were evaluated.

Criteria for USWs

Since there are no fixed criteria for USWs besides their low frequency (usually <2/min), USWs are, in some cases, confused with simple wax and wane of slow waves, a series of incomplete RAR elicited by spontaneous rhythmical contractions of the rectum, or subtle baseline fluctuations of the recordings. Therefore, based on descriptions by Hancock¹⁰ and Haynes¹¹, we proposed criteria for USWs as follows:

- 1) Rhythmical pressure fluctuations with a frequency less than 2/min
- 2) Amplitude greater than 25 cmH₂O
- 3) Lack of synchronicity with rectal contractions
- 4) Lack of complete disappearance of anal slow waves at the nadir of the wave

Statistical analysis

All measured values were presented as the means \pm SDs. When comparing three or more groups of data, the Scheffe F-test was used as a post hoc test, and significance was

set at a value less than 0.05 after analysis of variance.

Ethical aspects

Even though the anorectal function tests are common and essential diagnostic procedures in our clinical practice, the children and their parents need to be well-informed about the study. Every anorectal function test was done after obtaining informed consent from the subject. The procedures of the anorectal function test procedures were approved by the Ethics Committee of Akita University School of Medicine (Approval No 334).

Results

Manometric findings

Two infants and two children with constipation were positive for USWs. No USWs were seen in the controls or those with Hirschsprung's disease. When Hirschsprung's disease was excluded, the prevalence rate of USWs in constipated patients was 5.7% (4/70). The manometric findings of the USW-positive patients showed a markedly high anal resting pressure and a high frequency of slow waves (107.5 ± 18.9 cmH₂O and 17.3 ± 3.0 Hz, respectively) compared with controls (57.6 ± 23.7 cmH₂O and 12.5 ± 2.7 Hz, respectively), patients with constipation not accompanied by USWs (54.1 ± 24.9 cmH₂O and 13.9 ± 3.2 Hz, respectively) or patients with Hirschsprung's disease (45.0 ± 20.5 cmH₂O and 10.0 ± 2.0 Hz, respectively) (Figs. 1 and 2). RAR was judged as present in all of the subjects except those with Hirschsprung's disease and one constipated patient with atypical RAR. The frequency and amplitude of USWs in the four patients were 1.06 ± 0.14 (range 0.92-1.20 Hz) and 52.5 ± 13.0 (range 40.0-70.0 cmH₂O), respectively. We had 21 infantile cases with constipation, six of which were highly suspected of Hirschsprung's disease based on their clinical symptoms and history. RAR were exhibited in three of the six infants at the first evaluation while the other three infants, including the two with USWs, failed to show RAR in the first manometric study; however, no particular clinical difference was noted between the three patients.

Saline enema test, fecoflowmetry and clinical presentations of USW-positive cases

Case 1: A one-month-old boy with marked abdominal distension, vomiting and explosive defecation was referred to our hospital. The first manometric tests failed to rule out Hirschsprung's disease, because RARs were poorly reproduced and had no latent time after balloon inflations in the rectum. He was kept under medical treatment with daily glycerin enema for one month. The second anorectal function test at two months of age revealed RARs and USWs (Fig.3). In the six-month follow-up period, he

showed much improvement with suppositories given as needed.

Case 2: A 12-day-old girl was referred to our hospital because of marked abdominal distension, vomiting and explosive defecation. Plain abdominal X-ray film showed marked intestinal gas (Fig. 4, a). Manometry failed to show internal anal sphincter relaxation on balloon dilatation of the rectum. USWs were seen. Suction rectal biopsies showed increased acetylcholinesterase activity at 3 cm; however, ganglion cells were present (Fig. 4, b, c). Barium enema showed no transitional zone. Thyroid function tests were normal. She underwent laparotomy because of partial ileal obstruction caused by an extrinsic band on the 19th day of birth. On the 26th day, ileostomy was performed for persistent intestinal obstruction. The ileum was normal on histological examination. Manometry at two months of age revealed high anal pressure (120 cmH₂O), atypical poorly reproducible RARs and USWs (Fig. 4, d). A series of rectal contractions were seen during rectal saline infusion. Her family moved to another city before definitive diagnosis was made.

Case 3: An eight-year-old girl was referred to our hospital because of constipation lasting since she was two months old when she underwent barium enema of the colon, anorectal manometric studies and suction biopsy of the rectum at another hospital. These tests revealed no abnormality except for an elongated sigmoid colon on barium enema. When she was referred to our hospital, she had spontaneous bowel movements every day with the aid of laxatives. Anal fissure was seen. Reevaluation of her anorectal functions revealed high anal pressure (120 cmH₂O) and USWs. RAR was positive. During a saline enema test, her rectum showed contractions synchronous with relaxations of the anal canal. Fecoflowmetry showed a segmental evacuation curve and a low maximal flow rate (15.1 ml/sec), typical findings in constipated patients (Fig. 5). The total evacuation time was too long to be measured by the flow meter.

Case 4: This four-year-old boy was referred to our hospital because of constipation lasting more than two years. Every time he made an effort to pass hard stool, hemorrhoids were noticed by his mother. The anal pressure was 80 cmH₂O. RAR was positive. USWs were observed before and during a saline enema test. Fecoflowmetry revealed an evacuation curve of segmental type with a low maximum flow rate (15.0 ml/sec) (Fig. 6). During the fecoflowmetric study, he needed intermittent straining for evacuation. The total evacuation time was too long to be measured by the flow meter. After three years of follow-up, he showed improvement with the aid of laxatives and temporal use of suppositories, yet he was still constipated and positive for USWs.

Discussion

Chronic constipation is a common clinical entity for pediatricians or pediatric surgeons. A wide variety of conditions such as Hirschsprung's disease, anorectal anomalies, neural defects and hormonal diseases may cause chronic constipation in infancy and childhood. It is important to differentiate these diseases from idiopathic chronic constipation; however, there may still remain unrevealed clinical entities in so-called "idiopathic constipation". In our series, two infants with USWs had clinical symptoms mimicking Hirschsprung's disease. And two children with USWs were suffering from long-lasting chronic constipation with hemorrhoids in one. To our knowledge, little attention has been paid to USWs accompanying high anal pressure in the evaluation of constipated children. Therefore pediatricians and pediatric surgeons have had no statistical data on the prevalence of USWs among the general pediatric population or children with chronic constipation. In healthy adults, the prevalence rate of USWs ranges from 0.0% to 70.0% (Table 2). The prevalence rate reported by Wankling et al.¹ in 1968 is exceptionally high (70%). The large diameter (1 cm) of the pressure sensor inserted in the rectum utilized by Wankling et al.¹ might have affected the prevalence rate. In addition, absence of definite criteria for USWs may be responsible for the wide range of the prevalence rate in these studies. In our unpublished data, we found two subjects with USWs and high anal pressure out of 34 adults without defecatory problems (prevalence rate = 6.3%), which is consistent with other reports^{2,3}. Considering the fact that our hospital is a tertiary general hospital, the prevalence rate of USWs in the general pediatric population may be much lower than that in our series. As has been reported by other investigators^{2,3,4,6}, USWs are accompanied by high anal pressure and are thought to represent hyperactivity of the internal anal sphincter. Ohashi et al.⁷ reported six children with chronic constipation characterized by 1) megarectum, 2) extremely high anal pressure, 3) present but diminished recto-anal reflex and 4) presence of normal ganglia in rectal biopsy, and they proposed a clinical entity named "high anal pressure syndrome (HAPS)" for such patients. Dilatation of the colon and/or rectum is not rare in severe chronic constipation in children. Three cases out of the four with USWs in our series had a dilated colon or sigmoid colon at the first visit to the pediatric surgical division. The clinical presentations of HAPS resemble those observed in our series; however, Ohashi et al.⁷ did not mention USWs in their report. Exclusion of Hirschsprung's disease is extremely important in evaluating children with severe chronic constipation. It is troublesome to make a correct manometric diagnosis when typical RARs are not recorded in patients with USWs, as in cases 1, 2 and 3 in this study.

We found USWs were rare in Hirschsprung's disease, and there were significant differences in the anal pressure and frequency of anal slow waves between the patients with USWs and those with Hirschsprung's disease. Our data on the low frequency of anal slow waves in Hirschsprung's disease were compatible with the data reported by Faverdin et al¹². Another clinical entity to be discussed is "ultrashort Hirschsprung's disease" or internal anal sphincter achalasia¹³. Patients with ultrashort Hirschsprung's disease have ganglion cells on ordinal rectal suction biopsy but lack RAR, and no transition zone is demonstrated on barium enema. There still remain controversies regarding the criteria for ultrashort Hirschsprung's disease^{14,15}; Lynn's rectal myectomy¹⁶ is a standard treatment. As presented by case 1 in our series, gastrointestinal symptoms accompanied by USWs and high anal pressure mimic Hirschsprung's disease. In the presence of high anal pressure and anal USWs, it would be beneficial for the patient to be re-evaluated, even if definite RARs were not demonstrated at the first evaluation. There is no established treatment for chronically constipated children with USWs and high anal pressure. Ohashi et al⁷ treated chronically constipated children with megarectum and high anal pressure using Lynn's operation with favorable results, though there was no description of USWs. In adult cases, lateral internal sphincterotomy and forceful anal dilatation are effective as surgical treatments for anal hypertonia associated with anal fissure or hemorrhoids^{3,4,17}. As a possible medical treatment for anal hypertonia, topical use of nitrates was proposed^{17,18}. In recent papers, topical nitric oxide was utilized in the treatment after pull through operations for Hirschsprung's disease to improve obstructive symptoms^{19,20}. In our series, three out of the four patients responded well to conventional medical managements such as laxatives, suppository and glycerin enema. Therefore, we have no experience applying nitric oxide to constipated children with USWs and high anal pressure. When high anal pressure in our series was present, topical nitric oxide might have been a rational choice of treatment for these cases.

Though USWs are observed in normal healthy persons, we found a correlation between USWs and adult megacolon in our recent study (unpublished data). Bouchoucha et al.²¹ observed an increase of USWs during maintained rectal distention in normal healthy persons and patients with irritable bowel syndrome. It is yet to be investigated whether USWs are actively playing a causal role in megacolon or passively generated by colonic distention. To understand the physiopathology and rational treatment of chronic constipation in children with USWs, more information is required. The presence of USWs on anoctal manometry may prompt a search for hemorrhoids or an anal fissure in children with intractable constipation. In infants, we would like to emphasize the

fact that two out of the three patients who lacked RAR in the first evaluation were positive for USWs. UWSs may shed light on an un-clarified clinical entity mimicking Hirschsprung's disease. When evaluating chronic constipation in infants and children, attention should be paid not only to RAR but also to USWs.