

障害の病態を中心に検討を行ってきた。排便機能評価法には従来デフェコグラフィー<sup>1)</sup>やシンチグラフィー<sup>2)</sup>、さらに最近ではMRIを用いたものなど<sup>3)</sup>が行われているが、大掛かりな設備が必要であるため、我々は生理食塩水注入腸・排泄による簡便な排便機能評価法を導入した。排便機能とは便を適切に保持し、適切な時と場所で排泄する機能であるが、その障害には直腸、肛門、骨盤底筋群、腹筋などの骨格筋とその支配神経、認知機能を含む中枢神経機能、さらに体の移動を行う能力など多くの要素が含まれる。本稿では、まず簡便な排便機能評価法の概略を紹介し、加齢に伴う変化として片付けられてきた便秘や失禁も広く対象とした検討で得られた所見と、脊椎疾患を有する例で見られた所見について、直腸と肛門機能に焦点をあてて紹介したい。

### I. 排便機能評価法手順

我々が施行している排便機能評価法は通常の直腸肛門内圧(肛門静止圧、随意収縮圧、直腸バルーン刺激による直腸肛門反射の確認など)、生理食塩水注腸時の経時的直腸肛門圧モニター(以下、Saline enema test: SET)、直腸からの生理食塩水排泄曲線記録(以下、fecoflowmetry: FFM)の順に行われる。前処置は当日来院後の浣腸のみである。使用機器の詳細はすでに他誌<sup>4)~6)</sup>に記載してあるが、2チャンネル内圧測定装置(日本光電1台とFFM用の尿流量計1台)の単純な構成である。機器は施設の事情や環境に合わせた選定で良い。尿流量計は種々の解析装置のついた高価なものも販売されているが、単純軽量の維持管理の楽な安価なもので十分である。ただし最高流量は100ml/sec程度まで記録できるほうがよい。以下に手順を記すが、当日の検査目的によって簡略化して行う。FFMのみの場合は極めて短時間で終了する。

- 1) 排便状況の問診
- 2) 診察・局所の観察：肛門周囲知覚・反射性の肛門収縮の有無を確認する。
- 3) 直腸肛門内圧検査：我々は直腸内圧と肛門管圧をオープンチップ式トランスジューサーを介してモニターする。近年では細径の膜型トランスジューサーを用いる施設が増えているが高価である。被験者を左側臥位として大腿を屈曲させ、肛門部の視野を確保する。肛門管静止圧、随意収縮圧、肛門管圧律動波記録、1~2分を周期とするゆっくりとした大きい肛門管の圧変動(以下、Ultra slow wave)の有無、バルーン刺激法による直腸肛門反射定性と定量を行う。
- 4) 生理食塩水注腸時の経時的直腸肛門圧モニター(Saline enema test: SET)：左側臥位のまま、生理食塩水を60~100ml/min程度で直腸内に軟性プラスチックバッグからの自然落下で注入する(Fig. 1A)。高い圧は不要である。通常成人例では250~400ml注入されたあたりから直腸の周期的収縮とそれに同調した肛門管圧の下降がはじまり、徐々に便意が強まる(Fig. 2)。肛門管圧連続下降開始時注入量・直腸連続収縮開始時注入量・最大直腸収縮圧・肛門管と直腸の協調運動パターンなどを測定項目とする。便意が強い場合や、漏れがひどい場合は注入を中止する。注入量が500mlを超えるような場合も原則中止とする。

5) 直腸からの生理食塩水排泄曲線記録(Fecoflowmetry: FFM)：SET終了後測定機器を外し、尿流量計の設置された便座に移動し排出してもらう(Fig. 1B)。いつもと同じに排出できるよう、プライバシーへの配慮が必要である。浣腸が行われていれば便で流量計が詰まったりすることは殆どない。排出曲線では時間軸に沿って流量が表示される。測定項目は、最大流量・排出時間・平均流量・排出量などである。

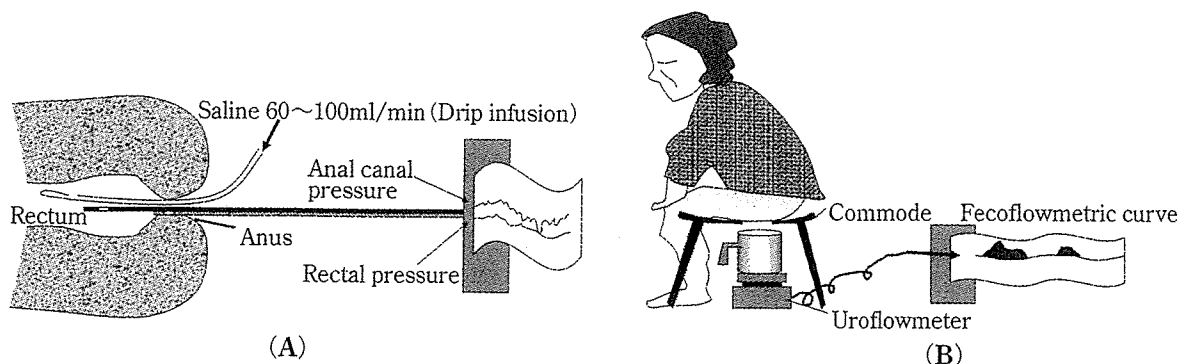
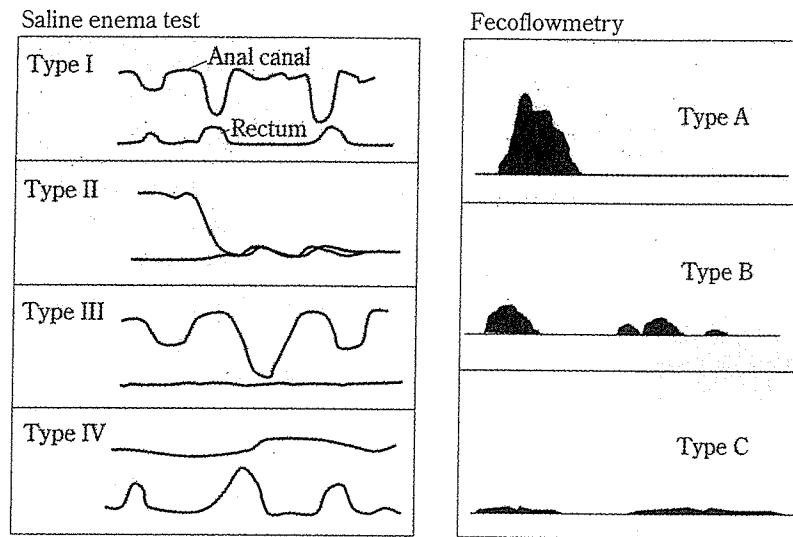


Figure 1 Diagram showing the pressure monitoring in saline enema test (A), and fecoflowmetry (B)



**Figure 2** Classifications of pressure fluctuations of the rectum and anal canal in saline enema test (left panel) and fecoflowmetric curve (right panel).

In type I, which is dominantly seen in normal subjects, the anal canal relaxes periodically synchronous with rectal contractions. Type II is dominantly seen in the patients with fecal incontinence. The pressure of the anal canal drops soon after the beginning of saline infusion in the rectum. Type III, lacking rectal contractions, is often seen in the patients with long-standing constipation. Type IV lacks relaxations of the anal canal in spite of the presence of rectal contractions. Type IV pressure profile may be seen in patients with Hirschsprung's disease. Fecoflowmetric curves are classified into three types. Type A has short evacuation time and a high flow rate. Type B has a segmental pattern of excretion with low flow rate. Type C is usually seen in the patients with severe fecal incontinence whose rectum allows very small volume of saline to be excreted.

## II. SET, FFM のパターン分類

### A. SET パターン

SET 所見は大まかに以下の4型に分類される (Fig. 2)。

**I型** : ある程度の量の生理食塩水を注入していくと、直腸の収縮と肛門管の圧下降が同期して起こり、次第にその収縮と圧下降が大きくなって強い便意が発来するもの。正常例に多い。

**II型** : 生理食塩水の注入で肛門管圧は下降し、直腸圧との較差が消失し、元に復さないもの。直腸収縮圧が下降した肛門管圧を容易に凌駕するため、生理食塩水はすぐに漏れ出てしまうことが多い。便失禁例に多い。

**III型** : I型と同様にある程度生理食塩水が注入されると肛門管の圧下降は連続して惹起されるものの直腸の収縮が伴わないもの。便意も通常欠如する。慢性便秘でしかも治療に抵抗する頑固なものに多い。

**IV型** : III型とは逆に直腸収縮は惹起されるが肛

門管圧下降が同期して起こらないか逆に上昇してしまうもの。ヒルシュスプリング氏病術後症例の一部でみられる。

**V型** : 実際には上記の類型に分類し難いものや、直腸収縮と肛門管圧下降の同期の判定が不能なもの、あるいは記録が不良な例があり、それらは便宜上V型(判定不能)としている。

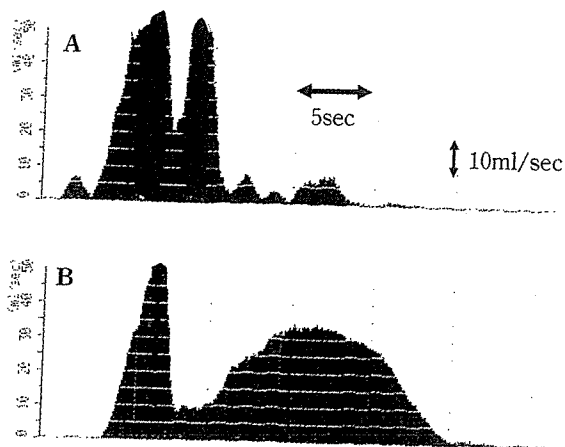
### B. FFM 排泄曲線パターン

FFM の排泄曲線パターンは大きく A : 塊状, B : 分節, C : 平坦の3型に分類できる。

**A型(塊状型)** : 生理食塩水が一気に排出され流量が大きく、排出も十数秒でおわるもの。正常例に多い。

**B型(分節型)** : 排出が小分けに繰り返し行われ、曲線は分節状となる。排出時間は長く、平均流量は低値である。便秘例に多い。

**C型(平坦型)** : 直腸に殆ど生理食塩水を保持できない便失禁例に多く、わずかにたまった食塩水がだらだらと排出される。曲線にはピーク形成はなく、流量は低い。まれに高度な肛門狭窄例でもこの型を



**Figure 3** Typical fecoflowmetric presentations in the subjects without defecatory problems

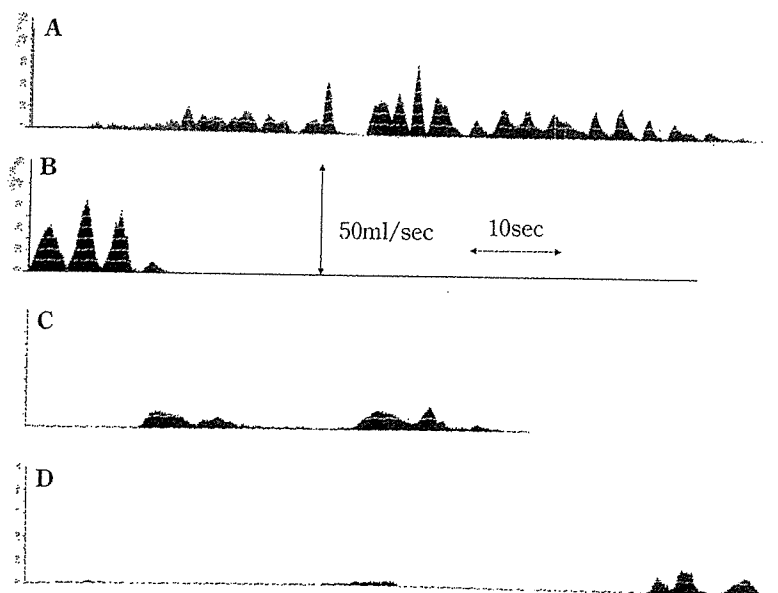
(A) A 76 year old female showed a high flow rate exceeding 50ml/sec. (B) A 64 year old healthy female tolerated 500ml of saline infusion in the rectum. She felt apparent urge to defecate after 400ml of saline was infused. Subjects without defecatory problems could evacuate saline from the rectum within 30 seconds at a high flow rate.

とる。

ただし、実際の測定では各型が種々の程度に混合した型もみられる。すなわち、A型同様に最初に殆どまとまって排出するものの、曲線がいくつかの山の集合体のようにみえるものや、塊状のA型排出曲線のあとに分節状のB型排出曲線が続くものなどがあり、混合成分の度合いに応じて便宜的にA>>B、やA>Bのように記載して用いている。SET-FFM類型の組み合わせは、正常例のではI-A、便失禁例ではII-Cが優勢となる。便秘例ではFFMはB型が優勢であるが、SETは種々の型にばらつきがある。

### III. 高齢者での排便障害とFFMパターンの例

高齢者においても安全にSET-FFM連携法は施行可能であった。排便障害の自覚症状はFFM曲線型にはおおむね反映された。すなわち、排便障害の自覚のないものではFFMで塊状型(Fig. 3)、便秘では分節型(Fig. 4A, B)、便失禁では最大流量の小さい平坦型に近いものが優勢であった(Fig. 4C, D)。



**Figure 4** Fecoflowmetric curves in patients with constipation, and fecal incontinence

(A) A 67 years old male patient suffering from chronic constipation and anal prolapse showed a cluster of small evacuation curves. Only a part of his evacuation curve was presented. It required much effort to accomplish evacuation.

(B) A 79 year old female, often required manual disimpaction because of impacted stool in the rectum, showed a cluster of evacuation with a small volume.

(C) and (D) A 79 years old female patient (C) and 61 years old male patient (D) both represented low flow rate. They could hold very small amount of saline in the rectum.

#### IV. 脊髄に病変がある症例での検討

脊髄の障害がある場合は直腸肛門反射の抑制が弱くなり、直腸肛門反射での過大反応(肛門管圧降下時間の延長)<sup>7,8)</sup>やSETでの直腸収縮と肛門管圧降下が少量の生理食塩水注入で惹起されるなどの反応が出るのが二分脊椎の小児例の検討で確認されている<sup>9)</sup>。高齢者ではしばしば圧迫骨折、椎間板ヘルニア、さらには脊柱管狭窄症脊椎などにより脊髄圧迫症状が出る場合があり、自覚症状に乏しい場合でも排便機能に影響を与えている可能性がある。そこで、脊椎疾患を持つ患者11例(男4例、女7例、年齢61~88歳、平均72歳)でSET、FFMによる検討を行った。対照には特に脊椎病変がなく排便障害もない3例(男1例、女2例、年齢症状66~88歳、平均74歳)でデータを取った。患者11例の疾患内訳は、腰椎椎間板ヘルニア(7例)、腰椎圧迫骨折(2例)、腰部脊柱管狭窄症(1例)、頸椎後縦靱帯硬化症(1例)である。また、排便障害は6例では自覚症状を認めず、3例が便秘、2例が便失禁であった。

SETでは、生理食塩水注入開始後はじめの直腸収縮はコントロール群で平均196mlに対し、脊椎疾患群では92.5mlと有意( $p=0.012$ )に早く、はじめての肛門管圧降下もコントロール群で243.3mlに対し脊椎疾患群では92.5mlと有意( $p=0.046$ )に早かった。

FFMでは連続した直腸収縮のシリーズ形成開始は正常群264.0ml、脊椎疾患146.4mlと脊椎疾患群で早く、これらの結果から脊椎疾患群では上位中枢からの排便反射抑制が減弱していると考えられた(Fig. 5)。

FFM型は対照例では全例塊型であったが、脊椎疾患患者では自覚症状の無いものでも6例中3例は分節型であり、塊型は3例のみであった。便失禁例では平坦型と分節型が各々1例、便秘例では種々の型に分散した。測定項目では、例数が少なく有意差はないものの、脊椎疾患患者では最大流量、平均流量が低く、排出時間は長い傾向が見られた(Fig. 6)。

#### V. 考 案

saline enema test および fecoflowmetry の原型は、各々 Reedら<sup>10)</sup> および Shafikら<sup>11)</sup> により提案されたものである。排便生理の主要な部分である直腸肛門機能を表現する saline enema test、さらに排便行為そのものを数量化できる fecoflowmetry を連携した排便機能評価法(SET-FFM)は簡便性と安全性を兼ね備えている。SET-FFMは直腸肛門の連動運動と排泄曲線とを元にSETは4つの型、FFMは3つの型に分けたが、高齢者においてもおおむねこの分類の使用が可能で、FFM曲線も患者自身の訴えとよく合致するものであった。

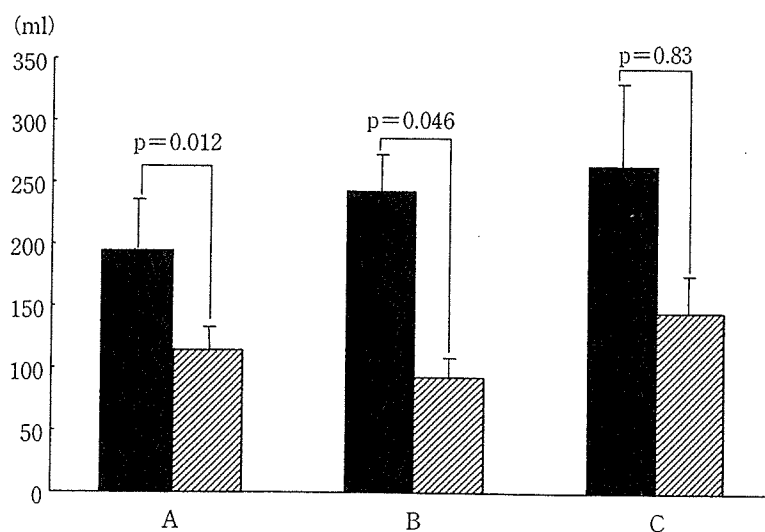
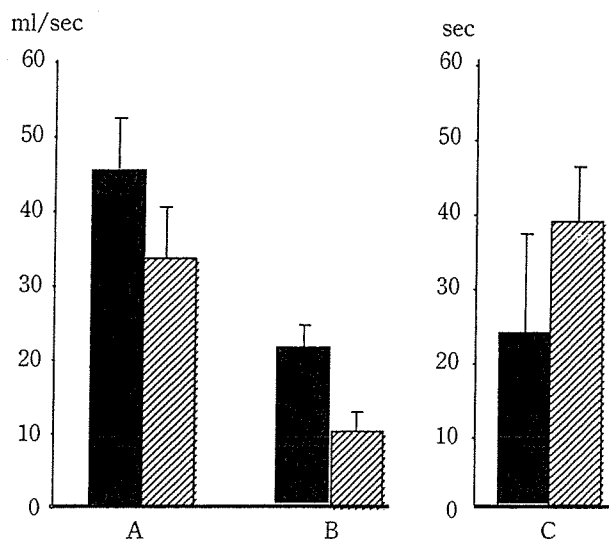


Figure 5 Results of saline enema test

Comparison of the minimal saline volume required to elicit the first rectal contraction(A), relaxations of the anal canal(B), and a series of rectal contractions(C) between controls(filled bars) and patients with diseases of the spine(hatched bars) were shown. Results were expressed as mean values  $\pm$  SE.



**Figure 6** Results of fecoflowmetry

Comparison of the maximal flow rate (A), mean flow rate (B), and evacuation time (C) between controls (filled bars) and patients with diseases of the spine (hatched bars) were shown. Results were expressed as mean values  $\pm$ SE.

高齢者ではしばしば便秘や便失禁などの排便障害が出現するが、加齢に伴う変化として捉えられることが多く、その病態の詳細はあまり検討されない。高齢者では老化に伴って頻度が高くなるものの一つに脊椎病変がある。我々は成人や若年者において脊髄障害を有する患者で肛門機能が障害されることを報告<sup>7)</sup>してきたが、今回の検討において、未だ例数は少ないものの、高齢者においてもやはり直腸肛門機能に影響がみられ、排便反射が起こりやすく、直腸が便を保持できる量も減少している可能性が示唆された。さらに脊椎疾患を有する高齢者は下肢の運動能も障害されている場合が少なくなく、日常生活ではコンチネンスの不安に加えて、適切な移動のままならない状況が生じている可能性がある。

本文では触れなかったが排便機能評価を行った高齢者では筋力低下によりいきみのできないもの、度重なる痔の手術から高度の肛門狭窄をきたして排便が障害されたもの、排泄介護が不十分で直腸に便塊が充満して腸炎を併発して便汁が便塊周囲から漏れ出る状況に陥っているもの、多産のために骨盤低筋群機能が低下し骨盤臓器の下垂を来たしたもの、さらに肛門括約筋の過活動を示す肛門管の高振幅かつ長周期の圧変動である ultra slow wave に巨大結腸を呈する一群の存在<sup>12)13)</sup>が確認されるなど直腸肛門に

限っても種々の病態が関与することが知られた。

昨今の高齢者介護問題が深刻化するにつれ、排泄のケアの問題が取り上げられる機会が増えてきた。介護者や被介護者の精神的・肉体的負担を軽減するためにも、排泄障害の病態を見極めた上での対応が必要と思われ、排便機能障害の病態に合わせた適切な医学・介護・社会的アプローチが重要と思われる。

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

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TAKU HEBIGUCHI,<sup>1</sup> WATARU ITO,<sup>2</sup> JUNICHI CHIHARA<sup>2</sup> and TETSUO KATO<sup>1</sup>

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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 ( $106.0 \pm 37.0$  cmH<sub>2</sub>O) was significantly higher than that in the group without defecatory problems ( $56.0 \pm 27.0$  cmH<sub>2</sub>O) or constipated patients without USWs ( $55.0 \pm 26.0$  cmH<sub>2</sub>O). 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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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
				Epilepsy	1
				Parkinson's syndrome	1
Chronic constipation	34	68.0 ± 17.1	21/13	Cerebral bleeding	3
				Cerebral infarction	2
				Subarachnoid hemorrhage	1
				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 cmH<sub>2</sub>O
- 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

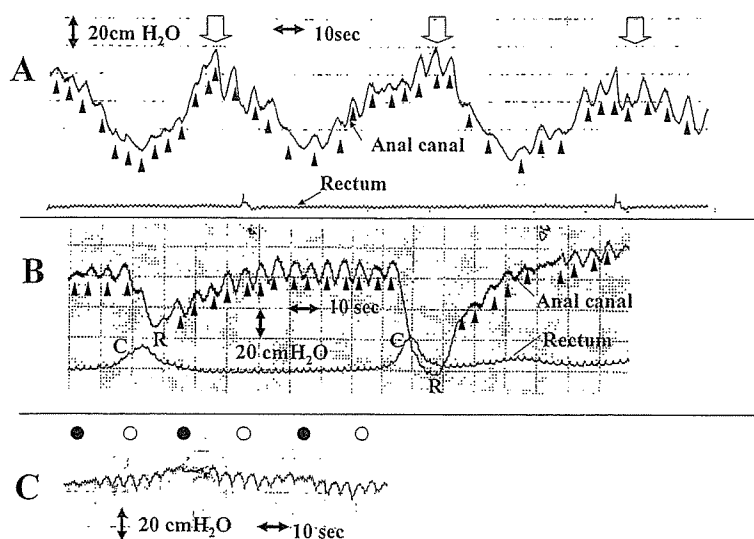


Fig. 1. USWs and USW-like tracings to be distinguished.

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  $\leq 100$  cmH<sub>2</sub>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  $59.8 \pm 33.2$  cmH<sub>2</sub>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 <sub>2</sub> 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.

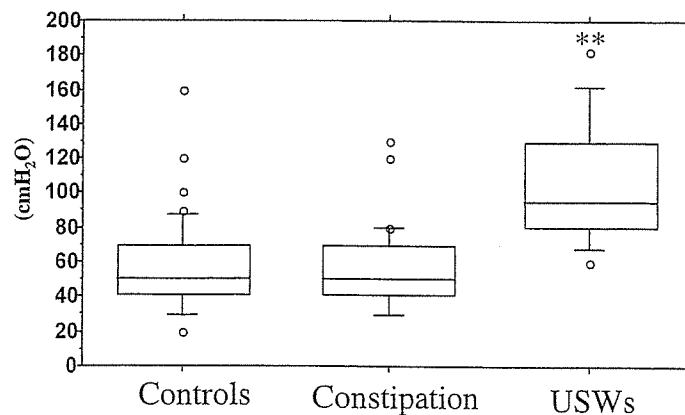


Fig. 2. Diagram illustrating high anal resting pressure in patients with USWs.

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 <sub>2</sub> 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 ( $106.0 \pm 37.0$  cmH<sub>2</sub>O) was significantly higher than that in the groups without USWs (subjects without defecatory problems:  $56.0 \pm 27.0$  cmH<sub>2</sub>O and constipated patients:  $55.0 \pm 26.0$  cmH<sub>2</sub>O) (Fig. 2). Based on the clinical characteristics of the 10 patients, chronic constipation, hemorrhoids, megacolon, high anal pressure (resting pressure of 100 cmH<sub>2</sub>O 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.

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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 al<sup>1</sup>. Since then, USWs have been described in several clinical conditions closely related to chronic constipation such as hemorrhoids<sup>2,3</sup>, anal fissure<sup>3-5</sup> and dischezia<sup>6</sup>. 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"<sup>7</sup> 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 constipation<sup>8</sup> 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 elsewhere<sup>9</sup>. 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 Hancock<sup>10</sup> and Haynes<sup>11</sup>, we proposed criteria for USWs as follows:

- 1) Rhythmical pressure fluctuations with a frequency less than 2/min
- 2) Amplitude greater than 25 cmH<sub>2</sub>O
- 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 ( $107.5 \pm 18.9$  cmH<sub>2</sub>O and  $17.3 \pm 3.0$  Hz, respectively) compared with controls ( $57.6 \pm 23.7$  cmH<sub>2</sub>O and  $12.5 \pm 2.7$  Hz, respectively), patients with constipation not accompanied by USWs ( $54.1 \pm 24.9$  cmH<sub>2</sub>O and  $13.9 \pm 3.2$  Hz, respectively) or patients with Hirschsprung's disease ( $45.0 \pm 20.5$  cmH<sub>2</sub>O and  $10.0 \pm 2.0$  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  $1.06 \pm 0.14$  (range 0.92-1.20 Hz) and  $52.5 \pm 13.0$  (range 40.0-70.0 cmH<sub>2</sub>O), 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 19<sup>th</sup> day of birth. On the 26<sup>th</sup> 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 cmH<sub>2</sub>O), 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 cmH<sub>2</sub>O) 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 cmH<sub>2</sub>O. 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.<sup>1</sup> in 1968 is exceptionally high (70%). The large diameter (1 cm) of the pressure sensor inserted in the rectum utilized by Wankling et al.<sup>1</sup> 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<sup>2,3</sup>. 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<sup>2,3,4,6</sup>, USWs are accompanied by high anal pressure and are thought to represent hyperactivity of the internal anal sphincter. Ohashi et al.<sup>7</sup> 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.<sup>7</sup> 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.