Brief Report

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# Assessment of rectal feces storage condition by a point-of-care pocket-size ultrasound device for healthy adult subjects: A preliminary study

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**Summary** **The aim of this study was to assess rectal feces storage condition by a pocket-size ultrasonography (PUS) in healthy adults so as to define normal rectal defecation desire. Participants were first assessed rectum by PUS imaging immediately after defecation desire (pre-defecation). Nurses checked the amount and quality of the participants' feces using King's Stool Chart and Bristol stool scale. Finally, PUS was performed for defecation with no defecation desire (post-defecation). Pre-defecation PUS detected high echo area in all patients. All of the post-defecation PUS did not detect high echo area (perfectly no recognizable high echo area in 54.5%, high echo line in 36.4%, and low echo of entire circumference in 9.1% of the patients). Average diameter of rectal crescent was 4.22 ± 0.8 cm. Bristol Stool Scale 1 or 2 (indicating hard stool) of pre-defecation PUS indicated high echo area and acoustic shadow in 100% of the patients. This study showed that healthy adult with defecation desire had high average rectal echo area of 4.0 cm in diameter. PUS may be able to define the rectum diameter for defecation desire of elderly people. PUS is capable of assessing fecal retention of the rectum for point-of-care examinations in home care.**

***Keywords:*** Ultrasonography, Constipation, Defecation care, Rectal diameter

## 1. Introduction

Chronic idiopathic constipation is a common functional gastrointestinal disorder in communities (*1*). Elderly patients complain mainly of difficulty in defecating, hard feces, and a feeling of incomplete evacuation (*2*). In addition, constipation degrades quality of life and causes economic burdens for patients and healthcare providers (*3,4*). Therefore, it is very important for healthcare providers to make efforts to prevent chronic constipation and to initiate appropriate assessment to manage the condition in the case of it. For diagnostic tests for constipation, colonic transit, anorectal manometry, balloon expulsion parameters, and various imaging studies (plain abdominal radiography, barium enema, colonoscopy, defecography, abdominal computed tomography, magnetic resonance imaging) are widely recommended as physiologic tests (*5*). However, these procedures have a number of limitations. Plain abdominal radiography, barium enemas, defecography, and computed tomography scanning expose patients to radiation. Colonoscopy is often poorly tolerated by

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patients. Magnetic resonance imaging and defecography are costy and lack standardization (*6*).

On the other hand, transabdominal ultrasonography (US) could be a practical test in primary and point-of-care ultrasonography since it is low cost and fast, and the follow-up test is noninvasive (*7*). Furthermore, point-of-care examinations have come to be used more in home care and bedside by the spread of the pocket-size ultrasonography (PUS) (*8*). Several recent studies have reported cases for which a US technique was used to diagnose constipation for measuring the rectal diameter in children. US images show a fecal mass in the rectum as a crescent-shaped acoustic shadow (*9-14*). Several authors have proposed the use of US as a first-line clinical imaging and initial diagnostic technique for colon (*15,16*). In particular, rectal defecation care for chronic-constipation patients is important in home care setting since the high rate of recurrence of constipation with rectal outlet problems in elderly contributes to complications such as fecal impaction (*17*).

However, there is little information available on sonographic visualization of rectal feces storage condition in adults including elderly people. Since defecation desire of elderly with dementia are unclear, PUS needs to be performed to confirm normal rectal feces storage condition in healthy adults prior to investigation of defecation situation of constipation patients in home care and bedside. The objective of this study is to assess rectal feces storage condition by PUS in healthy adults so as to define normal rectal feces storage condition.

## 2. Materials and Methods

### 2.1. *Patients*

Fourteen healthy adult volunteers (6 men and 8 women; mean age 37.6 ± 10.8 years) underwent rectal US. The subjects had no history of abdominal surgery, irritable bowel syndrome, organic disease, feeling of unsatisfied defecation were excluded. The Ethical Review Board of The University of Tokyo approved the study protocol (#11521). The researchers obtained written informed consent from all volunteers for participation in the study. All participants were free to retract their consent at any time and were encouraged to report any pain or discomfort during the PUS examination.

### 2.2. *Ultrasound technique*

For all of the participants, rectum was assessed by PUS imaging immediately after defecation desire (pre-defecation). Nurses checked the amount and quality of the participants' feces using King's Stool Chart and Bristol stool scale. Finally, PUS was performed after defecation with no defecation desire (post-defecation). PUS was scanned on the abdominal skin approximately 2 cm above the symphysis with the supine position. The resulting PUS imaging was performed with behind a full or partially filled bladder at an angle of approximately 15 degrees downward from the transverse plane (*10*). The sonographic examinations lasted for a total of approximately 5 min. All of the PUS was performed by nurses who had received sufficient PUS training. A PUS system (SONOSITE iViz: PUD-A, Sonosite, Bothwell, WA, USA) with a curvedarray (5 MHz) probe was used. The iViz offers twodimensional imaging and allows adjustments of global gain and depth. Images were compressed and stored for review.

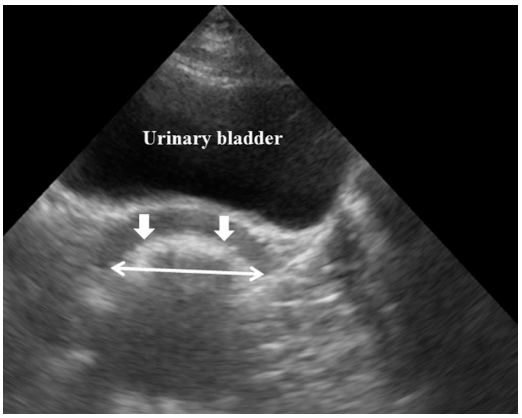


**Figure 1. Presence of feces US image showing a crescent shaped high echoes area in transverse sections (arrows).** Measured rectal crescent (seen behind the urinary bladder).

### 2.3. *Data analysis*

Image J software was used for image analysis and processing. For all of the ultrasound images, transverse rectal diameter from the outer to outer rectum wall was then measured at the level of high echo area three times by two certified sonographers (Figure 1). Two independent certified sonographers evaluated the ultrasound images to ensure inter-rater reliability. All images were evaluated under blind conditions. The relations between the rectal diameters were assessed by Cohen's kappa statistic to establish agreement between the two certified sonographers. All statistical analyses were conducted using SPSS for Windows version 22.0 software (SPSS Inc., Chicago, Illinois, USA). The following variables were recorded: age, gender, amount of defecation after constipation by King's Stool Chart and Bristol stool scale.

## 3. Results and Discussion

Participant characteristics are shown in Table 1. Among the 14 eligible participants, 3 participants were excluded for their feeling of unsatisfied defecation after defecation; thus the final analysis was performed for 11 patients (5 men, 6 women; mean age, 40.1 years; range,

**Table 1. Clinical characteristics of the participants** ($n$ = 11)

| ID | Age | Sex | Bristol Stool Scale | kings stool chart (g) | Measuring rectal crescent (cm) | Pre-defecation US findings | AS | Post-defecation US findings |
|---|---|---|---|---|---|---|---|---|
| 1 | 60 | F | 1 | Less than100 | 3.615 | High echo area | + | High echo line |
| 2 | 32 | F | 2 | 100-200 | 3.935 | High echo area | + | High echo line |
| 3 | 32 | F | 2 | Less than100 | 4.185 | High echo area | + | Low echo of all circumference |
| 4 | 30 | F | 3 | Over 200 | 3.881 | High echo area | - | Low echo of all circumference |
| 5 | 43 | M | 3 | 100-200 | 2.832 | High echo area | - | High echo line |
| 6 | 53 | M | 4 | 100-200 | 4.099 | High echo area | - | Low echo of all circumference |
| 7 | 32 | M | 4 | Less than100 | 4.394 | High echo area | - | High echo line |
| 8 | 30 | M | 4 | 100-200 | 4.490 | High echo area | - | Low echo of all circumference |
| 9 | 55 | M | 4 | Over 200 | 4.861 | High echo area | - | High echo line |
| 10 | 54 | F | 4 | 100-200 | 4.565 | High echo area | + | Low echo of all circumference |
| 11 | 31 | F | 4 | Over 200 | 4.980 | High echo area | - | High echo line |

AS, acoustic shadows.

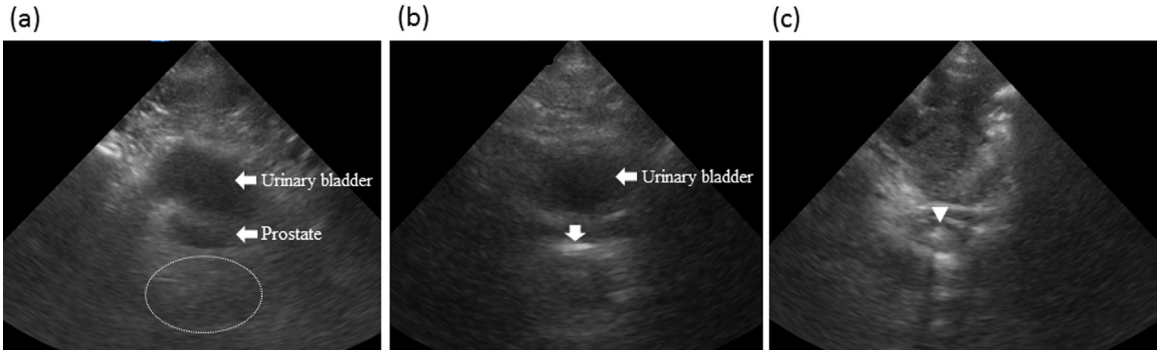


**Figure 2. Absence of feces: (a) US image showing perfectly no recognizable high echo area (circle). (b) US image showing high echo line in transverse sections (arrow). (c) US image showing low echo of all circumference (arrowhead).**

**Table 2. Comparison of Bristol Stool Scale and pre-defecation PUS findings** ($n$ = 11)

| Pre-defecation PUS findings | Bristol stool form scale | | | |
|---|---|---|---|---|
| | 1 ($n$ = 1) | 2 ($n$ = 2) | 3 ($n$ = 2) | 4 ($n$ = 6) |
| High echo area | | | | |
| + | 1 (100.0%) | 2 (100.0%) | 2 (100.0%) | 6 (100.0%) |
| - | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) |
| AS | | | | |
| + | 1 (100.0%) | 2 (100.0%) | 0 (0.0%) | 1 (16.7%) |
| - | 0 (0.0%) | 0 (0.0%) | 2 (100.0%) | 5 (83.3%) |

30-60 years). All of pre-defecation PUS detected high echo area with defecation desire in 100% (11/11). All of post-defecation PUS did not detect high echo area with no defecation desire, perfectly no recognizable high echo area in 54.5% (6/11), high echo line in 36.4% (4/11), and low echo of all circumference in 9.1% (1/11) (Figure 2). Average diameter of the measured rectal high echo areas was 4.22 ± 0.8 cm (Mean ± SD). Table 2 shows comparison of Bristol Stool Scale and pre-defecation PUS findings. Bristol Stool Scale 1 or 2 of pre-defecation PUS findings indicated high echo area and AS in 100%. Intra class correlations (95% CI) for the measured rectal diameters were: inter-rater reliability ($r$ = 0.99).

The present study assessed normal rectal feces storage condition for pre-defecation PUS and post-defecation PUS in healthy adults. The normal rectal with defecation desire indicated high echo area with average 4 cm in diameter, and hard stool correlated with AS since the deep AS indicated loading of hard feces in the colon (*15*). Moreover, all of post-defecation PUS did not detect high echo area with no defecation desire, indicating no residual feces in rectum.

The pelvic US was used in similar studies to evaluate rectal diameter in children (*9-11,13,14*). Children with normal defecation patterns in the studies by Joensson *at al*. (*9*) and Singh *et al*. (*11*) had an average rectal diameter of 2.1 cm and 2.4 cm, respectively. However, US increased the rectal diameter with age in both the patient and healthy groups (healthy

age group were: ≤ 3 years 2.7 cm, 3.1-6.0 years 2.92 cm, 6.1-12.0 years 3.28 cm, and > 12.0 years 3.18 cm) (*12*). Therefore, US of an enlarged rectal diameter cannot be the sole predictor to determine whether a child is constipated (*9*). Moreover, the fecal retention was defined to be present when a stool mass was palpable on digital rectal examination (*14*). However, it is difficult to define fecal retention on digital rectal examination since defecation desire is unclear in children. In this study, PUS detected average 4 cm rectal diameter in healthy adults with defecation desire. In a healthy subject, it may be possible to define defecation desire that represents fecal retention of the rectum. However, elderly people with dementia have difficulty in expressing defecation desire as well as infants. Therefore, rectum diameter greater than 4 cm may be defined as defecation desire of elderly people. In the next step, we have to investigate rectum diameter in elderly people with defecation desire.

US for rectal may be more appropriate for children than for adults because of less attenuation of the ultrasonic beam by subcutaneous fat and muscle, both of which are thinner in pediatric subjects (*18*). Several studies have used high-performance device or portable laptop type ultrasound equipment which can clearly visualize colon of fecal loading in adults (*15,16*). In our study, the authors have found that PUS is capable of clearly visualizing fecal retention of the rectum. We presume that PUS for defecation care tools will someday become an integral part of the physical assessment and be used as frequently as the stethoscope is (*7*) since the elderly population with chronic constipation which require home health care will be increasing (*17*).

The design of this study had some obvious limitations. First, the number of subjects was small. Future studies with large numbers of healthy subjects are required to further examine the use of US for determining the causes of normal rectal defecation status. Second, an additional consideration needs to be given to the dependence of the efficacy of US on operator skill and technique. Finally, PUS evaluation of the colon did not include sigmoid colon since it is difficult to perform a sigmoid colon located in the pelvis due to gastrointestinal gas and complex arrangement (*19*).

In conclusions, this study shows that healthy adult with defecation desire had a rectal diameter greater than 4.0 cm and PUS may be able to define rectum diameter for defecation desire of elderly people. PUS is capable of assessing fecal retention of the rectum for point-of-care examinations in home care.

*Conflict of Interest*

This was a joint research program with FUJIFILM Corporation, and the study was conducted under the sponsorship of this organization.

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