Korean J Gastroenterol Vol. 80 No. 6, 254-261
https://doi.org/10.4166/kjg.2022.111
pISSN 1598-9992 eISSN 2233-6869

ORIGINAL ARTICLE

고식적 항문내압검사를 이용하여 건강한 대상자에서 연령과 성별이 항문 직장 기능에 미치는 효과에 대한 연구

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Effects of Aging and Gender on the Anorectal Function of Healthy Subjects Assessed with Conventional Anorectal Manometry

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Background/Aims: Anorectal functions are influenced by gender and age. This study sought to define the normal anorectal pressure values measured with conventional anorectal manometry (ARM) and to evaluate the effects of age and gender on anorectal function in asymptomatic subjects.
Methods: Conventional ARM was used to measure the anorectal pressures of 164 asymptomatic healthy subjects, including 86 males and 76 females.
Results: The resting anal pressures of males and females aged >60 years were significantly lower than those ≤60 years (males, 44.09±14.22 vs. 57.45±17.69, p<0.001; females, 44.09±14.22 vs. 57.45±17.69, p<0.001). The anal high-pressure zone was significantly lower in older males than in younger males (2.42±0.93 vs. 2.82±0.739, p=0.048). In both age groups (<60 and ≥60 years), the anal squeezing pressures of males were significantly higher than those of females (<60 years old, 168.40±75.94 vs. 119.15±57.53, p=0.001; ≥60 years, 149.61±64.68 vs. 101.3±54.92, p=0.006).
Conclusions: The normal anorectal pressure values measured with ARM in males and females were different. Older males and females had lower anal resting pressures than those of the younger subjects, but squeezing pressure was not affected by age. **(Korean J Gastroenterol 2022;80:254-261)**

Key Words: Manometry; Anal canal; Aging; Sex

Received September 1, 2022. **Revised** November 9, 2022. **Accepted** November 16, 2022.

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Financial support: This work was supported by the Technology Innovation Program (20018499) funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea). The funding source had no role in the design, collection, analysis, or interpretation of the data.

Conflict of interest: None.

INTRODUCTION

It is known that anorectal functions are influenced by age[1] and gender,[2] similar to the lower esophageal sphincter[3] and urinary bladder sphincter.[4] Anorectal disorders such as fecal incontinence, chronic constipation, and dyssynergic defecation are highly prevalent in the elderly.[1] In addition, a recent meta-analysis has found that the prevalence of chronic constipation is almost twice as common in females as in males.[5] The changes in the anorectal physiology with aging are associated with significant alterations in age-related enteric neuronal structure and function.[1] Also, underlying diseases including dementia, decreased mobility, and the late effects of an illness such as diabetes or trauma resulting from anal surgery or childbirth contribute to the increased prevalence of constipation and fecal incontinence.[6] Females may have altered anorectal functions secondary to hormonal changes associated with menopause and childbirth.[2] Vaginal delivery, in particular, if associated with an instrument or prolonged delivery, is considered the most common underlying cause of anorectal dysfunction.[2] Multiparity has been associated with cumulative diffuse injury to the structural supports of the pelvic floor and trauma to the pelvic nerve supply.[2] Menopause has been shown to affect muscle strength, tissue elasticity, and resilience to load-bearing in the pelvis.[2] However, most of the data on anorectal function available in literature is on females. The age-related changes in the anal sphincter function in asymptomatic males have been observed to be minimal in previous studies compared to those in females.[7]

Anorectal manometry (ARM) provides a quantitative measure of anorectal function. The main indications for anorectal manometry are constipation and fecal incontinence which are the most frequent anorectal disorders, but less common indications include functional anorectal pain, megacolon, and megarectum. Recently, high-resolution anorectal manometry (HRARM) and 3D high-resolution manometry (3DARM) have been developed. However, many hospitals still use conventional ARM, which is an inexpensive screening technique and very useful for research on anorectal functions based on age and gender. For conventional ARM, there have been studies that have determined the normal values of ARM in male and female subjects. However, to date, most studies have not included large numbers of healthy subjects. Indeed, anorectal pressures vary largely according to age and gender together. Given this background, this study aimed to define the normal values for anorectal pressures measured with ARM and to evaluate the effect of age and gender on the anorectal function in asymptomatic subjects.

SUBJECTS AND METHODS

1. Study subjects

Subjects who were tested with conventional ARM between October 2003 and June 2020 at Seoul National University Bundang Hospital were retrospectively enrolled and their data analyzed. Subjects with insignificant symptoms such as abdominal discomfort, anal bleeding, anal discharge, anal discomfort, bloating, chronic diarrhea, dyspepsia, and pruritus ani which were considered not to affect the results of ARM were included. The subjects with significant symptoms or diseases such as constipation, incontinence, decreased anal tone, anismus, anal pain, hemorrhoids, anal fissure, anal prolapse, rectal prolapse, anal fistula, anal abscess, pelvic floor dysfunction, Behcet's disease, Crohn's disease, ulcerative colitis, rectocele, colorectal cancer, and anal cancer were excluded. Subjects who had undergone colorectal and anal surgery were also excluded. Finally, 164 subjects including 86 males and 76 females were enrolled and their data were analyzed. This study was approved by the Institutional Review Board (IRB) of the Seoul National University Bundang Hospital (IRB No. B-2111-722-101).

2. Conventional manometry

Before anorectal manometric evaluation, bowel preparation was performed by administering two pills of bisacodyl suppository. The anorectal function testing was performed in the left-lateral position with the hips flexed to 90°. Anorectal manometry was performed using the water-perfusion technique with an 8-channel Micro Tip catheter (Medtronic, Dublin, Ireland) connected to a perfusion pump (Stationary GI Motility System, Laborie, Portsmouth, NH, USA) in the left-lateral position. The physiological parameters included the anal canal resting pressure, squeezing pressure, compliance, defecation index, resting and squeezing vectogram, and the rectoanal inhibitory reflex (RAIR). The rectal sensation was assessed by the inflation of a latex balloon with an airflow of 1 mL per second, and the threshold volumes for the first minimal sensation, desire to defecate, urge, and maximal tolerance

were determined. The balloon expulsion test was carried out with a 50 mL water-filled balloon in the following order: the catheter was lubricated and inserted into the rectum, and then the balloon was filled with 50 mL of water at room temperature. The patients were instructed to sit on a commode chair in the usual defecation position and to pass out the balloon. After waiting for 5 min, patients who could not pass the balloon across the anal canal were considered to have failed the balloon expulsion test.

Conventional manometry used a 4.9-mm-diameter water-perfused catheter with eight channels arranged radially two cm from the catheter tip perfused at 0.6 mL/min, with a balloon attached to the tip to elicit RAIR (Supplementary Fig. 1). The pressure was recorded in cmH_2O relative to the atmospheric pressure. A standard station pull-through technique using 1-cm intervals was used for both resting and squeeze pressure measurements. To elicit the RAIR, the catheter was inserted into the station with the highest resting pressure. Rapid insufflation and desufflation of the balloon with 50 mL of air were performed by hand.

3. Statistical analysis

The continuous variables were summarized using means and standard deviations, while categorical variables were expressed as proportions. We compared the ARM results of the male and female subjects. Comparisons of the categorical outcomes were made using the Fisher's exact test or chi-squared test, and continuous outcomes were compared using a *t*-test or Mann-Whitney *U* tests. Statistical analyses were performed with the SPSS statistical software (version

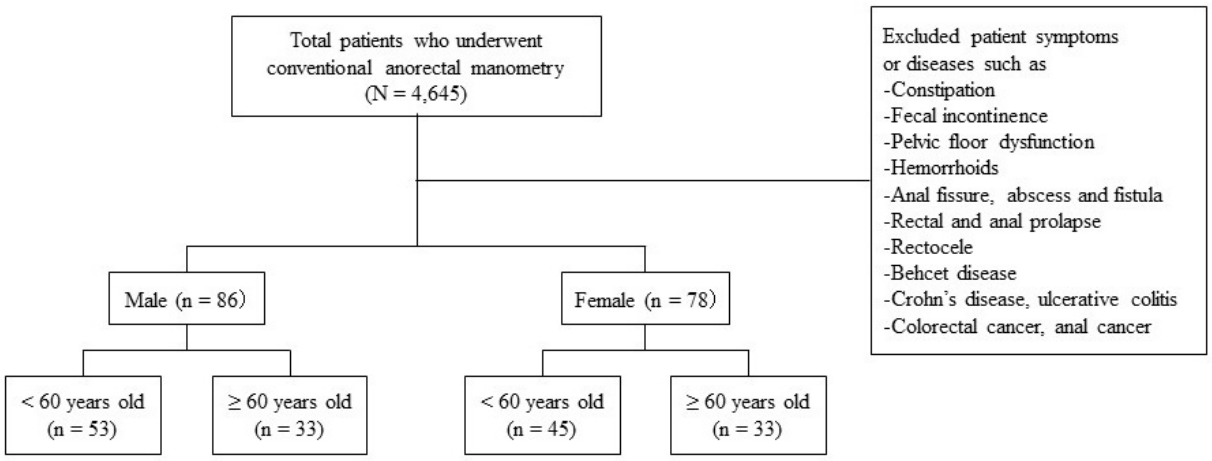

Fig. 1. Algorithm for the inclusion and classification of study participants.

Table 1. Mean Age and Mean Body Mass Index of Study Subjects

	Age group	Number	Mean age	Mean BMI[a]
Male	<40	17	30.12±6.45	24.89±3.71
	40-49	20	44.85±2.96	24.63±2.95
	50-59	16	54.69±3.21	24.36±3.85
	60-69	19	64.84±2.60	23.33±2.57
	≥70	14	74.93±3.73	25.02±3.57
Female	<40	11	28.91±5.55	20.47±2.82
	40-49	18	45.06±3.05	22.94±3.49
	50-59	16	54.50±2.70	22.46±3.13
	60-69	13	64.23±2.77	21.80±3.80
	≥70	20	73.40±3.34	25.42±2.49

Values are presented as mean±standard deviation.
BMI, body mass index.
[a]Date of 14 subjects were missing.

23.0; SPSS, Chicago, IL, USA). All p<0.05 were considered statistically significant.

RESULTS

The algorithm for participant inclusion and exclusion is shown in Fig. 1. The mean age and mean BMI of the study subjects is summarized in Table 1. The anorectal manometric values were compared according to the age of the male and female subjects (Table 2). The resting anal pressures of the male and female subjects aged ≥60 years were significantly lower than those <60 years (males, 44.09±14.22 vs. 57.45±17.69, p<0.001; females, 44.09±14.22 vs. 57.45±17.69, p<0.001). The anal high-pressure zone (HPZ) was significantly lower in the older than the younger males (2.42±0.93 vs. 2.82±0.739, p=0.048), while there was no significant difference observed between the younger and older females (3.02±4.77 vs. 2.27±0.81, p=0.329). Other manometric parameters such as maximal anal squeezing pressure, anal squeezing duration, sphincter length, RAIR, rectal sensation, and compliance were not significantly different between the two age groups.

Further analysis was performed after the subjects were divided into five groups according to age <40, 40-49, 50-59, 60-69, and ≥70 years. Among the parameters, only resting anal pressures were significantly different according to the age groups of male and female subjects. The resting anal pressures in males aged ≥70 years were significantly lower than those of males aged <40 (58.01±17.87 vs. 36.76±10.25, p=0.013), 40-49 (58.01±17.87 vs. 36.76±10.25, p=0.002), 50-59 (52.82±18.44 vs. 36.76±10.25, p=0.012), 60-69 years (49.50±14.52 vs. 36.76±10.25, p=0.014), and those in males aged 60-69 years were significantly lower than males aged 40-49 years (p=0.038) (Fig. 2). Among the female subjects, the mean resting pressures in the 60-69 age group was significantly lower than the <40 (55.62±17.89 vs. 39.65±17.56, p=0.030), 40-49 (54.83±19.57 vs. 39.65±17.56, p=0.012) and 50-59 years groups (54.63±17.77 vs. 39.65±17.56, p=0.020) (Fig. 2).

The parameters of ARM according to gender are summarized in Table 3. In both age groups (<60 years and ≥60 years), the anal squeezing pressures of males were observed to be significantly higher than those of females (<60 years old, 168.40±75.94 vs. 119.15±57.53, p=0.001; ≥60 years,

Table 2. Differences in the Anorectal Manometric Values according to Age

	Male			Female		
	<60 years old (n=53)	≥60 years old (n=33)	p-value	<60 years old (n=45)	≥60 years old (n=33)	p-value
Age (years)	43.09±10.79	69.12±5.93	<0.001[a]	44.47±10.50	69.79±5.49	<0.001[a]
Mean resting anal pressure (mmHg)	57.45±17.69	44.09±14.22	<0.001[a]	54.16±18.66	43.27±17.35	0.001[a]
Maximal squeezing anal pressure (mmHg)	168.40±75.94	149.61±64.68	0.311	119.15±57.53	101.3±54.92	0.211
Anal squeeze duration (s)	39.23±24.80	49.09±47.09	0.241	53.68±40.24	38.00±37.96	0.109
Sphincter length (cm)	4.09±0.51	3.92±0.78	0.284	3.72±0.75	3.58±0.65	0.416
Anal HPZ length	2.82±0.739	2.42±0.93	0.048[a]	2.27±0.81	3.02±4.77	0.329
Rectoanal inhibitory reflex	19.23±7.36	18.46±6.12	0.648	18.10±6.71	19.63±5.17	0.316
Rectal sensation						
Minimal volume (mL)	27.73±14.22	29.23±11.63	0.644	27.90±9.89	26.66±11.09	0.628
Desire to defecation volume (mL)	67.92±23.31	64.61±14.20	0.508	66.51±14.94	66.66±12.40	0.964
Urgency volume (mL)	126.79±34.84	128.46±28.94	0.833	128.83±43.49	126.66±45.06	0.842
Maximal volume (mL)	158.11±43.89	156.92±32.83	0.903	160.936±53.97	167.40±67.74	0.66
Compliance	1.30±0.67	18.46±6.12	0.821	1.33±0.58	19.63±5.17	0.849
Defecation index	1.88±1.25	1.69±1.08	0.481	1.54±1.84	1.33±0.75	0.531
Cough reflex (%)	82.08±65.57	101.26±70.49	0.204	89.67±73.01	1.33±0.75	0.177

Values are presented as mean±standard deviation.
HPZ, high-pressure zone.
[a]Indicate statistically significant differences.

149.61±64.68 vs. 101.3±54.92, p=0.006). The resting anal pressures of male and female subjects were similar in both age groups. The anal HPZ length was lower in younger females than in younger males (3.72±0.75 vs. 4.09±0.51, p=0.023). There were no statistical differences observed between the male and female subjects with respect to mean anal resting

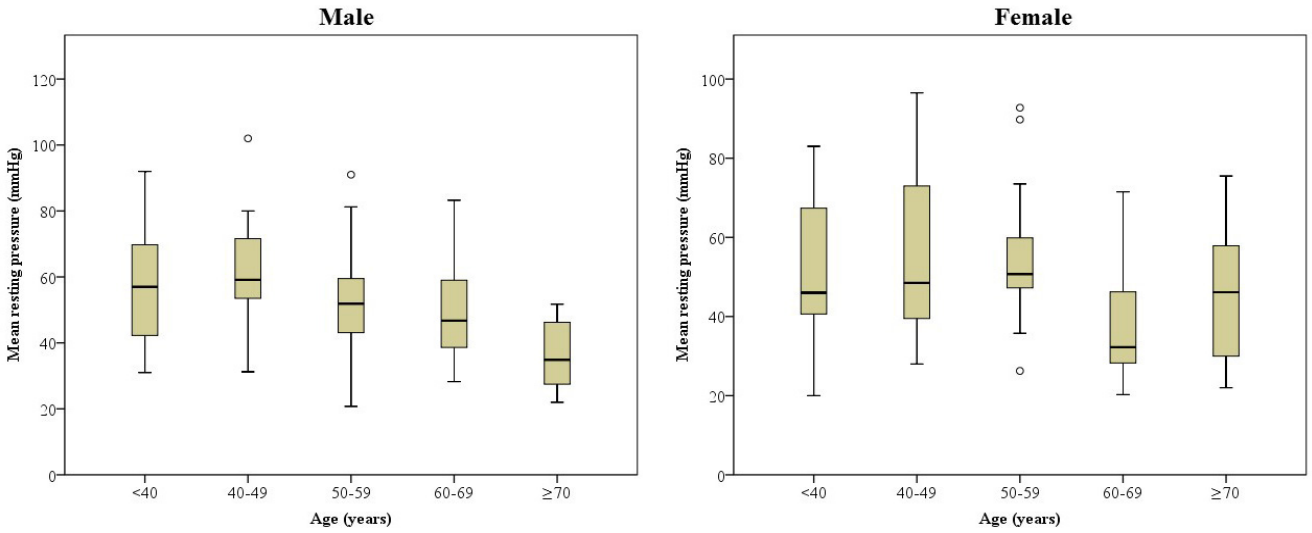

Fig. 2. Comparison of mean resting anal pressures in male and female subjects according to age. Resting anal pressures in males aged ≥70 years were significantly lower than in males aged <40, 40-49, 50-59, and 60-69 years, and those in males aged 60-69 years were significantly lower than in males aged 40-49 years. In female subjects, the mean resting pressures in the 60-69 age group were significantly lower than those of the <40, 40-49, and 50-59 years age groups.

Table 3. Differences in the Anorectal Manometric Values according to Gender

	Total	<60 years old			≥60 years old		
	(n=164)	Male (n=53)	Female (n=45)	p-value	Male (n=33)	Female (n=33)	p-value
Age (years)	54.08±15.50	43.09±10.79	44.47±10.50	0.527	69.12±5.93	69.79±5.49	0.637
Mean anal resting pressure (mmHg)	51.01±18.19	57.45±17.69	54.16±18.66	0.374	44.09±14.22	43.27±17.35	0.834
Maximal anal squeezing pressure (mmHg)	136.71±66.6	168.40±75.94	119.15±57.53	0.001[a]	149.61±64.68	101.3±54.92	0.006[a]
Anal HPZ length (cm)	2.63±2.25	2.82±0.739	2.27±0.81	0.001[a]	2.42±0.93	3.02±4.77	0.605
Anal squeezing duration (s)	44.51±36.75	39.23±24.80	53.68±40.24	0.059	49.09±47.09	38.00±37.96	0.338
Sphincter length (cm)	3.85±0.69	4.09±0.51	3.72±0.75	0.023	3.92±0.78	3.58±0.65	0.081
Rectal sensation							
Minimal volume (mL)	27.85±12.00	27.73±14.22	27.90±9.89	0.947	29.23±11.63	26.66±11.09	0.415
Desire to defecation volume (mL)	66.71±17.79	67.92±23.31	66.51±14.94	0.732	64.61±14.20	66.66±12.40	0.578
Urgency volume (mL)	127.65±38.24	126.79±34.84	128.83±43.49	0.799	128.46±28.94	126.66±45.06	0.864
Maximal volume (mL)	160.40±50.05	158.11±43.89	160.93±53.97	0.779	156.92±32.83	167.40±67.74	0.479
Compliance	1.31±0.58	1.30±0.67	1.33±0.58	0.839	1.27±0.39	1.35±0.55	0.515
Rectoanal inhibitory reflex	18.84±6.57	19.23±7.36	18.10±6.71	0.442	18.46±6.12	19.63±5.17	0.456
Defecation index	1.64±1.33	1.88±1.25	1.54±1.84	0.293	1.69±1.08	1.33±0.75	0.122
Cough reflex (%)	93.94±69.07	82.08±65.57	89.67±73.01	0.595	101.26±70.49	111.92±66.21	0.532

Values are presented as mean±standard deviation.
HPZ, high-pressure zone.
[a]Indicate statistically significant differences.

pressure, anal squeezing duration, sphincter length, RAIR, rectal sensation, and compliance.

DISCUSSION

Anal resting pressure, a primary indicator of internal anal sphincter function, and voluntary squeeze increment pressure, a measure of the external anal sphincter, and likely puborectalis contractility are the most recognized and consistently reported measures of anorectal function. In the present study, the resting pressure was significantly lower in male and female subjects aged ≥60 years compared to those <60 years. However, the squeezing pressures were not significantly lower in older male and female subjects. In the detailed analysis of the older subjects, males aged ≥70 years were observed to have significantly lower resting anal pressures than those aged 60-69. Females aged 60-69 had significantly lower resting anal pressures than younger females. However, no significant differences were seen between females aged 60-69 and those ≥70 years. The maximal squeezing pressures and other parameters did not significantly differ with age.

In our analysis using conventional manometry, there were significant changes in anorectal function with age, and gender-based differences were also seen in the asymptomatic subjects. As a matter of fact, many studies have shown that some anorectal functions deteriorate with age. The results of our analysis using conventional manometry were consistent with those of earlier studies. Anal resting pressure[7-12] and anal squeezing pressure[7-9,11,13] measured by conventional ARM, HRM, and 3DARM were lower in older female subjects compared to their younger counterparts, while some studies showed that anal squeezing pressure was not affected by aging.[10] In asymptomatic males, the mean anal resting pressures[8,10] and squeezing pressures[7] decreased with age. Additionally, in previous studies using HRM and 3DARM, aging was associated with a higher rectoanal gradient during the simulated evacuation and higher rectal pressure during evacuation in males and females, and a shorter balloon expulsion test (BET) in females.[10]

Previous research has shown that the maximum and mean resting pressure falls significantly with age in both male and female subjects. However, the anorectal pressure declined substantially in females, while the age-related change of anorectal function in males was minimal.[7,8] In contrast, in our study, males were observed to have a large change in resting anal pressure with age. In most previous studies on the changes in the anorectal function with age, subjects were categorized based on age 50,[9-11,13] and very few individuals over the age of 70 were included. Moreover, the studies on males were very few and the number of male subjects was small.[7,10,13] Aging itself is associated with the loss of muscle mass and muscle fiber density that contributes to diminished function.[2] This process begins around the age of 50, but it becomes more marked over the age of 60.[2] Age-related changes in the anorectal function and structure have been documented in several studies. Thinning and atrophy of the internal and external anal sphincter decrease in pudendal nerve function, rectal sensation and compliance, and anal sphincter and rectal capacity have been known to occur.[1] Age is associated with the neurogenic and myogenic injuries of the external anal sphincter which have been evaluated with electromyography.

Gender differences in the ARM parameters are well-known from previous studies. Conventional manometric parameters such as sphincter length,[7,8] maximal squeezing pressure[7,8,] and perception threshold[7] were higher in males than females. The parameters of HRM and 3DARM such as anal resting pressures,[13,14] anal squeezing pressure,[13-15] anal rectal pressures during evacuation,[14] minimal balloon volume for the desire to defecate,[14] anal squeeze pressure increment,[10] squeeze duration,[10,15] and HPZ length[10] were higher in males than females.[10] The maximal tolerable volume was lower in females.[13] Some of the physiologic differences may be related to the baseline anatomic differences between the genders. It is known that men have greater skeletal muscle mass and a longer anal sphincter compared to women as documented by ARM, MRI, and tridimensional EUS (3D-EUS). Additionally, increased anterolateral abdominal wall musculature in males compared to females may allow for increased abdominal pressure during defecation. These differences are caused by the differences in the muscle mass and contractile force of the anal sphincter, rectal volume, and sensory nerve functions.[14]

In the present study, the anorectal pressure parameters were lower than in western studies. These differences could be explained by differences in demographics, manometric equipment, and techniques used. Also, our parameters of conventional ARM were lower than those of HRAM and 3DHRM.

Conventional manometry has been performed using either solid-state or water-perfused catheters incorporating a limited number of recording sensors (less than ten), with data displayed as pressure line traces that are interpreted separately.[16] Instead HRM uses an increased number of closely spaced pressure sensors which enhance spatial resolution and measure pressure changes circumferentially and displays them as a color contour plot.[16] HRAM has been found to correlate well with conventional manometry, and previous studies have shown that resting pressures[17] and squeezing pressures measured by HRM[18,19] were slightly higher than conventional water-perfused manometry.

The data on normal ARM values for the Asian population is scarce. There are some differences between the Asian and Western populations that can affect these values including dietary habits, parity, and physical status. The previous Korean studies on HRM revealed significant differences between males and females with respect to anal resting and squeezing pressures, and rectal and anal pressures during the simulated evacuation; however, they did not show a comparison of manometric values between younger and older males and females.[14]

There are some potential weaknesses in our study. The most important limitation of this study is its selection bias due to its retrospective design. Second, the observed normal values could have been affected by other obstetric variables such as birthweight and parity. However, these were not evaluated. Third, we did not perform the BET on all subjects. The BET is highly specific for diagnosing pelvic floor dysfunction documented with defecography. Approximately 10% of the healthy participants could not expel a 50 mL balloon filled with water.[20] This could be due to asymptomatic pelvic floor dysfunction. Fourth, we enrolled subjects without using validated questionnaire forms. Thus, subjects with functional bowel or anorectal disorders could be enrolled. However, we tried to exclude subjects with meaningful disorders which could affect the anorectal sphincter pressure by reviewing the medical records in detail. Fifth, the currently published studies on anorectal function tend to use HRARM. HRARM is rather expensive and conventional ARM is still used widely in Korea. Despite these limitations, the present study has strengths in that it included a larger number of asymptomatic elderly males to clarify the influence of aging on the ARM parameters.

In conclusion, our results suggest that the normal values for rectoanal pressures measured using ARM were different in males and females. Compared to younger males and females, older subjects had lower anal resting pressures. The anal squeeze pressures were not affected by age.

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Supplementary Fig. 1. Image of conventional anorectal manometry.