

The efficacy of the anorectal functional examinations and the correlation with the symptoms of evacuation difficulty

YONG ZHANG¹, SHOTA TAKANO¹, KAZUTAKA YAMADA², MASAHIRO TAKANO¹

¹ Department of Coloproctology Takano Hospital Kumamoto, Japan

² Department of Surgery Takano Hospital Kumamoto, Japan

Abstract: **Aim.** The aim of this study was to assess the efficacy of anorectal functional examinations. **Method:** Forty-three patients who fulfilled the Rome III diagnostic criteria for functional constipation were enrolled in this study from March 2013 to May 2014. Balloon expulsion test (BET), anorectal manometry (ARM) during attempted defecation, and defecography were performed. The correlation between BET, ARM, defecography and symptoms of evacuation difficulty was assessed. **Results:** There was a significant correlation in the difference between the balloon expulsion volume and recto-anal pressure, the recto-anal pressure and evacuation of paste, and the anal relaxation rate and evacuation of paste. Moreover, there was a significant correlation between the balloon expulsion volume and evacuation of paste in the symptom represented by the item, "Minutes in lavatory per attempt" and between the recto-anal pressure and evacuation difficulty. **Conclusion:** The findings for each of the anorectal functional examinations revealed that there was not much of a correlation between the symptoms of defecatory disorders and patient complaints. However, a combination of examinations can probably benefit the characterization of the functional defect and the precise diagnosis of functional defecation disorders (FDD).

Keywords: Anal manometry; Balloon expulsion test; Defecography; Evacuation difficulty.

INTRODUCTION

Anorectal disorders are becoming the number one cause of evacuation difficulty. Constipation, in particular, is a relatively common complaint but may be the result of complicated causes. In general, the causes are functionally separated into the following subgroups: slow colonic transit, normal colonic transit, and defecatory or rectal evacuation abnormalities.¹ Smooth defecation involves the complex physiological interaction of the rectum, the effective motility of the gastrointestinal tract, the coordination of the pelvic floor muscles, and the relaxation of the external anal sphincter.² Anorectal dysfunction is detected by a series of physiological examinations which include the balloon expulsion test (BET), anorectal manometry (ARM), X-ray, MR defecography and electromyogram. These examinations provide a lot of information about anorectal function and shows just how complex this system is. The Rome III criteria recommends the above mentioned anorectal examinations but does not provide any guidelines on the status and the analytical procedure of the combined application.³ However, due to the complicated nature of the symptoms, a thorough examination is performed to learn as much as possible about the patient's anorectal dysfunction.

The aim of this study was to assess the efficacy of the anorectal functional examinations to make the evaluation system more simple and effective.

PATIENTS AND METHODS

Subjects

Forty-three consecutive patients who fulfilled the Rome III diagnostic criteria for functional constipation and who completed the anorectal function evaluation questionnaire were enrolled in this study from March 2013 to May 2014 at Takano Hospital after informed consent was obtained. We assessed the correlation between BET, ARM and defecography. In addition, we assessed the correlation between each examination and the symptoms identified using the constipation scoring system (CSS)⁴ and the information given by the patients themselves. Patients were excluded from the study if they had significant cardiovascular, respiratory, neurologic, psychiatric illnesses, severe psychologi-

cal problems and/or endocrine and metabolic diseases.⁵ The patients were interviewed before the examinations and after they completed the constipation scoring system (CSS) and indicated whether or not they experienced evacuation difficulty (Yes or No). Once institutional review board (IRB) approval was obtained a prospective non-randomized study was launched. The risks of additional x-ray exposure were disclosed to the patients in the process of getting informed consent.

Methods

Balloon expulsion test (Balloon expulsion volume)

Patients were administered a phosphate enema (left lateral decubitus position with flexion of the knees and hips) at least 30 minutes prior to the procedure. An empty well lubricated rubber balloon was gently inserted into the rectum. The other side of the balloon was attached to a plastic tube and a catheter with an air-filled syringe to inflate the balloon. Patients were then asked to move into a sitting position and try to expel the balloon. After each successful attempt, the volume of air was gradually increased by 10ml increments and continued over a period of two minutes until the patient was unable to expel the balloon. The volume of air residue in the last successfully expelled balloon was measured and recorded as the "balloon expulsion volume (BEV)". A BEV reading equal to or greater than 30ml was considered normal (max. 50ml).

Manometry during attempted defecation (recto-anal pressure difference & anal relaxation rate).

Patients were administered a phosphate enema at least 30 minutes prior to the procedure. ARM was performed using a solid-state manometric assembly with 2 lateral sensors spaced at 6.5cm intervals (Star Medical, Japan). After the 2-channal pressure assembly was gently inserted into the rectum (left lateral decubitus position), by placing the proximal sensor in the anal canal and the distal sensor in the rectum, the patients was asked to push. The pressure in the rectum and anal canal during attempted defecation were measured simultaneously. The difference in the recto-anal pressure (RAPD) was calculated by subtracting the minimum anal residual pressure during attempted defecation from the maximum rectal pressure during attempted defecation. The anal relaxation rate (ARR) was calculated as follows; max-

imum anal rest pressure - residual pressure during attempted defecation)/maximum anal rest pressure.⁶ The patients were then divided into three subtypes based on the RAPD results and in accordance with the Rome III diagnostic criteria for functional defecation disorders (FDD).

Defecography (evacuation of paste & anal-rectal angle difference). Patients were administered a phosphate enema (left lateral decubitus position) of approximately 100 ml of barium paste 30 minutes prior to the procedure. The barium paste was mixed with oatmeal to create a consistency of stool similar to Bristol type 4. The patient was then asked to sit on a commode. Lateral photos of the pelvis were taken during the pushing phase and while the patient was in a sitting position. The results of the “evacuation of paste” were classified as either “none”, “partial” or “complete”. The anal-rectal angle was the angle between the anal canal and the tangential line drawn along the posterior rectal wall behind the impression just proximal to the upper anal canal. The normal anal-rectal angle (ARA) during rest and defecation was increased. The results of the anal-rectal angle difference were classified as either “normal” or “abnormal”.⁷

Statistical analysis

The statistical analysis was performed using the statistical package for social science (SPSS) software version 19.0. Spearman’s correlation coefficient was used to determine correlations and the chi square (χ^2) test was used for group comparisons of dichotomous variables. Statistical significance was preset at $P < 0.05$.

RESULTS

Patient characteristics and examination results

The mean age of the 43 patients (27 male; 16 female) enrolled in this study was 69 years (range 19 - 87 years). The balloon expulsion volume and number of patients are as follows; 0 ml (6 patients), 10 ml (11 patients), 20 ml (11 patients), 30 ml (7 patients), 40 ml (3 patients), and 50 ml (5 patients). The mean RAPD was -23.2 ± 48.63 cmH20 (range -146.2 - 87.7 cmH20) and the mean ARR was $-50.0 \pm 90.6\%$ (range 226.1 - 100). The X-ray defecography revealed that 11 patients had complete evacuation, 13 patients had partial evacuation and 19 patients were unable to evacuate the paste. Twelve patients were able to increase the anal-rectal angle during the push phase compared to the rest phase, and the remaining 31 patients were unable to change the anal-rectal angle and in some cases it even decreased. The pre-examination interview results revealed that 35 patients complained of evacuation difficulty and the CSS score ranged from 2 to 20 with a mean of 10.1 ± 5.0 (Table 1).

Correlation between examinations

The correlative evaluation was performed based on the recorded data. The statistical analysis revealed that there was a significant relationship in four matches of the examinations. Correlative analysis revealed that the balloon expulsion volume was positively correlated with the recto-anal pressure difference ($R = 0.565$, $P < 0.01$) and evacuation of paste ($R = 0.451$, $P < 0.01$), but did not correlate with the anal relaxation rate ($R = -0.293$, $P = 0.056$) and ARA difference ($R = -0.08$, $P = 0.602$). There was a significant correlation between the recto-anal pressure difference and evacuation of paste ($R = 0.488$, $P < 0.01$), but there was no correlation with the ARA difference ($R = -0.05$, $P = 0.748$). There was a positive correlation between the anal relaxation rate and evacuation of paste ($R = 0.482$, $P < 0.01$), but there was no significant correlation with ARA difference

TABLE 1. Basic characteristics and examination results.

| Characteristics | |
|--|--------------------------|
| Age (yr/[mean/range]) | 69/19~87 |
| Gender (male/female) | 27/16 |
| Balloon Expulsion Volume(n) | |
| 0/10/20/30/40/50ml | 6/10/11/7/3/6 |
| RAPD(cmH20[mean/range]) | -23.2±48.63[-146.2~87.7] |
| ARR(%[mean/range]) | -50.0±90.6[-226.1~100] |
| Evacuation of paste(n) | |
| None/ Partial/ Complete | 19/13/11 |
| Anal-rectal angle difference(n) | |
| Increase | 12 |
| No change or decrease | 31 |
| Complaint of “evacuation difficulty” (n) | |
| Yes | 35 |
| No | 8 |
| CSS(mean score/range) | 10.1±5.0/2~20 |
| FDD according to Rome III (n/total) | 31/43 |

TABLE 2. Correlational analysis of results of the examinations.

| Exam 1 | Exam 2 | Correlation coefficient | P value |
|--------|---------------------|-------------------------|-----------|
| BEV | RAPD | R = 0.565 | P < 0.01 |
| BEV | ARR | R = -0.293 | P = 0.056 |
| BEV | Evacuation of paste | R = 0.451 | P < 0.01 |
| BEV | ARA difference | R = -0.08 | P = 0.602 |
| RAPD | Evacuation of paste | R = 0.488 | P < 0.01 |
| RAPD | ARA difference | R = -0.05 | P = 0.748 |
| ARR | Evacuation of paste | R = 0.482 | P < 0.01 |
| ARR | ARA difference | R = -0.1 | P = 0.53 |

($R = -0.1$, $P = 0.53$). These findings are available for inspection in Table 2 and Figure 1.

Correlation between each examination and symptom

The CSS was applied to evaluate the symptoms of constipation. We performed a correlation analysis between the examinations and the CSS results. We identified a single symptom for evacuation difficulty and discovered that there was a correlation with the results of the examinations. Also, we evaluated the efficacy of the results to the complaint of evacuation difficulty and found that there was no significant correlation between the CSS and each examination result ($P = 0.64$, $P = 0.96$, $P = 0.79$, $P = 0.58$, $P = 0.07$). There was a significant correlation between the symptom represented by the item “Minutes in lavatory per attempt” and the balloon expulsion volume ($R = -0.419$; $P < 0.01$) and evacuation of paste ($R = -0.300$; $P = 0.04$). The evacuation difficulty complaint significantly correlated with the recto-anal pressure difference ($R = -0.304$, $P = 0.04$). See Table 3.

Correlation between the FDD diagnosis and the patients’ complaint according to the Rome III criteria of FDD.⁸

Thirty-one patients were diagnosed as having FDD but only three did not complain about evacuation difficulty. However, of the 12 patients excluded by the criteria, 7 patients did complain about evacuation difficulty. The statistical analysis revealed a significant difference between the complaint of evacuation difficulty and the diagnosis of functional disorders ($\chi^2 = 5.846$, $P = 0.016$). Four patients were complicated with abnormal rectal sensation and one patient was complicated with abnormal anal sensation. Two patients experienced anal pain and three patients experienced fecal incontinence (Figure 2).

DISCUSSION

Defecatory disorders are common in the community affecting 10-15% of the population.^{9, 10} The anorectum is a

TABLE 3. Correlational analysis of results of the examinations and the CSS, examinations and symptoms, and examinations and patient complaints.

| | CSS (~30) | Frequency of bowel movements (0~4) | Painful evacuation (0~4) | Feeling incomplete evacuation (0~4) | Minutes in lavatory per attempt (0~4) | Evacuation difficulty (No or Yes) |
|--------------------------------|-----------------------|------------------------------------|--------------------------|-------------------------------------|---------------------------------------|-----------------------------------|
| Balloon expulsion volume | R = -0.073 (P = 0.64) | R = -0.071 (P = 0.65) | R = -0.053 (P = 0.74) | R = 0.107 (P = 0.50) | R = -0.419 (P < 0.01) | R = -0.204 (P = 0.19) |
| Recto-anal Pressure difference | R = -0.007 (P = 0.96) | R = 0.179 (P = 0.25) | R = -0.060 (P = 0.71) | R = 0.114 (P = 0.47) | R = -0.218 (P = 0.16) | R = -0.304 (P = 0.04) |
| Anal relaxation rate | R = 0.041 (P = 0.79) | R = 0.095 (P = 0.55) | R = 0.053 (P = 0.74) | R = -0.138 (P = 0.38) | R = 0.174 (P = 0.26) | R = 0.275 (P = 0.07) |
| Evacuation of paste | R = -0.086 (P = 0.58) | R = 0.083 (P = 0.60) | R = -0.020 (P = 0.90) | R = 0.026 (P = 0.87) | R = -0.300 (P = 0.04) | R = -0.109 (P = 0.48) |
| ARA difference | R = 0.271 (P = 0.58) | R = -0.043 (P = 0.78) | R = 0.274 (P = 0.07) | R = 0.217 (P = 0.16) | R = 0.184 (P = 0.24) | R = -0.026 (P = 0.87) |

complex functional unit that collaborates with the pelvic floor muscles and nerves. Despite the advances in the examinations for the diagnosis of FDD, the characteristics of functional disorders are still difficult to distinguish. Therefore, a comprehensive clinical assessment is extremely important for the accurate diagnosis and management of FDD. The balloon expulsion test, defecography and ARM are frequently used for diagnosis and effective evaluation. However, many examination results overlap in the evaluation of defecatory disorders. Therefore, it is necessary to assess the correlation of each anorectal functional examination and the corresponding symptoms.

The balloon expulsion test is well known as a simple and inexpensive examination for screening defecatory dysfunction. Previous studies have shown that the balloon expul-

sion test has relatively high specificity and negative predictive values.¹¹ Inability to expel a 50-ml water/air-filled balloon from the rectum within 120 seconds of attempted defecation is defined as dyssynergic defecation by BET. However, some studies found contradictory results for BET.¹¹⁻¹³ Different diagnostic criteria for pelvic floor dyssynergia in these studies may be the cause of these contradictory results. The aim of this study was to assess the correlation between the results of ARM, defecography and complaint of evacuation difficulty and therefore the balloon expulsion volume (BEV) test was adopted. The findings in this study revealed that there was a significant positive correlation between BEV and the results of RAPD (R = 0.565, P < 0.01) and evacuation of paste (R = 0.451, P < 0.01), but there was no significant correlation with the results of the

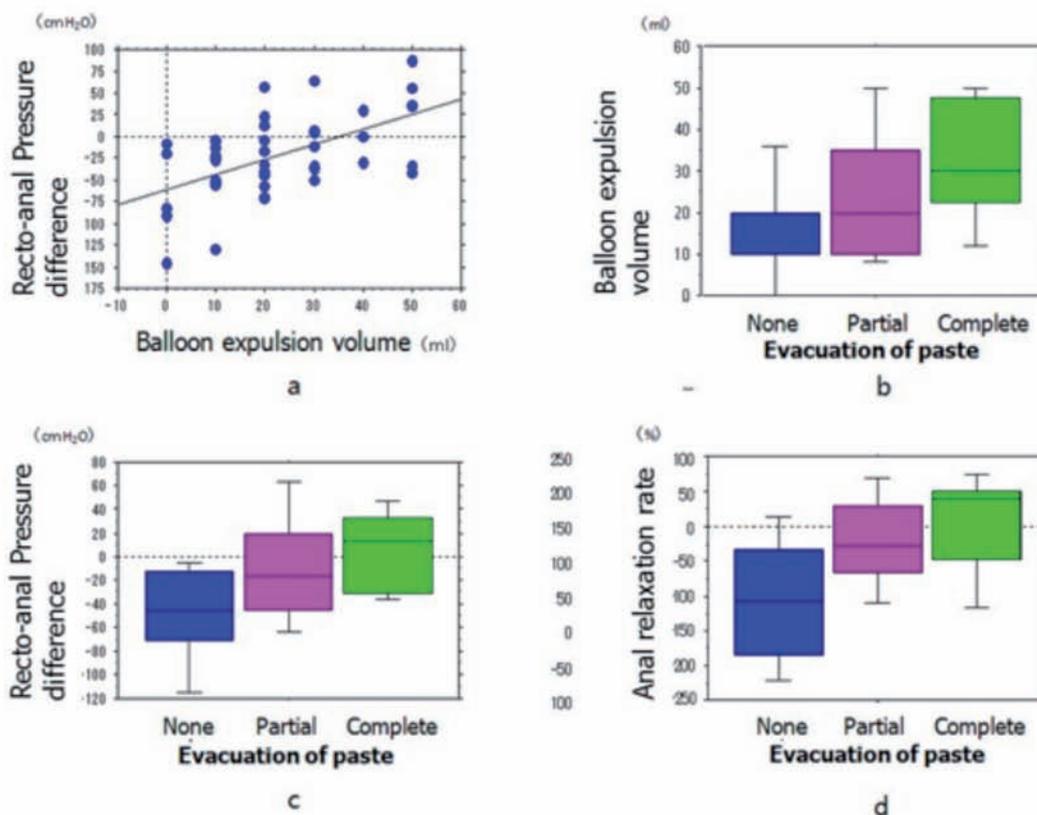


Figure 1. – Significant correlation between examinations. a, Significant correlation between recto-anal pressure difference and balloon expulsion volume; b, Significant correlation between balloon expulsion volume and evacuation of paste; c, Significant correlation between recto-anal pressure difference and evacuation of paste; d, Significant correlation between anal relaxation rate and evacuation of paste.

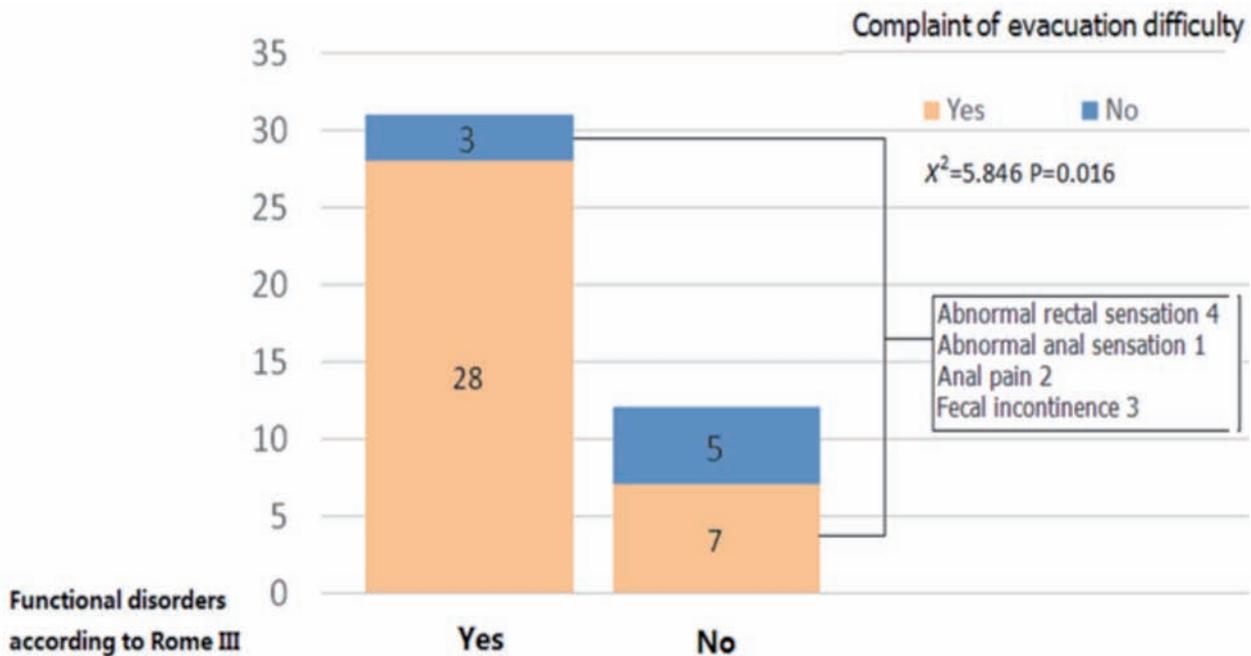


Figure 2. – Significant difference between patient complaint of evacuation difficulty and the FDD diagnosis according to the Rome III criteria.

ARR and ARA difference. Anorectal manometry is the most well established and widely available tool for investigating anorectal function. The ARR and RAPD are the most widely used tests for the detection of anorectal functional disorders.¹⁴ Normal ARR and RAPD suggest an adequate increase in rectal pressure and relaxation of the external anal sphincter (EAS). Failure to perform this coordinated maneuver confirms the diagnosis of dyssynergic or obstructive defecation.¹⁵ Compared to the other tests measured during the resting state, ARR and RAPD measured during an attempt to defecate can exhibit more valuable information about the characteristics of functional defects. In our study, the results revealed that there were significant positive correlations between RAPD and BEV ($R = 0.565$, $P < 0.01$), RAPD and evacuation of paste ($R = 0.488$, $P < 0.01$), and ARR and evacuation of paste ($R = 0.482$, $P < 0.01$). Therefore, based on the above mentioned results, ARR and RAPD are effective examinations.

Defecography is another widely used examination for patients with evacuation difficulty, especially when the clinical symptoms are inconsistent or when there are anatomic causes resulting in obstruction (i.e. internal intussusception, solitary rectal ulcers, rectoceles, and rectal prolapse).^{7, 16, 17} The most significant findings related to defecatory disorders include inadequate widening of the anorectal angle and/or the decent of pelvic organs and tissues (i.e., internal intussusception, rectoceles, and rectal prolapse).¹⁸ The anorectal angle has been well defined but the correlation between the extent of the decent and the obstructive defecation has not yet been established. However, the residue of paste after attempting to defecate suggests that there may be a functional defect. In our study, the results revealed that there was a significant positive correlation between the evacuation of paste and BEV ($R = 0.451$, $P < 0.01$), RAPD ($R = 0.488$, $P < 0.01$) and ARR ($R = 0.482$, $P < 0.01$). However, the ARA difference poorly correlated with the other examinations. Up until now, no studies have been done to investigate the clinical significance of ARA.

Interviews with patients are important in the diagnosis and assessment of anorectal functional disorders. The CSS was established based on patients' subjective symptomatic complaints and physiologic findings.⁴ We evaluated the

correlation between the examinations and CSS results. The results showed that none of the single examinations had a significant correlation to the CSS score and RAPD was negatively correlated with the patient self-assessment of evacuation difficulty ($R = -0.304$, $P = 0.04$). Further investigation revealed that there were significant negative correlations between BEV and the item "Minutes in lavatory per attempt" ($R = -0.419$, $P < 0.01$), and evacuation of paste and the item "Minutes in lavatory per attempt" ($R = -0.300$, $P = 0.04$). The symptoms of evacuation difficulty were the result of a series of causes (i.e., anismus, insensitive anorectum, rectocele) and therefore a single examination cannot pinpoint the exact cause of evacuation disorders.

CONCLUSION

There was a significant correlation between each examination. ARA was the only exception and should therefore not be included in routine examinations. However, there was no significant correlation between each result of the anorectal functional examinations and the symptoms of defecatory disorders and patient complaints. A combination of tests would probably be more beneficial in characterizing the functional defects and in determining the precise diagnosis of FDD.

DISCLOSURE STATEMENTS

We declare no conflict of interest.

Authorship: All authors were involved with initial research design, data collection and analysis, manuscript drafting, and final approval.

Conflict of interest: None

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

REFERENCES

1. Lembo A, Camilleri M. Chronic constipation. *N Engl J Med* 2003; 349: 1360-1368.
2. Steele SR, Mellgren A. Constipation and Obstructed Defecation. *Clin Colon Rectal Surg.* 2007; 20(2): 110-7.
3. Longstreth GF, Thompson W, Chey W, Houghton L, Mearin F, Spiller R. Functional bowel disorders. *Gastroenterology* 2006; 130(5): 1480-1491.
4. Agachan F, Chen T, Pfeifer J, Reissman P, Wexner SD. A constipation scoring system to simplify evaluation and management of constipated patients. *Diseases of the colon and rectum* 1996; 39: 681-5.
5. Chiarioni G, Heymen S, and Whitehead WE. Biofeedback therapy for dyssynergic defecation. *World J Gastroenterol*, 2006; 12(44): 7069-7074.
6. Kim J-H. How to Interpret Conventional Anorectal Manometry. *Journal of Neurogastroenterology and Motility.* 2010; 16(4): 437-439. doi:10.5056/jnm.2010.16.4.437.
7. Shorvon PJ, McHugh S, Diamant NE, Somers S, Stevenson GW. Defecography in normal volunteers: results and implications. *Gut.* 1989; 30(12): 1737-1749.
8. Drossman DA. The functional gastrointestinal disorders and the Rome III process. *Gastroenterology* 2006; 130: 1377-90.
9. Bharucha AE, Zinsmeister AR, Locke GR, Seide B, McKeon K, Schleck CD, Melton LJI. Prevalence and burden of fecal incontinence: A population based study in women. *Gastroenterology.* 2005; 129: 42-49.
10. Bharucha AE, Locke GR, Pemberton JH. AGA Practice Guideline on Constipation: Technical Review. *Gastroenterology.* 2013; 144: 218-238.
11. Minguez M, Herreros B, Sanchiz V et al. Predictive value of the balloon expulsion test for excluding the diagnosis of pelvic floor dyssynergia in constipation. *Gastroenterology* 2004; 126: 57-62.
12. Bordeianou L, Savitt L, Dursun A. Measurements of pelvic floor dyssynergia: which test result matters? *Dis Colon Rectum* 2011; 54: 60-5.
13. Kassis NC, Wo JM, James-Stevenson TN, Maglinte DD, Heit MH, Hale DS. Balloon expulsion testing for the diagnosis of dyssynergic defecation in women with chronic constipation. *Int Urogynecol J.* 2015 Sep; 26(9): 1385-90.
14. Sun WM, Rao SS. Manometric assessment of anorectal function. *Gastroenterol Clin North Am* 2001; 30: 15-32.
15. Rao SS, Hatfield R, Soffer E, Rao S, Beaty J, Conklin JL. Manometric tests of anorectal function in healthy adults. *Am J Gastroenterol* 1999; 94: 773-783.
16. Faubion SS, Shuster LT, Bharucha AE. Recognition and management of nonrelaxing pelvic floor dysfunction. *Mayo Clin Proc.* 2012; 87: 187-193.
17. Diamant NE, Kamm MA, Wald A, et al. American Gastroenterological Association medical position statement on anorectal testing techniques. *Gastroenterology.* 1999; 116: 732-760. [PubMed: 10029631].
18. Bharucha AE, Pemberton JH, Locke GR 3rd. American Gastroenterological Association Technical Review on Constipation. *Gastroenterology.* 2013 Jan; 144(1): 218-38.

Correspondence to:

Shota Takano, M.D., Ph.D.
Coloproctology Centre Takano Hospital
4-2-88 Obiyama, Chuo-ku, Kumamoto 862-0924, Japan
Tel: +81-96-384-1011
Fax: +81-96-385-2890
E-mail address: micg@takano-hospital.jp

Yong Zhang
4-2-88 Obiyama, Chuo-ku - Kumamoto 862-0924 - Japan
E-mail: mic@takano-hospital.jp

Multidisciplinary Uro-Gyne-Procto Editorial Comment

To improve the integration among the three segments of the pelvic floor, some of the articles published in **Pelvipерineology** are commented on by **Urologists, Gynecologists, Proctologists/Colo Rectal Surgeons or other Specialists** with their critical opinion and a teaching purpose. Differences, similarities and possible relationships between the data presented and what is known in the three or more fields of competence are stressed, or the absence of any analogy is indicated. The discussion is not a peer review, it concerns concepts, ideas, theories, not the methodology of the presentation.

Uro-gynecologist... This article emphasizes, yet again, that there is no correlation between anal manometry and anorectal symptoms. As such it is a valuable addition to the literature. My perspective is to correlate the findings of this paper with the 2008 Musculoelastic Theory of Anorectal Function and Dysfunction in the Female.¹

The Theory has no place for manometry as it has been demonstrated that it is the Internal Resistance to fecal flow and the external opening mechanism thereof (not pressure) which are the key factors in anorectal opening and closure and therefore, obstructive defecation and fecal incontinence.^{2,3}

The theory does, however, have a place for the anorectal angle, as this is opened out by external muscle forces, figure 1 With a weak uterosacral ligament (USL) insertion point, the opening and closure forces may weaken⁴ to cause both fecal incontinence or obstructive defecation symptoms.^{1,3}

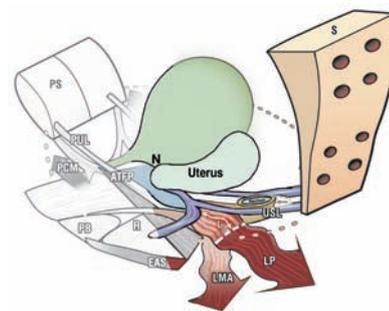
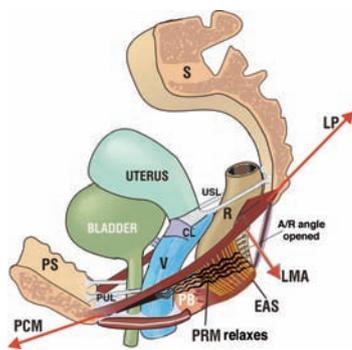


Figure 1. – **Anorectal closure and defecation** standing, sagittal view.

Anorectal closure m. puborectalis (PRM) contracts; LP stretches the posterior rectal wall backwards; LMA rotates the rectal wall around the contracted PRM to create the anorectal angle and closure.

Defecation m. puborectalis (PRM) relaxes (broken lines). This allows the posterior vectors LP/LMA to stretch open the posterior wall of the anorectum, opening out the anorectal angle. The PCM stabilizes the anterior rectal wall, preventing it from prolapsing inwards. Active opening exponentially decreases the internal frictional resistance, inversely by the 3rd power of radius change. The rectum contracts and empties.

Figure 2. – **Potential consequences of loose uterosacral ligaments as interpreted by Gordon's Law** View from above.

The uterus has prolapsed to 1st degree. The USLs have elongated by 'L', as have LP and LMA. The rectum also has descended, by virtue of its attachments laterally to the elongated USL. The contractile strength of LP/LMA has diminished. The external mechanism for opening out the posterior wall of the rectum has weakened according to Gordon's Law;⁴ the anal canal remains partly closed; the patient interprets this as 'obstructive defecation'.

REFERENCES

1. Petros PE & Swash M A *Musculoelastic Theory of Anorectal Function and Dysfunction in the Female*. J Pelvipерineology (2008) 89-121.
2. Petros P, Swash M, Bush M, Fernandez M, Gunnemann A, Zimmer M *Defecation 1 - Testing a hypothesis for pelvic striated muscle action to open the anorectum*. Techniques in Coloproctology 2012 DOI 10.1007/s10151-012-0861-2
3. Bush M, Petros P, Swash M, Fernandez M, Gunnemann *Defecation 2: Internal anorectal resistance is a critical factor in defecatory disorders*. Techniques in Coloproctology 2012 DOI 10.1007/s10151-012-0860-3
4. Gordon AM, Huxley AF, Julian FJ. The variation in isometric tension with sarcomere length in vertebrate muscle fibres. J Physiol. 1966 May; 184(1): 170-92.

PETER PETROS
University of New South Wales, St Vincent's Hospital
Sydney AU
pp@kvinno.com