JNM
J Neurogastroenterol Motil, Vol. 17 No. 3 July, 2011
DOI: 10.5056/jnm.2011.17.3.300
Journal of Neurogastroenterology and Motility

Original Article

Determinant of Anal Resting Pressure Gradient in Association With Continence Function

Moo-Kyung Seong,* Ung-Chae Park and Sung-Il Jung

Department of Surgery, Konkuk University School of Medicine, Seoul, Korea

Background/Aims
Gradient of resting pressure across the anal canal, which is known to have a role in continence mechanism, has 2 components of determination; pressure and length factor of the anal canal. This study evaluates which factor between them plays more significant role for the determination of the gradient in association with continence function.

Methods
Anal manometric measurements of 69 patients with fecal incontinence and 60 controls were retrospectively reviewed. In addition to resting pressure gradient, typical manometric parameters such as maximum resting pressure, basal resting pressure, length of the anal canal, length of high pressure zone and relative position of highest pressure, which were measured with rapid pull-through technique were all contrasted.

Results
Demographics of the 2 groups were similar. Maximum resting pressures of patients with incontinence and controls were 59.1 ± 28.3, 74.6 ± 24.0 mmHg (P = 0.001), respectively. Basal resting pressures were 5.7 ± 6.4 and 7.3 ± 3.9 mmHg (P = 0.097), lengths of the anal canal were 35.8 ± 9.1 and 38.1 ± 8.3 mm (P = 0.133), lengths of high pressure zone were 21.2 ± 6.7 and 23.3 ± 6.5 mm (P = 0.091), relative positions of highest pressure were 69.2 ± 10.6 and 70.1% ± 14.9% (P = 0.717) and resting pressure gradients were 2.28 ± 1.08 and 2.74 ± 1.14 mmHg/mm (P = 0.019), respectively. Difference was significant in maximum resting pressure and resting pressure gradient, but not in length factors such as full length of the anal canal, length of high pressure zone and relative position of highest pressure.

Conclusions
Proximal location of high pressure zone in incontinent patients is not definite and resting pressure gradient of the anal canal depends more on pressure factor than length factor in association with continence function.
(J Neurogastroenterol Motil 2011;17:300-304)

Key Words
Anal canal; Fecal incontinence; Manometry

Received: December 28, 2010 Revised: March 4, 2011 Accepted: March 13, 2011

*Correspondence: Moo-Kyung Seong, MD
Department of Surgery, Konkuk University Hospital, 4-12 Whayang-dong, Gwangjin-gu, Seoul 143-729, Korea
Tel: +82-2-2030-7582, Fax: +82-2-2030-7346, E-mail: recto@kuh.ac.kr

Financial support: This study was supported by Konkuk University Hospital fund, 2008.
Conflicts of interest: None.

Introduction

Anal manometry has been used in the study of patients who have fecal incontinence as an attempt to quantify anal sphincter function. Typical basic parameters are resting pressure and squeeze pressure. Resting pressure denotes resting tonicity and thus is used as an index parameter for internal anal sphincter which is in charge of that tonicity, while squeeze pressure denotes the strength of voluntary contraction and is used for contractility of external anal sphincter. But resting pressure is usually regarded more reliable as an index of continence function judging from physical properties during metric procedure because squeeze pressure depends more on patient's subjective effort with resultant more variation.

Resting pressure has, however, a restriction that it represents cross sectional status of the anal canal without taking into consideration its three dimensional structure.[1,2] Resting pressure gradient (RPG) of the anal canal is devised as one of the advanced parameters to make up for such a restriction.[3,4] The RPG is given by the ratio of pressure difference between maximum resting pressure and basal resting pressure to interval distance between their levels. Therefore, it can be said that it has 2 components as factors of determination, which are pressure and length factor, respectively.

High pressure zone (HPZ) of the anal canal is known to be located in the middle or slightly distal part of the anal canal.[5,6] But there's no definite conclusion about the location shift according to the change of continence function. Some longitudinal resting profiles performed in patients with fecal incontinence have shown a qualitative proximal displacement of HPZ.[7,8] But it is paradoxical to the concept of RPG, because theoretically the patients should be more continent by such proximal shift and consequent increase of RPG. The objectives of this study were to determine whether proximal shift of HPZ which could alter the length factor of RPG really existed in patients with incontinence, and which did play more significant role between pressure and length factors in determination of RPG.

Materials and Methods

Anal manometric measurements of 69 patients with fecal incontinence and 60 controls were retrospectively reviewed. Data of patients were collected on a group of patients who visited our clinic from March 2008 through August 2010 and those of controls were from January 2010 through August 2010. This study was approved by institutional review board at Konkuk university hospital.

Criterion for patient selection was clinical history of incontinence for solid or liquid feces. Patients with incontinence only for gas or occasional leakage (less than 5 by modified Miller incontinence score[9]) were not included, and patients with previous history of colon or rectal surgery and CNS disease were excluded because their incontinence might not come solely from anal dysfunction. Because the purpose of this study was to compare normal with decreased anal sphincter function, the etiology of incontinence was not considered in patient selection. Controls were other patients who visited colorectal clinic for symptoms not related to incontinence and over 60 years old. Those who have previous history of anal trauma, anal surgery and neurological disease were excluded. Reported diseases of exclusion were hemorrhoids in 37, anal fistula in 16 and constipation in 7.

All patients and controls underwent anal manometry using a water-perfused catheter with eight radially aligned channels attached to a hydraulic capillary infusion system (Medtronic Inc, Minneapolis, MN, USA). The catheter was 4.5 mm in diameter with side-holes of 0.8 mm in diameter. Examination was performed in left lateral position with rapid pull-through technique. The catheter was pulled by mechanical device with a speed of 10 mm/sec under resting condition. Enema before examination was not done routinely. The following variables were recorded: maximum resting pressure (highest pressure along the functional anal canal), basal resting pressure (pressure at the proximal border of the functional anal canal, nearest to the rectum), total length of the anal canal, length of HPZ, relative position of highest pressure (ratio of distance from basal pressure level to maximum pressure level in relation to full length of the anal canal) and RPG. Those were analyzed using data collected in Polygram software (version 4.1, Medtronic). RPG was calculated by dividing pressure difference between maximum resting pressure and

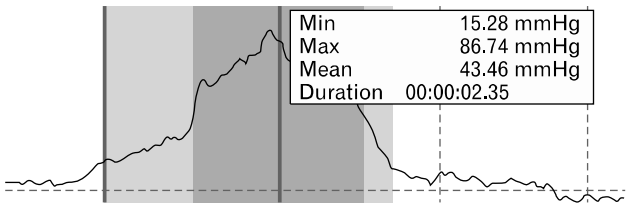

Figure. A manometric graph under resting state with rapid pull-through (10 mm/sec) technique. The variables used to calculate resting pressure gradient are shown.

basal resting pressure with interval distance between their levels. All variables for its calculation were given by the software (Figure).

Statistical analysis was performed using *t* test and Chi-square test with SPSS software (version 16.0, SPSS Inc, Chicago, IL, USA). Normality of data was checked by Shapiro-Wilk test. The continuous variables were expressed as mean ± SD. Statistical significance was set at $P = 0.05$.

Results

For patients group, mean age was 64.4 ± 15.2 years. Male patients were 29 and female patients were 40. For control group, mean age was 65.9 ± 7.1 years. Male controls were 30 and female controls were 30. Demographics of the 2 groups were similar without any significant difference. Mean incontinence score (modified Miller score[9]) of patients group was 18.9 ± 10.9, and it was 19.2 ± 10.8 in male patients and 18.6 ± 9.3 in female patients. No significant difference was shown between them.

Maximum resting pressures of patients group and control group were 59.1 ± 28.3 and 74.6 ± 24.0 mmHg ($P = 0.001$), respectively. Basal resting pressures were 5.7 ± 6.4 and 7.3 ± 3.9 mmHg ($P = 0.097$), lengths of the anal canal were 35.8 ± 9.1 and 38.1 ± 8.3 mm ($P = 0.133$), lengths of HPZ were 21.2 ± 6.7 and 23.3 ± 6.5 mm ($P = 0.091$), relative positions of highest pressure were 69.2 ± 10.6 and 70.1% ± 14.9% ($P = 0.717$) and RPGs were 2.28 ± 1.08 and 2.74 ± 1.14 mmHg/mm ($P = 0.019$) (Table), respectively. Difference was significant in RPG, and in maximum resting pressure as pressure factor, but not in full length of the functional anal canal, length of HPZ and relative position of highest pressure as length factors.

Table. Univariate Analysis of Parameters: Incontinence Group Versus Control Group

	Incontinence group (n = 69)	Control group (n = 60)	*P*-value
BRP (mmHg)	5.7 ± 6.4	7.3 ± 3.9	0.097
MXRP (mmHg)	59.1 ± 28.3	74.6 ± 24.0	0.001
ACL (mm)	35.8 ± 9.1	38.1 ± 8.3	0.133
HPZL (mm)	21.2 ± 6.7	23.3 ± 6.5	0.091
DR (%)	69.2 ± 10.6	70.1 ± 14.9	0.717
RPG (mmHg/mm)	2.28 ± 1.08	2.74 ± 1.14	0.019

BRP, basal resting pressure; MXPR, maximum resting pressure; ACL, anal canal length; HPZL, high pressure zone length; DR, ratio of distance from basal pressure level to maximum pressure level in relation to full length of the anal canal; RPG, resting pressure gradient.
Figures are expressed as mean ± SD.

Discussion

Although several conditions must be met to ensure continence, the anal sphincters are known to play a leading role among them. In detail, tonicity and voluntary contractility of anal sphincters take that role. The former tonicity is known to be in charge of internal sphincter and the latter contractility is in those of external sphincter. But, in view of normal physiology, voluntary contractility is rarely used in usual life to keep anal continence. Only when intra-abdominal pressure and rectal pressure rise suddenly as in coughing, it acts for strengthening the contraction of external sphincter to keep continence as a part of automated learning response just like a reflex. In this sense, tonicity which is in charge of internal sphincter has more significant role in continence function than external sphincter. Physiologic parameter for that tonicity is anal resting pressure.

Anal manometry has been used in the study of patients who have fecal incontinence as an attempt to quantify anal sphincter function. As basic parameters there are resting pressure, squeeze pressure, length of the anal canal, length of HPZ and so on. Their values frequently drop in most patients with fecal incontinence regardless of their etiologies. However, some limitations of anal manometry are still a matter of concern. They frequently show moderate variations intra and inter-individually, and their correlations with clinical symptom cannot always be shown.[1,10-12] Nevertheless it can be said that resting pressure is more reliable than squeeze pressure judging from physical properties during metric procedure.

Resting pressure as basic manometric parameter has, however, a restriction that it represents cross sectional status of the anal canal without considering dimensional structure. Therefore, advanced parameters which can reflect dimensional pressure distribution such as vector volume, radial asymmetry,[13,14] and RPG of the anal canal are devised.

The RPG of the anal canal is a new physiologic parameter based on the fact that relative value of anal resting pressure in relation to rectal pressure is more important for continence than absolute value. It not only takes into account the usual resting pressure but also the distance over which these pressure changes occur, that is from basal to maximum. The resultant figure is expressed as a gradient. The pressure gradient becomes more important than simple difference between basal and maximum pressure as an index for continence function. The RPG has been pre-

sented to support the assertion of idiopathic anal incontinence arising from dysfunction of internal anal sphincter.[3] Although few studies reported the role of RPG in continence mechanism, it was shown recently that the concept of RPG can also be applied to evaluating usual incontinences other than idiopathic ones.[4] And this is confirmed in the present study.

Anatomically and physiologically, the main forces acting in the anal canal are attributable to the tonic activity of the internal and external anal sphincters and the puborectalis muscle. Distribution of these forces has been previously studied, showing that, at HPZ of the anal canal, there is a symmetrical radial distribution that is located in the middle or slightly distal part of the anal canal. By virtue of this distal location, incidental incontinence during sampling process could be prevented. Some longitudinal resting profiles performed in patients with anal incontinence have shown a qualitative proximal displacement of HPZ.[7,8]

The RPG is given by dividing pressure difference between maximum resting pressure and basal resting pressure with interval distance between their levels. On that account, it is in proportion to pressure difference and in reverse proportion to interval distance. It means that more proximal location of HPZ leads to higher RPG and makes the anal canal more favorable for maintaining continence. It is, however, paradoxical in view of previous studies which showed a qualitative proximal displacement of HPZ in patients with incontinence. But it was shown in this study that except RPG, differences were significant between patients with incontinence and control only in maximum resting pressure, not in length factors such as full length of the functional anal canal, length of HPZ and relative position of highest pressure. These facts suggest that proximal shift of HPZ in incontinent patients alleged previously is not definite, and in consequence major determinant of RPG is pressure factor rather than length factor when it comes to continence function.

There might be some limitations in this study. First, patients with incontinence were not subdivided according to underlying etiologies. There can be a subtle difference in change of resting pressure according to whether incontinence is sphincteric or neurogenic. Even in sphincteric incontinence, further difference can be expected according to whether damaged muscle is internal or external sphincter. However, regardless of their etiologies, most patients with incontinence usually present with functional depression of anal sphincter and decreased anal resting and squeeze pressure. In this regard, it is not unreasonable to treat patients in a whole category in this study. Another limitation is in selection of controls. Controls in this study are not normal healthy people, but are another patients group who visited our clinic for symptoms not related to incontinence. Their diseases which brought them to clinic were hemorrhoids, anal fistula and constipation which makes them not ideal controls. We regarded them as controls because it was hard to believe there was a clear role of hemorrhoids or anal fistula on anal sphincter function which could modify anal resting pressure, except in extreme cases. No one among controls was extreme about their diseases. Constipation might be accompanied by increased anal resting pressure in some patients, especially in those with anal canal hypertonia. But anal canal hypertonia is a rare condition, and no one among controls with constipation was diagnosed with it. To keep the age difference within patients to minimum, all controls were kept over 60 years old.

In conclusion, relative position of HPZ in the anal canal is not significantly different in patients with incontinence compared with controls, and major determinant of RPG is pressure factor rather than length factor regarding the continence function.

References

1. Deutekom M, Dobben AC, Terra MP, et al. Clinical presentation of fecal incontinence and anorectal function: what is the relationship? Am J Gastroenterol 2007;102:351-361.
2. Morgado PJ Jr, Wexner SD, Jorge JM. Discrepancies in anal manometric pressure measurement - important or inconsequential? Dis Colon Rectum 1994;37:820-823.
3. Stojkovic SG, Balfour L, Burke D, Finan PJ, Sagar PM. Role of resting pressure gradient in the investigation of idiopathic fecal incontinence. Dis Colon Rectum 2002;45:668-673.
4. Seong MK. Kim KY, Yoo YB. [Evaluation of anal continence function by advanced anal manometric parameters.] J Korean Soc Coloproctol 2009;25:20-25. [Korean]
5. Williamson JL, Nelson RL, Orsay C, Pearl RK, Abcarian H. A comparison of simultaneous longitudinal and radial recordings of anal canal pressures. Dis Colon Rectum 1990;33:201-206.
6. Coller JA. Clinical application of anorectal manometry. Gastroenterol Clin North Am 1987;16:17-33.
7. Coller JA. Computerized anal sphincter manometry performance and analysis. In: Smith LE, ed. Practical guide to anorectal testing. New York: Igaku-Shoin 1990:65-109.
8. Goes RN, Simons AJ, Beart RW Jr. Level of highest mean resting pressure segment in the anal canal. A quantitative assessment of anal sphincter function. Dis Colon Rectum 1996;39:289-293.
9. Rothenberger DA. Anal incontinence. In: Cameron JL, ed. Current surgical therapy. 3rd ed. Philadelphia: BC Decker 1989:186-194.
10. Eckardt VF, Elmer T. Reliability of anal pressure measurements. Dis Colon Rectum 1991;34:72-77.
11. Felt-Bersma RJ, Klinkenberg-Knol EC, Meuwissen SG. Anorectal function investigations in incontinent and continent patients.

Differences and discriminatory value. Dis Colon Rectum 1990;33: 479-485; discussion 485-486.
12. Hiltunen KM. Anal manometric findings in patients with anal incontinence. Dis Colon Rectum 1985;28:925-928.
13. Perry RE, Blatchford GJ, Christensen MA, Thorson AG, Attwood SE. Manometric diagnosis of anal sphincter injuries. Am J Surg 1990;159:112-116; discussion 116-117.
14. Sentovich SM, Blatchford GJ, Rivela LJ, Lin K, Thorson AG, Christensen MA. Diagnosing anal sphincter injury with transanal ultrasound and manometry. Dis Colon Rectum 1997;40:1430-1434.