An exploring study of defecography, digital rectal examination, and balloon expulsion test for screening and predicting of symptoms with defecation disorders

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Abbreviations: DF: Defecography; DRE: Digital Rectal Examination; BET: Balloon Expulsion Test; DD: Defecation Disorder; ARA: Anorectal Angle; RC: Rectocele; PD: Perineum Descending; SPFS: Spastic Pelvic Floor Syndrome; S-RS: Sacrum-Rectal Separate; SP: Splanchnoptosis; PFH: Pelvic Floor Hernia; AMP: Anterior Mucosal Prolapse; PMH: Puborectalis Muscle Hypertrophy; IRI: Internal Rectal Intussusception; ERP: External Rectal Prolapse.

Abstract

Background: Defecation disorder is widely common in constipation, which diagnosed by Defecography (DF), Digital Rectal Examination (DRE), Balloon Expulsion Test (BET), and others. It remains not clear that which one would be more accessible and effective due to no comparison of defecation disorders among diagnosis, classification and treatments, based on symptoms. The aim of this study is to evaluate which method should be used more easy operational and accurately in clinics with prediction based on symptoms.

Methods: Consecutive patients with chronic constipation (Rome III criteria, n=141) underwent DF, DRE, and BET between 2014 and 2018. Those examination findings and symptoms with constipation were recorded and analyzed.

Results: Of the 141 patients included in our study, 67 (47.5%) had a sensation of incomplete defecation, 66 (46.8%) of these were identified to have clinical symptoms with obstruction. The sensitivity and specificity of DF for identifying patients with obstruction were 42.4% and 78.7%, respectively; the positive predictive value was 63.6%, with [AUC: 0.62 (95% CI: 0.54-0.71)]. The sensitivity and specificity of DRE for identifying patients with a sensation of incomplete defecation were 76.1% and 44.6%, respectively; the positive predictive value was 55.4%, with [AUC: 0.60 (95% CI: 0.53-0.68)]. It is only useful dignosis for abdominal distention used BET. The sensitivity and specificity of BET for identifying patients with abdominal distention were 75.0% and 43.6%, respectively, with [AUC: 0.59 (95% CI: 0.51-0.68)]. The positive correlation between sacrum-rectal separate and obstruction was observed in the study, the similar correlation was observed in between Pelvic floor hernia and abdominal distention.

Conclusions: It is a valuable tool for diagnosis and further treatment of these six symptoms used an index combining DF and DRE. In addition, DF and DRE would be a more accessible and effective clinical tool for screening and diagnosis of patients with obstruction and a sensation of incomplete defecation, respectively. However, it would be only valuable tool for abdominal distention used BET. Both methods could facilitate the selection of appropriate patients for further examinations and tailored therapy accordingly.

Introduction

Constipation is a common gastrointestinal symptoms through out the world in primary care, which affects the quality of life and increases medical costs related to diagnosis and treatment, especially the elderly. The previous study showed that its prevalence has been steadily increasing from 11% to 18% in communities [1]. Based on the literature [2], the occurrence of constipation has also been shown to vary according to race and the regions that sufferers live in. Although the symptoms of constipation are generally harmless, they are sometimes warning signs of more serious conditions including colorectal cancer, cardiocerebrovascular and kidney disease [3-5]. Patients with chronic constipation often have mental and psychological disorders such as anxiety and depression [6,7], which seriously affect the physical and mental health of the patients and significantly reduces their quality of life.

The constipation is classified into two types, namely functional and organic. Nevertheless, functional constipation subtypes are considered to include functional defecation disorders, slow transit constipation, and a combination of the former two. Due to literatures [8,9], the functional defecation disorders diagnosed in 12%-24% of patients' complaints with a sensation of incomplete defecation and obstruction.

The defecation disorders could be accurately diagnosed by some examinations in clinics, including DF, DRE, and BET [10]. DF is a traditional barium enema technique for dynamic and static observation of the structure and function of the anorectal and pelvic floor using X-rays during defecation[11]. Although the function of the anal sphincter function, presence of dyssynergia, and fecal impaction can be fully shown by DRE, the defecation disorder should be diagnosed with DF and (or) BET, not solely [12]. It is unclear for patients with defecation disorders how to select these three methods in clinics. Hence, our aim is to how to fastly, accurately and conveniently select one method, which would be more suitable for first screening in primary care, based on symptoms.

Materials and methods

Characteristics of enrolled patients

A total of 141 patients aged from 18 to 80 were enrolled with clinical symptoms of constipation and received examination in our hospital between 2014 and 2018, including DF, DRE, and BET. The clinical diagnosis of constipation is mainly based on the Rome III diagnostic criteria and patient complaints [9,13,14], including a history of the foregoing symptoms for at least 6 months and having at least 2 of the following complaints for at least 3 months: difficulty in passing stools, dry balls or hard feces, anorectal obstruction that needs manual assistance, and a frequency of bowel movement <3 times a week. All patients were asked to complete a questionnaire including their names, gender, constipation symptoms including frequency of bowel movements, hard stools, difficulty in passing stools, a sensation of incomplete defecation, obstruction, abdominal distention, presence of anorectal organic diseases such as tumor, surgical history etc, with or without systemic diseases (diabetes, Parkinson's, hypothyroidism and so on) after patients were excluded. The study protocol was approved by the Research Ethics Committee of our Hospital and written informed consent was obtained from all participants.

Defecography examination

Usually, defecography can be performed without any preparation. At most, a 60-120 mL glycerin enema has to be administered.

A multi-functional digital perspective photography system and a DS-1 seater were used in the present study. First, each patient was asked to cooperate actively with the radiologists. Second, each patient adopted a lateral (distal) supine position and was injected with barium through the anus. Lastly, each patient was permitted to sit sideways on a self-made pervious and rotator X-ray barrel for the convenience of dynamic observation of the rectal and anal canal morphology and the mucosa during rest, lift, contraction and defecation. The X-ray barrel is shown in Figure 1A.

Digital rectal examination

DRE is not only important but also the most revealing part of a clinical evaluation [15]. This manoeuvre consisted of 2 steps. With the patient in the left lateral position, and hips flexed to 90°. Firstly, the anus and surrounding tissue were exposed to good light to check for skin of the anus. Next, digital palpation was performed by slowly advancing a lubricated and gloved index finger into the rectum. Not only the resting and squeeze sphincter tone of the anal sphincter, but also puborectalis muscle could be assessed by asking the subject to squeeze for as long as possible. Simultaneously, the examiner should perceive relaxation of the external anal sphincter and (or) the puborectalis muscle, together with perineal descent. Next, the patient then was asked to push and bear down as if to defecate when the examiner placed the left hand on the abdomen to assess the pushing effort [12]. Any absence of these findings should suggest the suspicion for dyssynergic defecation.To ensure the veracity of the responses, each step should be repeated once or twice [15,16]. The presence of any 2 of the following findings was used to clinically diagnose dyssynergia: the inability to contract the abdominal muscles, inability to relax the anal sphincter, a paradoxic contraction of the anal sphincter, or the absence of perineal descent.

Balloon expulsion test

The balloon expulsion test [17] is a simple, clinical examination to judge whether the function of rectum and pelvic floor muscles is abnormal. In this test, A 4-cm long balloon tipped catheter is inserted in to the ampulla rectal and inflated with warm water at 37°C or air to 50 mL. The subject is asked to take the habitual defecation posture to expel the balloon while timed.

Major measurements and observations

DF: According to the modified diagnostic criteria for X-ray defecography reported in a previous study [18], the measurements and observation made in the present study mainly included: 1) The Anorectal Angle (ARA), which was defined as the angle of the longitudinal axis of the anal canal and the posterior rectal line, mainly reflected the activity of the puborectalis. The value at rest was between 92 and 114 degrees; during muscle contraction the ARA becomes more acute, while during the re-

laxing phase it became obtuse. In spastic pelvic floor syndrome, the ARA was unchanged during defecation compared to the angle at rest. 2) The distance between the anorectal junction and the pubococcygeal line (DUAC) is the vertical distance from the upper midpoint of the anal canal to the pubococcygeal line (the joint of the lower margin of the pubic symphysis to the tip of the coccyx). The value of perineum descending was > 30 mm. 3) The distance between the sigmoid colon and the pubococcygeal line (DSPC); the vertical distance from the lowest point of the sigmoid colon or the small intestine to the pubococcygeal line should be a negative value except for the condition of splanchnoptosis. 4) The distance between the sacrum and the rectum (DSR); the distance between the anterior wall of the third sacrum and the posterior wall of the rectum. The value of the Sacrum-Rectal Separation (S-RS) should be > 20 mm; the above measurements are shown in Figure 1B.

DRE: The presence of any stricture, spasm, tenderness, mass, blood or stool were noted. It assess the strength of anal resting sphincter and rectal squeeze tone. The normal should be considered to be relaxed for former and increased for later. In addition to assess the anal sphincter tone with defecation whether relaxed or not, the change of ARA should be observed. If normal, the former should be relaxed, the ARA would be increased, compared with the resting.

BET: The normal result of this test is considered within one to two minutes, whereas, dyssynergia is suspected if the patient is unable to expel the balloon in under two minutes.

Statistical analysis

SPSS Statistics for Windows software (ver. 22.0, SPSS Inc., US) and R 3.6.1 software were used for all statistical analyses. Measurements of normally distributed data are presented as the mean ± standard deviation ($\chi \pm SD$). Enumeration data are described as constituent ratios. A chi-squared test was performed to compare the rates between two groups. Logistic regression was used to fit model to detect the constipation symptoms and ROC curves were used to evaluate classification effect of the predictors. A value of $P < 0.05$ was considered to be of statistical significance.

Results

Basic demographic characteristics of the enrolled cohort

In the present study, 141 patients (34 male and 107 female, with a M/F ratio of 1:3.2) with clinical symptoms of constipation who received examinations in our hospital between 2014 and 2018. The main clinical symptoms were a low frequency of bowel movements, hard stools, difficulty in passing stools and a sensation of incomplete defecation, as well as a feeling of obstruction and abdominal distension, which accounted for 28.4-58.2% of patients (Table 1). In different age ranges, it was found that constipation was more common in the middle and older age groups (30-69 years), the incidence being 17.7% at 30-39 years, 24.8% at 40-49 years, 17.0% at 50-59 years and 19.9% at 60-69 years old, respectively. A significant difference in the defecation disorder distribution between patients < 30 years old and patients > 70 years old was revealed (Figure 2).

Next, we evaluated the DF findings and classified constipation patients in the 141 patients. Rectocele (RC) and perineum descending (PD) are the two main pathogens found in defecation disorders with DF, accounting for 78.7% and 65.3% in the

141 patients, respectively. We further attempted to analyze whether an index combining DF and others would be useful for the screening and diagnosis of symptoms with defecation disorders.

Correlation analysis of constipation symptoms and defecographic findings

In our present study, we found that the clinical symptoms of a lower frequency of bowel movements, hard stools, difficult defecation, and a sensation of incomplete evacuation, were difficult to associate with any defecography indicators (Table 2), while obstruction as a clinical symptom was related to sacrum-rectal separate (S-RS) defecography ($\chi^2 = 5.034$, $P=0.025$). In addition, abdominal distension was not only related to PD but also with Pelvic Floor Hernia (PFH) ($P=0.031$, $P=0.001$). These findings indicated that it could be diagnosed and confirmed with DF of the S-RS with obstruction, which once had abdominal distention, and could be further confirmed to be a defecation disorder with PD or PFH.

Based on patients with obstruction, the positive correlation between S-RS and a feeling of obstruction was found by multi-factor logistic regression (OR=3.1, $P=0.03$). The sensitivity and specificity of DF for identifying patients with this symptom were 42.4% and 78.7%, respectively. In addition, the positive predictive value was 63.6%, with the AUC of 0.62 and 95% confidence interval of 0.54-0.71 (Table 3). Based on patients with abdominal distention, the positive correlation between PFH and abdominal distention was found by multi-factor logistic regression (OR=0.43, $P=0.003$). The sensitivity and specificity of DF for identifying patients with this symptom were 42.5% and 87.1%, respectively, with AUC of 0.67 and 95% confidence interval of 0.57-0.77.

Correlation analysis of constipation symptoms and DRE findings

The change of ARA, when push efforts, is normal in a total of 92 patients (65.2%), and 49 patients (34.8%) is unchanged or less than 90 degree, compared with the resting (Table 4). There was a negative correlation between the change of ARA and a sensation of incomplete defecation detected by multi-factor logistic regression (OR=0.39, $P=0.011$). The sensitivity and specificity of DRE for identifying patients with a sensation of incomplete defecation were 76.1% and 44.6%, respectively; the positive predictive value was 55.4%, with AUC of 0.60 and 95% confidence interval of 0.53-0.68. It was not valuable diagnosis for a sensation of incomplete defecation used DF, with the AUC of 0.56 and 95% confidence interval of 0.48-0.63 (Table 5). There is no significant difference between other symptoms and DRE findings detected by detected by multi-factor logistic regression.

Correlation analysis of constipation symptoms and BET findings

A total of 141 patients (38.3%) had normal balloon expulsion time, 87 patients (61.7%) could not expel the balloon or prolonged balloon expulsion time. It has an valuable dignosis of abdominal distention used BET. The sensitivity and speciicity of BET for identifying patients with abdominal distention were 75.0% and 43.6%, respectively, with AUC of 0.59 and 95% confidence interval of 0.51-0.68. However, there was no significant difference in patients with abdominal distention between DF and BET (Delong test: $P=0.24$).

Correlation analysis of constipation symptoms and the combined index findings

We further attempted to analyze whether an index combining DF and DRE would be useful for the detection and diagnosis of defecation disorders. The sensitivity and specificity of the combined index for identifying patients with obstruction were 43.9% and 77.3%, respectively. In addition, the positive predictive value was 63.0%, with the AUC of 0.64 and 95% confidence interval of 0.55-0.73 (Figure 3). And there is no difference in the classification effect between DF index and the combined index by comparing the areas under the ROC curves (AUC) (Delong test, *P*=0.64).

The sensitivity and specificity of an index combining DF and DRE for identifying patients with a sensation of incomplete defecation were 44.6% and 76.1%, respectively. In addition, the positive predictive value was 63.0%, with the AUC of 0.61 and 95% confidence interval of 0.53-0.70 (Figure 4). And there is no significant difference in a sensation of incomplete defecation between DRE and combined examination (Delong test, *P*=0.64).

The sensitivity and specificity of an index combining DF and DRE for identifying patients with abdominal distention were 42.5% and 87.1%, respectively, with AUC of 0.68 and 95% confidence interval of 0.59-0.79. And there is no significant difference in abdominal distention between BET and combined examination (Delong test, *P*=0.64).

Predictive logistic model for symptoms with examination

According to ROC curves, the comparison between DF, DRE, and BET, based on symptoms, were in Table 6. It was valuable diagnosis for these six symptoms used an index combining DF and DRE. BET was a useful tool for one symptom. Based on these results, the logistic model containing an index combining DF and DRE findings and six symptoms were as follows:

The logistic model containing an index combining DF and DRE findings and obstruction was as follows: logit(π)= - 0.58 + 1.09 $X$104 − 0.51 $X$105 + 0.66 $X$106 + 0.58 $X$109 + 0.31 $X$201 + 0.18 $X$202 − 0.22 $X$203: [$X$104: S-RS: [(+): 1, (-): 0], $X$105: SP: [(+): 1, (-): 0], $X$106: PFH: [(+): 1, (-): 0], $X$109: IRI: [(+): 1, (-): 0], $X$201: ARA: [Unchanged or less than 90°]: 1, (Increased): 0], $X$202: Anal testing tone: [(Normal): 0, (Increased): 1, (Decreased): 2], $X$203: Anal squeeze pressure: [(inadequate contraction): 1, (Normal): 0], and cut-off value was 0.495.

The logistic model containing an index combining DF and DRE findings and a sensation of incomplete defecation was as follows: logit(π)=0.26 − 0.25 $X$103 − 0.86 $X$201: [$X$103: SPFS: [(+): 1, (-): 0], $X$201: ARA: [(Unchanged or less than 90°): 1, (Increased): 0], and cut-off value was 0.428.

The logistic model containing an index combining DF and DRE findings and low frequency of bowel movements was as follows: logit(π)= 0.28 − 0.27 $X$101 + 0.66 $X$105 - 0.74 $X$106 − 1.61 $X$110+ 0.17 $X$201 - 0.32 $X$202 + 0.24 $X$203 + 0.09 $X$204:[$X$101: RC: [(+): 1, (-): 0], $X$105: SP: [(+): 1, (-): 0], $X$106: PFH: [(+): 1, (-): 0], $X$110: AMP: [(+): 1, (-): 0], $X$201: ARA: [Unchanged or less than 90°]: 1, (Increased): 0], $X$202: Anal testing tone: [(Normal): 0, (Increased): 1, (Decreased): 2], $X$203: Anal squeeze pressure: [(inadequate contraction): 1, (Normal): 0], $X$204: Anal sphincter relaxation: [(Impaired): 1, (Paradoxic contraction): 2, (Normal): 0], and cut-off value was 0.426.

The logistic model containing an index combining DF and DRE findings and hard stools was as follows: logit(π)= 0.30 − 0.28 X102 + 0.56 X103 - 0.83 X104 + 0.82 X108 - 0.80 X109 - 0.48 X110 + 0.34 X201 + 0.34 X203: [$X$102: PD: [(+): 1, (-): 0], $X$103: SPSF: [(+): 1, (-): 0], $X$104: S-RS: [(+): 1, (-): 0], $X$108: PMH: [(+): 1, (-): 0], $X$109: IRI: [(+): 1, (-): 0], $X$110: AMP: [(+): 1, (-): 0], $X$201: ARA: [Unchanged or less than 90°]: 1, (Increased): 0], $X$203: Anal squeeze pressure: [(inadequate contraction): 1, (Normal): 0]], and cut-off value was 0.662.

The logistic model containing an index combining DF and DRE findings and difficulty in passing stools was as follows: logit(π)= - 1.19 - 0.19 X102 − 0.27 X106 + 1.26 X110 + 0.42 X201 + 0.47 X202 - 0.37 X203:[$X$102: PD: [(+): 1, (-): 0], $X$106: PFH: [(+): 1, (-): 0], $X$110: AMP: [(+): 1, (-): 0], $X$201: ARA: [Unchanged or less than 90°]: 1, (Increased): 0], $X$202: Anal testing tone: [(Normal): 0, (Increased): 1, (Decreased): 2], $X$203: Anal squeeze pressure: [(inadequate contraction): 1, (Normal): 0]], and cut-off value was 0.254.

The logistic model containing an index combining DF and DRE findings and abdominal distention was as follows: logit(π)= - 1.62 + 0.65 X102 − 0.39 X103 - 0.53 X104 + 1.29 X106 + 0.16 X201:[$X$102: PD: [(+): 1, (-): 0], $X$103: SPSF: [(+): 1, (-): 0], $X$104: S-RS: [(+): 1, (-): 0], $X$106: PFH: [(+): 1, (-): 0], $X$201: ARA: [Unchanged or less than 90°]: 1, (Increased): 0]], and cut-off value was 0.405.
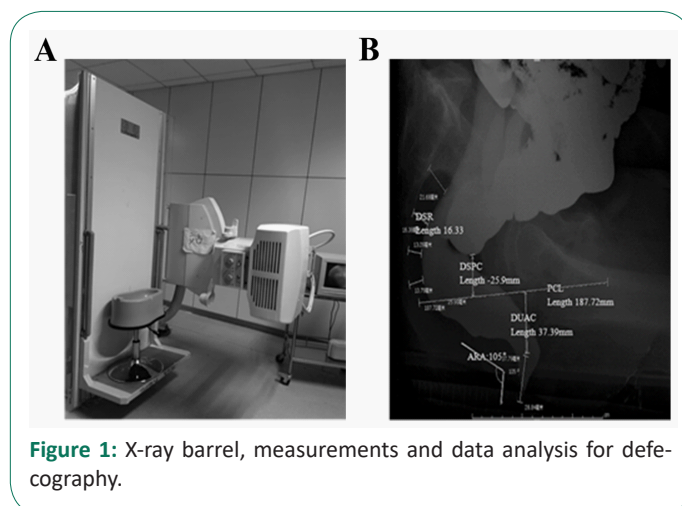

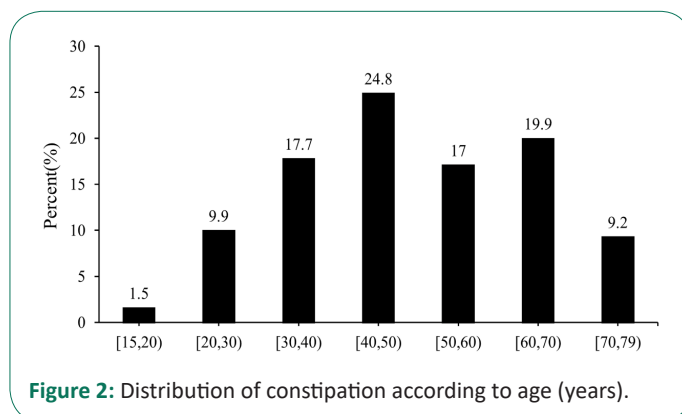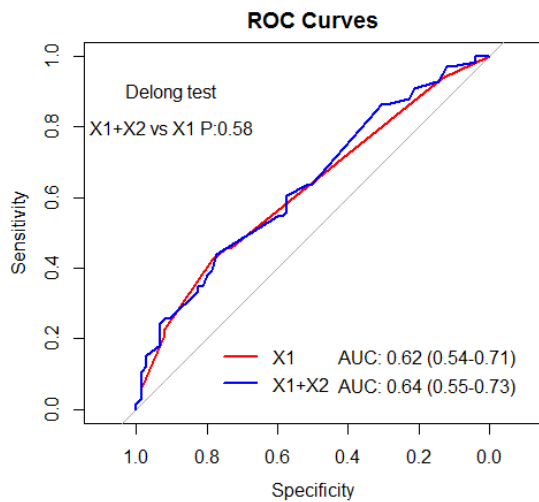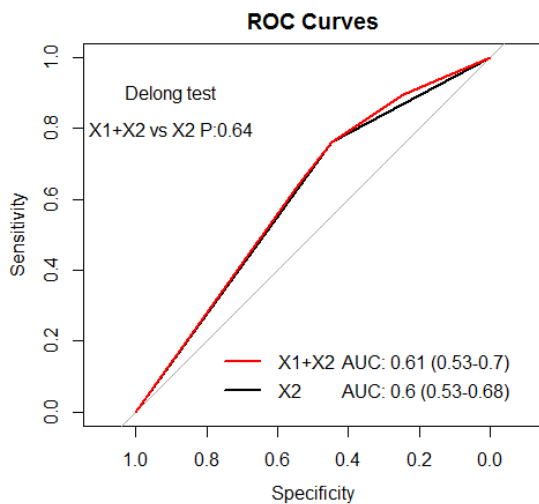**Figure 1:** X-ray barrel, measurements and data analysis for defecography.

Figure 2: Distribution of constipation according to age (years).

ROC Curves

Figure 3: AUCs obtained from each ROC Curve using DF (X1) and combined dignosis (X1+X2) and obstruction.

ROC Curves

Figure 4: AUCs obtained from each ROC Curve using DF (X1) and combined dignosis (X1+X2) and obstruction.

Table 1: Basic demographic characteristics of patients.

Variables	N	%
Age (years) < 50	76	53.9
Gender (Male)	34	24.1
Clinical symptoms		
Low frequency of bowel movements	66	46.8
Hard stools	82	58.2
Difficulty in passing stools	43	30.5
A sensation of incomplete defecation	67	47.5
Obstruction	66	46.8
Abdominal distention	40	28.4
Defecography		
Rectocele (RA)	111	78.7
Perineum descending (PD)	92	65.3
Spastic pelvic floor syndrome (SPSF)	40	28.4
Sacrum-rectal separate (S-RS)	20	14.2
Splanchnoptosis (SP)	22	15.6
Pelvic floor hernia (PFH)	33	23.4
External rectal prolapse (ERP)	1	0.7
Puborectalis muscle hypertrophy (PMH)	5	3.6
Internal rectal intussusception (IRI)	3	2.1
Anterior mucosal prolapse (AMP)	5	3.6
Regular defecography	1	0.7

RC: Rectocele; PD: Perineum Descending; SPSF: Spastic Pelvic Floor Syndrome; S-RS: Sacrum-Rectal Separate; SP: Splanchnoptosis; PFH: Pelvic Floor Hernia ERP: External Rectal Prolapse; PMH: Puborectalis Muscle Hypertrophy; IRI: Internal Rectal Intussusceptions; AMP: Anterior Mucosal Prolapse.

Table 2: The relationship between clinical symptoms and DF indicators.

	N (%)	Low frequency of bowel movements	Hard stools	Difficulty in passing stools	A sensation of incomplete defecation	Obstruction	Abdominal Distention
RC							
Yes	111 (78.8)	50 (45.0)	63 (56.8)	33 (29.7)	52 (46.8)	51 (45.9)	32 (28.8)
No	30 (21.2)	16 (53.3)	19 (63.3)	10 (33.3)	15 (50)	15 (50)	8 (26.7)
PD							
Yes	92 (34.7)	44 (47.8)	50 (54.3)	26 (28.2)	43 (46.7)	44 (47.8)	31(33.7)*
No	49 (65.3)	22 (44.9)	32 (65.3)	17 (34.7)	24 (49.0)	22 (44.9)	9 (18.4)
SPSF							
Yes	40 (28.4)	20 (50.0)	28 (70.0)	13 (32.5)	15 (37.5)	18 (45.0)	9 (22.5)
No	101 (71.6)	46 (45.5)	54 (53.5)	30 (29.7)	52 (51.5)	48 (47.5)	31 (30.7)
S-RS							
Yes	20 (14.2)	8 (40)	8 (40.0)	7 (35.0)	10 (50.0)	14 (70.0)*	4 (20.0)

	N(%)	Low frequency of bowel movements	Hard stools	Difficulty in passing stools	A sensation of incomplete defecation	Obstruction	Abdominal distention
No	121 (85.8)	58 (47.9)	74 (61.2)	36 (29.8)	57 (47.1)	52 (43.0)	36 (29.8)
SP							
Yes	22 (15.6)	12 (54.5)	13 (59.1)	6 (27.3)	11 (50.0)	8 (36.4)	6 (27.3)
No	119 (84.4)	54 (45.4)	69 (58.0)	37 (31.1)	56 (47.1)	58 (48.7)	34 (28.6)
PFH							
Yes	33 (23.4)	11 (33.3)	18 (54.5)	8 (24.2)	17 (51.5)	19 (57.6)	17 (51.5)*
No	108 (76.6)	55 (50.9)	64 (59.3)	35 (32.4)	50 (46.3)	47 (43.5)	23 (21.3)
ERP							
Yes	1(7.1)	1 (100)	1 (100.0)	0 (0)	1 (100.0)	0 (0)	1 (100.0)
No	140 (92.9)	65 (46.4)	81 (57.9)	43 (30.7)	66 (47.1)	66 (47.1)	39 (27.9)
PMH							
Yes	5 (3.5)	3 (60.0)	4 (80.0)	2 (40.0)	3 (60.0)	3 (60.0)	2 (40.0)
No	136 (96.5)	63 (46.3)	78 (57.4)	41 (30.1)	64 (47.1)	63 (46.3)	38 (27.9)
IRI							
Yes	3 (2.1)	1(33.3)	1 (33.3)	1 (33.3)	1 (33.3)	2 (66.7)	1 (33.3)
No	138 (97.9)	65(47.1)	81 (58.7)	42 (30.4)	66 (47.8)	64 (46.4)	39 (28.3)
AMP							
Yes	5 (3.5)	1(20.0)	2 (40.0)	3 (60.0)	3 (60.0)	3 (60.0)	1 (20.0)
No	136 (96.5)	65(47.8)	80 (58.8)	40 (29.4)	64 (47.1)	63 (46.3)	39 (28.7)
RD							
Yes	1 (7.1)	1(100.0)	0 (0)	0 (0)	1 (100.0)	0 (0)	0 (0)
No	140 (92.9)	65(46.4)	82 (58.6)	43 (30.7)	66 (47.1)	66 (47.1)	40 (28.6)

*Representing that the *P* value of the significant test of chi-squared is smaller than 0.05; RC: Rectocele; PD: Perineum Descending; SPSF: Spastic Pelvic Floor Syndrome; S-RS: Sacrum-Rectal Separate; SP: Splanchnoptosis; PFH: Pelvic Floor Hernia ERP: External Rectal Prolapse; PMH: Pub-orectalis Muscle Hypertrophy; IRI: Internal Rectal Intussusceptions; AMP: Anterior Mucosal Prolapse; RD: Regular Defecography.

Table 3: The relationship between clinical symptoms and DF indicators.

		95% CI	
	Estimated value	Lower limit	Upper limit
Sensitivity	0.424	0.306	0.552
Specificity	0.787	0.673	0.869
For any particular positive test result, the probability that it is:			
True positive	0.636	0.477	0.772
False positive	0.364	0.228	0.523

Table 4: Detection rate of DRE in 141 patients with symptoms.

	N(%)	Low frequency of bowel movements	Hard stools	Difficulty in passing stools	A sensation of incomplete defecation	Obstruction	Abdominal distention
ARA							
Increased	92 (65.2)	40 (60.6)	49 (59.8)	25 (58.1)	51 (76.1)*	41 (62.1)	28 (70)
Less than 90° or unchanged	49 (34.8)	26 (39.4)	33 (40.2)	18 (42.9)	16 (23.9)	25 (37.9)	12 (30)
Anal resting tone							
Normal	27 (19.1)	16 (24.2)	16 (19.5)	5 (11.6)	13 (19.4)	12 (18.2)	10 (25)

Increased	107 (75.9)	46 (69.7)	62 (75.6)	36 (83.7)	50 (74.6)	49 (74.2)	27 (67.5)
Decreased	7 (5.0)	4 (6.1)	4 (4.9)	2 (4.7)	4 (6.0)	5 (7.6)	3 (7.5)
Anal squeeze pressure							
Normal	107 (75.9)	48 (72.7)	60 (73.2)	35 (81.4)	51 (76.1)	52 (78.8)	30 (75)
Decreased	34 (24.1)	18 (27.3)	22 (26.8)	8 (18.6)	16 (33.9)	14 (21.2)	10 (25)
Anal sphincter relaxation							
Normal	57 (40.4)	25 (37.9)	32 (39.0)	18 (41.9)	25 (37.3)	27 (40.9)	16 (40)
Impaired	65 (46.1)	30 (45.5)	39 (47.6)	20 (46.5)	33 (49.3)	31 (47.0)	20 (50)
Paradoxic contraction	19 (13.5)	11 (16.7)	11 (13.4)	5 (11.6)	9 (13.4)	8 (12.1)	4 (10)

Table 5: Performance characteristics of DRE in the diagnosis of a sensation of incomplete defecation.

		95% CI	
	Estimated value	Lower limit	Upper limit
Sensitivity	0.761	0.639	0.85
Specificity	0.446	0.332	0.57
For any particular positive test result, the probability that it is:			
True positive	0.554	0.447	0.657
False positive	0.446	0.343	0.553

Table 6: Classification effect of predictors for six outcomes (AUC(95%CI)).

	X1(DF)	X2(DRE)	X3(BET)	X2+X3	X1+X2
Y1 (Low frequency of bowel movements)	0.63(0.54-0.71)*	0.58(0.48-0.67)	0.57(0.49-0.65)	0.61(0.52-0.70)*	0.64(0.55-0.74)*
Y2 (Hard stools)	0.63(0.54-0.72)*	0.58(0.50-0.67)*	0.51(0.43-0.59)	0.58(0.50-0.67)*	0.64(0.55-0.73)*
Y3 (Difficulty in passing stools)	0.57(0.48-0.67)	0.61(0.52-0.71)*	0.52(0.44-0.61)	0.61(0.52-0.71)*	0.63(0.52-0.73)*
Y4 (A sensation of incomplete defecation)	0.56(0.48-0.63)	0.60(0.53-0.68)*	0.52(0.44-0.60)	0.60(0.53-0.68)*	0.61(0.53-0.70)*
Y5 (Obstruction)	0.62(0.54-0.71)*	0.57(0.48-0.66)	0.53(0.45-0.61)	0.56(0.46-0.65)	0.64(0.55-0.73)*
Y6 (Abdominal distention)	0.67(0.57-0.77)*	0.53(0.45-0.62)	0.59(0.51-0.68)*	0.61(0.52-0.71)*	0.68(0.58-0.78)*

* Represents that the *P* value of the significant test of AUC is smaller than 0.05
* based on Y2, Y3, and Y4, it would be considered as the same model between X2 and an index combining X2 and X3, due to X3 excluded with *P >* 0.5.

Discussion

Constipation is a very common disorder worldwide, with the variable symptoms of this gastrointestinal tract occurring most frequently in children, women and the elderly. The examination of the causes and treatment of constipation has recently become a very significant field of research [19]. As is shown that in previous study [20], detailed clinical examination, and in particular a DRE, DF, and (or) BET is indispensable in the evaluation of a patient with defecation disorder constipation. It can fully evaluate whether a patient has acute or chronic constipation, and whether the condition is primary or secondary. In our present study, it is a useful tool for patients with adominal distention used BET, and it is valuable dignosis for patients with these six symptoms used an index combining DF and DRE. However, DF [21] is currently considered as the primary method for the detection of obstructed defecation, as it produces more accu-

rate results than a barium enema and colonoscopy. At present, the DF used in clinics is limited, due to its radiation exposure, poor tolerance, lack of trained physician, embarrassment, and performed with MR defecography [22]. However, Foti et al. [23-25] pointed out that MR defecography was less sensitive than X-ray defecography for the diagnosis of enterocele, rectocele and rectal prolapse (56%, 38% and 85%, respectively) [26]. Patients with DRE, considered as physical testing, could be selected for further appropriate physiologic testing and treatment. It would be limited in clinics due to trainees lack of adequate skills, privacy and the poor consent. Hence, based on patients with symptoms, it is important for clinicians to select the most examinations, and further to guide treatment.

We found that the etiology of constipation had a tendency to be diversified. Unlike reported in previous investigations [27], RC was detected in 20 (40%) vs 111 (78.7%). No abnormalities

were observed in RC in 30 cases that had previously undergone colonoscopy. And a previous study [28] reported that detection rates of Internal rectal intussusception (IRI) and Anterior Mucosal Prolapse (AMP) were 37.5% and 15%, respectively. In contrast, unlike in our study, it was 2.1% and 5.5%, respectively. These different results might be associated with the patient's position, requirement for radiologists, and the types and traits of enemas employed.

Ramage et al. [29] concluded that the results of defecography were poorly correlated with the severity of 'patient reported' symptoms. Unlike the previous study, there was a substantial concordance in our study, not only with significant differences between obstruction and S-RS, but also between abdominal distention and PFH observed. It further shows that it is not obviously diagnosed by the DRE in patients with obstruction and abdominal distention in our present study. However, the S-RS can diagnose the 63.6% of obstruction in DF, and the 63.0% of it in an index combining DF and DRE, which suggests that patients with this symptom may be related to abnormal anatomy of defecation-related condition. It is found that DF could be used as a much more accessible diagnostic method for patients with obstruction and an index combining DF and DRE can further assess for the screening and diagnosis of the cause(s) of their symptoms, to guide treatment in clinics [30]. The treatment of constipation includes drug therapy, anorectal myectomy, biofeedback or surgery, but in general these treatments have poor efficacy due to various etiology [31,32]. Thus treatment decisions should not depend solely on this type of feedback.

Based on patients with a sensation of incomplete defecation, in our study, the ARA in pushing efforts is unchanged or the change is not more than 90 degree, compared with the resting. It seems that the sensitivity and specificity of DRE for identifying patients with a feeling of incomplete defecation were 76.1% and 44.6%, respectively. At the same time, there are the 55.4% of patients with a feeling of incomplete defecation who could be diagnosed by DRE. An index combining DF and DRE is no better than DRE alone, and we conclude that DRE would be first line screening for a sensation of incomplete defecation. Like to previous study [16], which showed that the symptoms of incomplete evacuation was independent predictors of functional defecation disorder on multivariate analysis. However, the previous study [33] showed that defecation disorders could be detected by DRE with a sensitivity of 75% and a specificity of 87%. This different result may be explained by the fact that it is associated with most physicians and trainees who has inadequate skills. Hence, we infer that this symptom could associate with pelvic floor spasm, and the pathogenesis may be related to functional defecation disorders. Those patients need to be further accurately diagnosed by the Anorectal Manometry [34], who may have a certain benefit from biofeedback therapy.

Due to literature [35,36], BET is a useful screening test for identifying patients with defecation disorder, and the previous study showed that the specificity of it it is high (80-90%), although the sensitivity is low (50%). However, based on previous study [37], one study showed that the prevalence of a positive test in favor of dyssynergia varies between 23% and 67%. Another study suggested a specificity of 89%, and a sensitivity of 88%. In addition, Grossi et al. [38] pointed that the BET has an 80%-90% specificity and sensitivity ranges from 33 to 94% for dyssynergia as defined by anorectal manometry (which itself remains a controversial diagnostic tool given its possible high false positive rate [39]). Unlike the previous study, there is significant difference between abdominal distention and BET in our present study, with the sensitivity of 75.0% and specificity of 43.6%. We consider that this different result may be related to testing techniques, body positions and types of balloons. However, an index combining DF and DRE is no better than BET and DF alone, and we conclude that BET or DF would be first line screening for abdominal distention.

In additon, based on ROC curves, an index combining DF and DRE could be as valuable diagnosis of these six symptoms. At the same time, low frequency of bowel movements, and hard stools could be detected by DF with a sensitivity of 36.4% and a specificity of 81.3%, and a sensitivity of 91.5% and a specificity of 25.4%, respectively. Difficulty in passing stools, and hard stools could be detected by DRE with a sensitivity of 79.1% and a specificity of 37.8%, and a sensitivity of 57.3% and a specificity of 55.9%, respectively. In addition, an index combining DF and DRE is no better than one used solely. However, there is no significant difference between above examinations and symptoms detected by multi-factors logistic regression. This phenomenon could be associated with our samples. Hence, it needs further explore these results in the future.

Some phenomena in our research data are worth noting. First, consistent with previous studies, the prevalence of constipation in females was higher than in males, a finding that may be explained by the characteristic female physiological form, such as a history of birth and degeneration of the pelvic floor muscles. Second, the prevalence of constipation was greater in the elderly, probably due to reduced intestinal movement because of a more sedentary life style and eating less of a diet? Thus, the suggestion is put forward that patients should do more exercise and increase their intake of water and dietary fiber.

The present study has a number of limitations. First, is the lack of a control group of 'healthy volunteers'. All patients in the study had been referred due to the presence of constipation symptoms, although these may not fully explain both the high prevalence of symptoms and the DF, DRE, and BET findings. Second, multiple factors may affect the occurrence of constipation, including age, sex, eating habits and the education level of patients. In addition, our study did not analyze the impact of these factors on bowel movements, which may cause sample bias. Finally, the sample size was relatively small. Therefore, a larger cohort of patients will be required in future studies to refine the distribution of constipation types for these symptoms so as to provide a more accurate decision making basis in the clinic.

Our study suggests that symptoms together with DRE or DF can be a useful tool for detecting and recognizing of a defecation disorder not only may facilitate an accurate diagnosis , tailored treatment but also lead to an improved clinical outcome, which can be widely applied in clinics and primary center. However, it is much more accessible and effective for such symptoms used one method solely.

Conclusions

In conclusion, it is necessary as well as primary for patients with obstruction to perform the DF examination. And DRE can be used for early identifying and predicting those who presenting symptoms of a sensation of incomplete defecation, which could be benefit from selecting tailored management. Suspicion of dyssynergic defecation on a proper DRE should be con-

firmed with anorectal manometry and/or DF, which associate with spastic pelvic floor muscle. Hence, it needs further refinement to develop more accurate and sensitive diagnostic indicators to simplify our understanding of defecation disorders. The logistic model containing an index combining DF and DRE findings, based on symptoms, would be valuable for clinicians to diagnosis and guide treatment in the future.

Declarations

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