

Abnormal Balloon Expulsion Test in Patients with Fecal Incontinence

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ABSTRACT

Background & Aims: Functional defecatory dysfunction is attributed to the pathophysiology of fecal incontinence (FI) in some patients. We hypothesized that patients with FI and abnormal balloon expulsion test (BET) have distinct manometric characteristics as compared to the patients with FI and normal BET. We aimed to compare the anorectal pressure profile in patients with FI, with or without abnormal BET and to identify risk factors associated with abnormal BET in FI.

Methods: We performed a retrospective review of 77 consecutive patients with ROME IV FI. Wilcoxon rank sum test, t-test, and Fisher exact tests were performed for comparison. Multivariable logistic regression was performed to identify factors associated with abnormal BET.

Results: Thirty-two percent of patients had abnormal BET. Demographics and surgical history and clinical symptoms, except for sensation of incomplete evacuation ($p=0.02$) and abdominal pain ($p=0.03$), were comparable in both groups. Anorectal pressure profile except for the median rectal propulsive pressures were similar between groups. Rectal propulsive pressures at simulated defecation were significantly lower in patients with abnormal BET ($p=0.02$). Mean sensory threshold for first sensation was also significantly higher in patients who had abnormal BET ($p=0.03$). Rectal propulsive pressures (OR: 1.03, 95% CI: 1.00-1.06, $p=0.032$) and rectal sensory threshold for first sensation (OR: 0.94, 95% CI: 0.90-0.99, $p=0.02$) were able to predict abnormal BET independently.

Conclusions: In patients with FI and similar clinical and anal pressure profile, rectal sensory threshold and rectal propulsive pressures at simulated defecation can determine normal BET.

Key words: fecal incontinence – functional defecatory dysfunction– balloon expulsion test – anorectal manometry.

Abbreviations: BET: balloon expulsion test; BMI: body mass index; FI: fecal incontinence; HR-ARM: high-resolution anorectal manometry.

INTRODUCTION

Fecal incontinence (FI) is a common yet under-recognized problem that affects nearly 15% of community dwelling men and women [1]. It has a devastating impact on the affected individual's quality of life [2]. ROME IV, the diagnostic classification for functional gastrointestinal disorders, defines FI as recurrent, uncontrolled passage of fecal material for at least 3 months [3]. Despite the delineation of a number of risk factors for FI

[advanced age, presence of diarrhea and urgency to defecate, high body mass index (BMI), cigarette smoking and presence of comorbid medical conditions] [4-6], the pathophysiology of FI remains poorly understood. Although a history of anorectal surgery, obstetric anal trauma sustained through the use of forceps or vacuum extraction, complicated episiotomy and presence of a rectocele have all been linked to the development of FI [4], anal sphincter dysfunction does not appear to be the principal pathology leading to loss of continence in many patients, and FI is considered to be a multifactorial disorder [7, 8].

Functional defecatory dysfunction with dyssynergic defecation has been described in some patients with fecal soiling or seepage. Indeed, Rao et al. [9] showed in a highly selective group of patients with fecal seepage, that more than 70% had a dyssynergic or obstructive pattern on anorectal

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manometry and that close to 30% had an abnormal balloon expulsion test (BET). While prevalence of FI seems to be similar between men and women [10], this form of FI has been reported more commonly among men [9]. Nonetheless, in studies of adult men with overt FI while only a minority had evidence of anal sphincter dysfunction, proctography revealed impaired rectal evacuation in 30% of these patients [11]. Those with evidence of rectal hyposensitivity were significantly more likely to have functional defecatory dysfunction [12]. Again, when compared to age-matched women with FI, functional defecatory dysfunction and rectal hyposensitivity were observed more frequently among males [11]. Overall, up to one-third of all patients with FI have no obvious sphincter pathology [7, 8]. These patients with FI and normal anal sphincter function, seem to be younger, have more severe constipation and less severe FI. On manometry they are more likely to demonstrate a dyssynergic pattern of defecation and higher rectal defecation pressures [8, 13]. Incomplete rectal evacuation has been associated with FI, not only in patients with normal anal sphincter function, but also in patients with a weak anal sphincter [7]. Overall, it appears that retained stools in the rectum increases the chance of leakage and, therefore, needs to be identified and corrected in patients with FI. Diagnosis of functional defecatory dysfunction in patients with FI is particularly important with regards to clinical management as these patients could be managed very effectively by biofeedback therapy [14, 15].

While functional defecatory dysfunction has been described among some patients with FI, the role of BET in patients with FI remains unclear. We hypothesized that patients with FI who have evidence of abnormal BET, have a distinctive anorectal pressure profile as compared to the ones with normal BET. Therefore, we sought to study differences in clinical and anorectal manometry parameters between patients with FI with regards to BET. Our study provides unique and much needed insight into the pathophysiology of FI which can lead to optimal clinical management of these patients.

METHODS

We reviewed records of 77 consecutive patients who had undergone high-resolution anorectal manometry (HR-ARM) at our motility laboratory for the diagnosis of FI based on ROME IV criteria, from November 2015 to July 2017. The Institutional Review Board approved the retrospective protocol. Patients younger than 18 years were excluded. Relevant data were collected on each patient, including age, gender, BMI as well as clinical information.

Anorectal pressures were assessed using a high-resolution catheter (Medtronic, Minneapolis, MN, USA) in the left lateral position. All patients were instructed to use an enema 1 hour prior to the anorectal manometry procedure and digital rectal exam was performed prior to the test to ensure an empty rectum. A high-resolution catheter comprises 10 circumferential sensors with 8 of them arrayed at 6 mm intervals along the anal canal and a further 2 sensors in the rectal balloon. The average pressure that was obtained from the sensors at each section resulted in the mean value of the anal

and rectal pressures. Rectal propulsive pressures were resulted from the proximal sensor located in the rectal balloon, and the average of pressures from anal sensors through the e-sleeve provided the anal pressures.

Protocol comprised of the assessment of anorectal pressures at rest, during squeeze, and simulated defecation with an empty rectal balloon. Resting pressures were recorded after 3 to 5 minutes of acclimation to the catheter. Squeeze pressures were obtained twice, 20 seconds of holding the squeeze and 1 minute of rest between the 2 squeezes. Then, patients were instructed to push and bear down to simulate evacuation for 20 seconds, twice with 1-minute interval resting period.

Thereafter, rectoanal inhibitory reflex and rectal sensory function were simultaneously evaluated by progressively distending a rectal balloon in 10 ml increments to reach the patient's first sensory threshold and thereafter in 30 ml increments until a maximum volume of 350 ml or until patients reported severe urgency or discomfort. Manoview, AR v3.0 was used to analyze the anorectal pressures. Rectal sensitivity was determined based on normal values previously obtained from healthy volunteers [16]. Patients were characterized as having abnormal sensory patterns if they had 2 consecutive abnormal sensory thresholds.

Balloon expulsion testing

Balloon expulsion was performed using a non-latex rectal balloon (Mui Scientific, Mississauga, Canada) filled with 50 mL of water. Patients were asked to expel the balloon while sitting on a commode in privacy. If subjects could not expel the balloon in 2 minutes, it was deflated and removed manually.

Statistical Analysis

Demographics, past surgical history and risk factors, coexisting symptoms, and anorectal physiology results were extracted for all subjects. Baseline characteristics and ARM parameters (shown as median and interquartile ranges) of patients with or without a normal BET were compared, using the Wilcoxon rank-sum test. Rectal sensory thresholds are shown as mean and SEM and compared using the Student t-test. Categorical statistical analysis was performed by a Fisher exact probability test. We used multivariate logistic regression to evaluate the association between ARM parameters and odds of abnormal BET (Stata 14, College Station, TX, USA). Statistical significance was defined by a p value of less than 0.05.

RESULTS

Demographic

We reviewed clinical data from a total of 77 consecutive patients (7 men), with ROME IV FI, who had undergone HR-ARM. Thirty two percent (25/77) of patients with FI had an abnormal BET. Age, BMI, history of previous anorectal and obstetrical surgeries of patients who passed BET were comparable to patients who had abnormal BET. Demographic features are presented in Table I. Patients with abnormal BET were more likely to report a sensation of incomplete evacuation (60% vs 33%, $p=0.02$) and abdominal pain (64% vs 38%, $p=0.03$).

Table I. Demographics based on the Results of Rectal Balloon Expulsion Test

Demographic Variables	Normal BET	Abnormal BET	p
Participants, n	52 (4 male)	25 (3 male)	
Age, years, median (IQR)	62.50 (54.00 - 72.50)	57.00 (52.00 - 67.00)	0.12
BMI, kg/m ² , median (IQR)	27.80 (22.93 - 30.70)	28.80 (25.30 - 33.78)	0.33
No of vaginal deliveries, median (IQR)	2 (0 - 3)	2 (0 - 3)	0.51
Episiotomy, n (%)	19 (36)	8 (32)	0.42
Anorectal surgeries, n (%)	7 (13)	6 (24)	0.36
No of BM/day, median (IQR)	1.50 (0.71 - 3.00)	1.00 (2.00 - 4.00)	0.20
Passive incontinence, n (%)	34 (65)	16 (64)	0.55
Gas incontinence, n (%)	31 (60)	9 (36)	0.05
Liquid incontinence, n (%)	33 (63)	19 (76)	0.31
Solid stool incontinence, n (%)	19 (36)	4 (16)	0.06
Abdominal bloating, n (%)	32 (61)	12 (48)	0.32
Abdominal pain, n (%)	20 (38)	16 (64)	0.03
Concurrent constipation, n (%)	13 (25)	9 (36)	0.23
Use of laxatives, n (%)	15 (28)	6 (24)	0.43
Incomplete evacuation, n (%)	17 (33)	15 (60)	0.02

BET: balloon expulsion test; BM: bowel movements; BMI: body mass index.

Anorectal pressure profile according to the balloon expulsion testing

The prevalence of a dyssynergic pattern on HR-ARM, based on paradoxical anal contraction or incomplete relaxation, during simulated defecation, was 81% (63/77) with 9 patients fulfilling the ROME IV criteria for functional defecatory dysfunction. Anorectal pressure parameters and rectal sensory thresholds for those with or without a normal BET are compared in Table II. During simulated defecation, patients with an abnormal BET had significantly lower rectal propulsive pressures (Fig. 1).

Rectal Sensation in Patients with Abnormal Balloon Expulsion Test

There was a significant difference in the mean sensory threshold for first sensation in patients with abnormal BET as

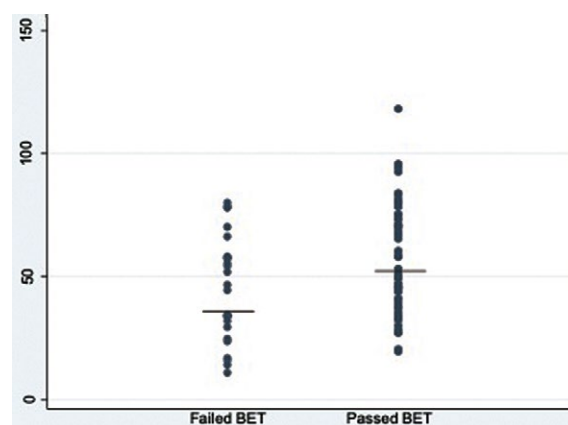


Fig. 1. Rectal propulsive pressures and balloon expulsion test (line shows the median).

Table II. Anorectal parameters according to the balloon expulsion test (Median and interquartile range)

Anorectal profile	Normal BET (n:52) Median (IQR)	Abnormal BET (n:25) Median (IQR)	p
Rest			
Mean resting anal pressure (mmHg)	52.15 (41.65 - 76.45)	68.30 (51.60 - 78.20)	0.13
Mean resting rectal pressure (mmHg)	49.30 (34.40 - 69.90)	65.60 (45.60 - 77.60)	0.15
Squeeze			
Squeeze anal pressure (mmHg)	109.45 (75.70 - 199.25)	146.80 (117.40 - 169.10)	0.08
Length of anal HPZ (cm)	3.00 (2.20 - 3.75)	2.80 (2.10 - 3.20)	0.35
Duration of sustained squeeze (sec)	19.75 (7.95 - 20.05)	16.10 (6.30 - 20.00)	0.52
Simulated defecation			
Anal pressure (mmHg)	76.45 (51.90 - 94.40)	78.30 (61.20 - 96.30)	0.69
Anal relaxation (%)	-21.91 (-82.33 - 10.19)	-13.24 (-36.38 - 25.07)	0.41
Rectal propulsive pressure (mmHg)	52.15 (39.70 - 73.25)	44.30 (29.20 - 57.80)	0.02
Rectoanal gradient (mmHg)	-16.90 (-37.90 - 2.10)	-34.90 (-42.50 - -11.20)	0.06
Functional defecation dysfunction, n	0	9	<0.001

BET: balloon expulsion test; HPZ: high pressure zone.

compared to the others [$19 (\pm 2)$ vs. $29 (\pm 5)$, $p=0.03$]. Despite variances in volumes required to trigger urge sensation and maximum tolerable volumes in patients with abnormal BET, differences were not statistically significant (Table III). Twenty five patients with normal BET and 8 patients with abnormal BET had impaired rectal sensation (≥ 2 sensory thresholds above normal published values [16]). All patients had an intact rectoanal inhibitory reflex.

Table III. Sensory thresholds parameters according to the balloon expulsion test (mean \pm SEM)

Rectal sensory thresholds	Normal BET (n:52) mean (SEM)	Abnormal BET (n:25) mean (SEM)	p
First sensation (ml)	19 (± 2)	29 (± 5)	0.03
Urge sensation (ml)	92 (± 6)	97 (± 14)	0.75
Maximal tolerable volume (ml)	142 (± 8)	136 (± 13)	0.69

Predictors of balloon expulsion test in patients with fecal incontinent

In multiple logistic regression analysis (Table IV), the presence of lower rectal propulsive pressures during simulated defecation was an independent risk factor for an abnormal BET while a higher anal sensory threshold for first sensation predicted successful balloon expulsion. In contrast, neither rectal or anal resting nor squeeze pressures, lower residual anal pressures and greater anal relaxation at simulated defecation predicted normal BET. Rectal sensory thresholds for urge to defecate or maximum tolerated volumes were also not predictive of normal BET.

Table IV. Multiple variable logistic regression models for the rectal balloon expulsion test.

	Odds Ratio	p	[95% Conf. Interval]
BMI	0.96	0.40	0.87 - 1.05
Sphincter Length	1.57	0.16	82 - 3.01
Duration of squeeze	1.03	0.42	0.95 - 1.12
Residual anal pressure	0.99	0.32	0.97 - 1.0
Percent anal relaxation	1.00	0.60	0.99 - 1.00
Rectal propulsive pressure	1.03	0.03	1.00 - 1.06
First sensation	0.94	0.02	0.90 - 0.99
Urge to defecate	0.99	0.82	0.97 - 1.01
Max tolerable volume	1.01	0.12	0.99 - 1.02

DISCUSSION

Functional defecatory dysfunction is a well described abnormality in patients with FI [6]. Identifying clinical and anorectal characteristics that are strongly associated with functional defecatory dysfunction in FI is important as they could determine the management strategy [2, 14, 15]. Our study demonstrated, first, that up to 32% of patients with diagnosis of FI, based on ROME IV criteria, had abnormal BET. Second, despite comparable clinical profile and anal pressure

profile, distinct differences exist in rectal propulsive forces and sensory profiles among FI patients with or without an abnormal BET. And third, that rectal propulsive pressures at simulated defecation and rectal sensory threshold for first sensation can independently predict BET results in patients with FI.

Anorectal manometry is recommended as the initial test, preceding anal imaging, for the evaluation of patients with FI who have failed conservative management [15]. Balloon expulsion test, routinely done in conjunction with anorectal manometry, has a high positive predictive value for a diagnosis of functional defecatory dysfunction [17]. Even though BET is a valuable test for the evaluation of functional defecatory dysfunction, its utility in patients with FI is not clear. This, at least in part, stems from the notion that FI is generally presumed to be a low anal sphincter pressure state, in which balloon expulsion should not pose any challenge. To our surprise, 32% of our patients who had undergone anorectal manometry and BET for a ROME IV diagnosis of FI proved to have abnormal BET. Abnormal BET was noted despite comparable symptoms and baseline anal sphincter pressures at rest and squeeze, as well as simulated defecation.

Bowel disturbances are described as one of the strongest independent risk factors for FI, in the community [5, 18]. While loose stool or diarrhea will be inclined to leak easily, other bowel disturbances, particularly constipation, seem to be rather common [2], and reported in up to 60% of patients with FI [8]. Not surprisingly, FI patients with normal anal function have more severe constipation related to functional defecatory dysfunction [8]. In our study, while the average number of bowel movements was comparable between groups, 25% of patients with normal BET and 36% of patients with abnormal BET had reported the presence of concurrent constipation, with a comparable need for laxative use. Consistent with previous studies, the liquid stool was the most common form of incontinent stool in both groups.

The presence of a sensation of incomplete evacuation has been reported previously in patients with FI. Indeed, a sense of incomplete evacuation is an established risk factor for FI [18]. In a cross-sectional population-based survey, self-reported sensation of incomplete evacuation robustly predicted the risk of developing FI (OR:3.4) [19]. Yet, the relationship between the sensation of incomplete evacuation and abnormal BET, in FI, has not been previously studied. We found that a sensation of incomplete evacuation was reported by 60% (15/25) of patients with FI who had an abnormal BET as compared to only 33% (17/52) of patients with normal BET ($p=0.02$). Also, we found that patients with an abnormal BET were more likely to complain of abdominal pain. This is likely to be explained by the presence of other concurrent functional pathologies such as irritable bowel syndrome and colonic retention of the stool, colonic distention and therefore abdominal distension and pain as described with other delayed colonic motility pathologies [20].

Passive incontinence or passage of stool without awareness is typically associated with an incompetent anal sphincter [21]. Alterations of rectal compliance, capacity, and rectoanal sensation have been documented as the culprit of this phenomenon in some patients [22]. On the other hand, in patients with severe constipation, overflow incontinence will

be associated with the symptoms of passive incontinence. We found that around 65% of our patients, regardless of BET results, had reported the presence of passive incontinence. Given the fact that anal pressures at rest, which mainly reflects internal anal sphincter, were overall preserved in our patients with abnormal BET. Incomplete rectal evacuation is presumed to cause passive leakage of stool in this group, whereas in patients with normal BET, resting anal sphincter pressures were slightly but not significantly lower. Whether sphincter impairment along with other rectal sensory dysfunction could be attributed to passive incontinence in patients with normal BET will require further investigation that was not in the scope of our study.

Rao et al. [9], have suggested that dyssynergic defecation is an important factor in the pathophysiology of fecal seepage. They showed that in comparison to those with overt incontinence, patients with fecal seepage had significantly higher residual anal pressures, but similar rectal propulsive pressures, during simulated defecation. Nine patients in this cohort had symptoms of constipation with anorectal manometry and BET confirming the ROME IV diagnosis of functional defecatory dysfunction. Functional defecation dysfunction is a well-recognized etiology of FI in some patients. Patients with functional defecation dysfunction and FI may have an impaired rectal sensation despite normal pudendal nerve function and sphincter function [9]. We also noted that patients with FI and functional defecatory dysfunction had significantly higher resting anorectal pressures as well as anal squeeze pressures as compared to patients with FI alone. The rectal sensory levels were comparable in this cohort between the groups (data not shown).

In contrast, in our study, rectal propulsive pressures during simulated defecation were significantly lower in patients with an abnormal BET as compared to normal BET, regardless of functional defecatory dysfunction. This was despite comparable residual anal pressures and rate of anal relaxation between the two groups. These findings underscore the point that impaired rectal pressures might be the underlying pathology in patients with FI and abnormal BET. Therefore, the mechanism of abnormal BET appears to be quite different in patients with FI as compared to those with FI and concurrent functional defecatory dysfunction.

In a recent study, abnormal BET (> 60 seconds) was reported in 15% of asymptomatic healthy females and 6% of asymptomatic healthy males [23]. Healthy women with an abnormal BET were found to also have a lower rectoanal gradient during evacuation. Future studies should further evaluate whether the abnormal BET in healthy controls and FI patients is related to abnormal structural pathologies such as rectocele.

Abnormal rectal evacuation is a known etiology of FI, as the retained stool in the rectum is prone to induce leakage. Functional defecatory dysfunction has been also described as an important pathophysiological mechanism in those patients with FI who have normal anal sphincter function [8, 11, 13]. This category has been described in up to 36% of men [11] and 13-15% of women [13] with FI. In our study, median anal resting tone and anal squeeze pressures were lower than normal overall. However, in some patients, anal sphincter function was preserved as evidenced by normal anal

pressures at rest and on squeeze. Among multiple anorectal parameters studied, only rectal propulsive pressures during simulated defecation were significantly lower in patients with abnormal BET. Nevertheless, in previous observations of patients with FI despite normal anal sphincter function, rectal propulsive pressures were significantly elevated at simulated defecation, indicating straining in these patients. Therefore, the primary mechanism of functional defecatory disorder in patients with normal sphincter function is quite distinct from that of our patients, where lower propulsive forces were the cause of impaired rectal evacuation. This highlights the fact that normal rectal evacuation requires coordinated anorectal function including both adequate rectal propulsive pressures and proper anal relaxation. Indeed, the only risk factor associated with abnormal BET, based on logistic regression, was a lower level of rectal pressure on simulated defecation analysis (Table IV). It is intuitive that in patients with comparable anal sphincter function the BET would rely mainly on rectal/intraabdominal pressures. And our study demonstrated that lower rectal propulsive pressures at simulated defecation was an independent risk factor for an abnormal BET and functional defecatory dysfunction in patients with FI.

Prevalence of dyssynergia on anorectal recordings was 81%, in our study, with type I dyssynergia being the most common subtype in this cohort; no differences in relative prevalence of the various subtypes of dyssynergia were seen between those with or without normal BET. In other studies, patients with seepage were found to have a higher rate of dyssynergia (72%) as compared to patients with overt FI (30%) [9]. Dyssynergia was also reported in 71% of women with normal sphincter function FI [13]. Indeed, dyssynergia with preserved rectal propulsive pressures (type I and IV dyssynergia), was identified as an important risk factor for FI in women with normal anal sphincter function [13]. This was despite comparable rates of abnormal BET between those with normal and impaired anal sphincter pressures. It must be conceded, nevertheless, that clinical utility of HR-ARM in diagnosis of dyssynergia has been questioned, as “dyssynergia”, as defined by manometry, seems to be a common finding among healthy individuals [24]. In one study, more than 90% of healthy controls showed evidence of dyssynergia on anorectal manometric recordings. Indeed, only Types III and IV proved to be discriminatory between those with normal and abnormal balloon expulsion times [25]. Therefore, relevance of findings of isolated dyssynergia to FI deserves further assessment.

Previous studies have shown that rectal sensation seems to be important to achieve effective rectal evacuation [6, 11]. Sensory retraining impacts the outcome of biofeedback in patients with FI [26]. It has been shown that FI patients with enhanced rectal sensory thresholds are less likely to respond to biofeedback therapy as compared to patients with normal rectal sensation [2]. A comparable number of our patients in each group had rectal hyposensitivity at ≥ 2 sensory thresholds above normal values and therefore, enhanced rectal sensory threshold for first sensation could indeed determine abnormal BET in patients with FI.

Limitations to our study include a relatively small sample size, its retrospective nature, and the lack of utilizing a validated

FI severity scale as well as anorectal imaging. Future prospective studies with validated questionnaires and employing dynamic imaging of anorectum and pelvic floor will help to further reveal the pathophysiology of FI.

CONCLUSIONS

We showed that one third of patients with Rome IV diagnosis of FI have abnormal BET, despite the comparable clinical and anal pressure profile. We found differences in rectal properties of patients with FI who had abnormal BET. Indeed, rectal first sensory threshold and rectal propulsive pressures are the independent risk factors for abnormal BET in patients with FI.

Our findings provide important novel data on the pathophysiology of FI. This work is the first to provide evidence for the rectal propulsive forces as the mechanism of abnormal BET in patients with FI. Future prospective studies to replicate these findings on larger patient cohorts will be required.

Conflicts of interest: None to declare.

Authors' contribution: L.N. designed the study, analyzed the data and drafted the manuscript. C.L.F. contributed to the data collection. E.M.Q. contributed to the conception and interpretation of data. E.M.Q. and C.L.F. critically revised the manuscript. All authors approved the final version of the article

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