Original Paper

Digestion

Digestion 2012;86:78–85
DOI: 10.1159/000338954

Received: February 13, 2012
Accepted: April 19, 2012
Published online: July 20, 2012

Accuracy of Anorectal Manometry in Patients with Fecal Incontinence

C. Pehl H. Seidl N. Scalercio F. Gundling T. Schmidt W. Schepp S. Labermeyer

Department of Gastroenterology, Hepatology and Gastrointestinal Oncology, Bogenhausen Academic Teaching Hospital, Technical University of Munich, Munich, Germany

Key Words
Sensitivity · Specificity · Accuracy · ROC analysis

Abstract
Background/Aim: Patients with fecal incontinence (FI) have lower anal resting (MRP) and squeeze (MSP) pressure and an impaired sensitivity compared to healthy people. However, whether anorectal manometry (ARM) can separate precisely between health and disease is discussed controversially. The aim was to evaluate the accuracy of ARM in a huge cohort of patients and controls. ***Methods:*** ARM was obtained in 144 controls and in 559 FI patients. MRP, MSP, and balloon volume at first perception (BVP) and urge sensation (BVU) were determined. Receiver operating curve analysis was used to determine optimal cut-offs and sensitivity, specificity and accuracy calculated. ***Results:*** FI patients showed lower MRP, MSP, BVU ($p < 0.001$) and a higher BVP ($p = 0.007$). Deterioration of the ARM parameter increased with FI severity. ARM demonstrated an excellent sensitivity (91.4%) and accuracy (85.8%), but only a moderate specificity (62.5%). The sensitivity of ARM rose with FI severity. The pressure data showed higher sensitivity and accuracy than the sensory data despite comparable specificity. ***Conclusions:*** Sensitivity and accuracy of single ARM parameters is only moderate for the pressure data and poor for the sensory data. In contrast, ARM demonstrated an excellent sensitivity, a moderate specificity, and a convincing accuracy justifying its use in clinical routine.

Introduction

Fecal incontinence (FI) affects 2.6–15.3% of the adult population [1]. Especially elderly patients suffer from these disorders which impair quality of life dramatically [2]. Several tests and techniques have been developed for evaluation of FI like anorectal manometry (ARM), endoanal ultrasonography (EUS) or sphincter EMG. EUS demonstrating sphincter defects and EMG demonstrating nerve damage are accepted diagnostic methods, while the role of ARM is discussed contrarily.

The statements about the value of ARM differ considerably in the literature. For example, Felt-Bersma et al. [3] state that differentiation between FI patients and conti-

KARGER
Fax +41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

0012–2823/12/0862–0078$38.00/0

Accessible online at:
www.karger.com/dig

PD Dr. Christian Pehl
Department of Medicine, Hospital Vilsbiburg
Krankenhausstrasse 2
DE–84137 Vilsbiburg (Germany)
Tel. +49 8741 60 3153, E-Mail christian.pehl@kkh-vilsbiburg.de

Table 1. Wexner score

Type of incontinence	Frequency				
	never	rarely	some-times	usually	always
Solid	0	1	2	3	4
Liquid	0	1	2	3	4
Gas	0	1	2	3	4
Wears pad	0	1	2	3	4
Lifestyle alteration	0	1	2	3	4

Never, 0; rarely, <1/month; sometimes, <1/week, ≥1/month; usually, <1/day, ≥1/week; always, ≥1/day. 0, Perfect; 20, complete incontinence.

nent people was not possible with ARM because there was complete overlap of the data ranges, while Sun et al. [4] found that more than 90% of patients had a pathological ARM result. These different statements can be related, at least in part, to small numbers of investigated healthy people, to the comparison of groups with a large age difference, or to differences in the female:male ratio. However, age and gender have to be considered when comparing healthy and incontinent people. Mean resting (MRP) and squeeze (MSP) pressure decreases with aging [5]. Furthermore, female sex influences anorectal pressure as well as sensory parameters [5].

If therapeutic decisions in patients with anorectal disorders are going to be based on the results of ARM, the test must separate precisely between health and disease. The present study re-evaluates the accuracy of ARM in a huge cohort of FI patients and controls.

Material and Methods

Subjects

Normal ARM data were obtained from 144 healthy people (71 women) with a median age of 63 years (range 21–90). These data were compared with 559 FI patients (407 women; median age 63 years (range 19–94)) referred for evaluation to our tertiary care gastrointestinal laboratory. All manometric data, severity of incontinence (Parks classification), Cleveland Clinic (Wexner) fecal incontinence score (table 1), age, and gender were prospectively listed in a database. Both groups were distributed in three age groups for comparison (table 2). The FI patients were classified according to the severity of their incontinence (table 2): FI for gas (Parks grade I) was seen in 153, for liquids (Parks grade II) in 272, and for solid stool (Parks grade III) in 213 patients. The study was approved by the local ethical committee; ethical guidelines followed the Declaration of Helsinki.

ARM Data

ARM was performed according to the recommendations of the German Society of Neurogastroenterology [6]. A water-perfused (0.5 ml/min) probe with eight circumferentially oriented measuring ports and a 5-cm latex-free balloon at the tip was used. Pressure data were obtained by stepwise pull-through of the intrarectally inserted probe. Perception and urge threshold were identified by rapidly inflating the balloon in the rectum with air by a hand-held syringe (5-ml steps; complete deflation after each step). MRP, MSP, balloon volume at first perception (BVP) and at urge sensation (BVU) were determined.

Statistics

A Mann-Whitney U test was performed for comparison of the control group with the FI patients since the ARM parameters (MRP, MSP, BVP, BVU) are not normally distributed. Spearman's rank correlation coefficient (ρ) was calculated to assess the relationship between the ARM parameter and the FI grade. A perfect Spearman correlation of +1 or –1 (inversely correlated) occurs when each of the variables is a perfect monotone function of the other. Receiver operating curve (ROC) analysis was used to determine optimal cut-offs between healthy people and FI patients. The ROC curve is a plot of the sensitivity versus 1 – specificity over all possible threshold values of the marker. The optimal cut-off was determined by the Youden index (maximum vertical distance or difference between the ROC curve and the diagonal or chance line). It occurs at the cut-point that optimizes the biomarker's differentiating ability when equal weight is given to sensitivity and specificity. Sensitivity, specificity and accuracy (true positives + true negatives/patients + probands) were calculated for each parameter as well as for ARM (at least one pathological parameter). In addition, the area under the ROC curve (AUC) was calculated as a global index of diagnostic accuracy (AUC = 0.5 means no discriminatory power; AUC = 1 means perfect discrimination of controls and FI patients).

Results

The FI patients had significantly lower MRP, MSP, and BVU as well as significantly higher BVP (table 2). These results were also seen when comparing only females (MRP, MSP, BVU $p < 0.001$ each; BVP 0.026) or males (MSP, BVU $p < 0.001$ each; MRP 0.002; BVP $p < 0.029$).

The pressure parameter and the urge threshold decreased significantly with increasing FI severity (MRP $\rho = -0.360$, MSP $\rho = -0.423$, BVU $\rho = -0.242$; $p < 0.001$ each), while the increase in perception threshold in higher grades of FI ($\rho = 0.071$; $p = 0.068$) did not reach the significance level (table 2; fig. 1).

Regarding the ROC cut-offs, MRP, MSP, BVP, and BVU were pathologic in 59, 59.2, 27.6, and 36.5% respectively of FI patients. The percentage of pathologic pressure parameters rose steadily with increasing severity of FI (data not shown), while nearly equal percentages of

Table 2. Study population (mean ± SD values)

Age groups	FI patients	Controls
≤60 years	209 (138 females; 48.3 ± 9.6 years)	52 (25 females; 45.8 ± 11.2 years)
60–70 years	137 (109 females; 65.2 ± 2.9 years)	46 (23 females; 65.0 ± 2.6 years)
>70 years	213 (160 females; 77.6 ± 5.2 years)	46 (23 females; 78.9 ± 5.1 years)
Grade I (Wexner score 3–8)	Grade II (Wexner score 5–15)	Grade III (Wexner score 7–20)
153 (107 females) 62.7 ± 14.5 years	272 (203 females) 62.5 ± 14.6 years	134 (97 females) 65.2 ± 14.2 years

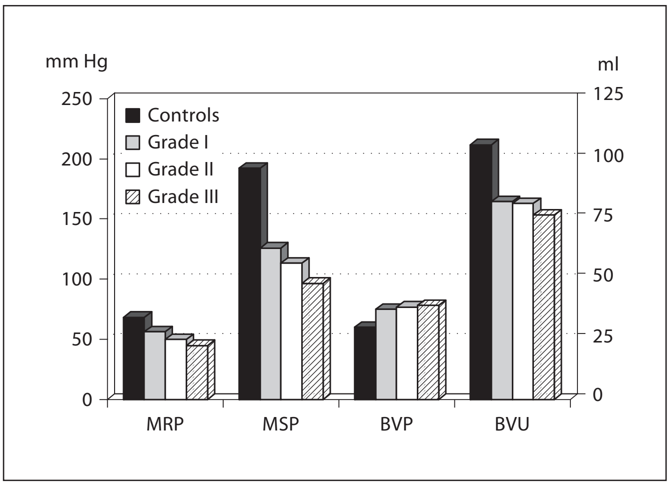

Fig. 1. Influence of severity of FI on ARM. Parks grades: I = incontinence for gas, II = incontinence for liquid stool, and III = incontinence for solid stool.

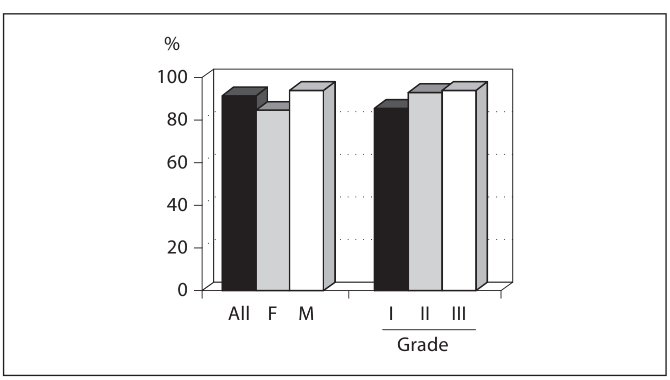

Fig. 2. Percentage of FI patients with a pathological ARM (at least one pathological parameter). All = All patients with FI; F = female incontinent patients; M = male incontinent patients. Parks grades: I = incontinence for gas, II = incontinence for liquid stool, and III = incontinence for solid stool.

pathologic sensory parameters were seen in all FI grades (exception: the pathological result of BVU doubled in grade III FI compared to the lower grades). A pathological result of ARM was observed in nearly all FI patients (fig. 2) with slightly higher values in females than in males. The percentage of pathological ARM rose also with increasing severity of FI (fig. 2).

Using again the ROC cut-offs, ARM demonstrated a good sensitivity and a moderate accuracy (table 3). However, the specificity was only moderate since one third of healthy controls had at least one pathological ARM parameter. The sensitivity of each single ARM parameter was much lesser than for the global ARM result, but it possesses a much higher specificity. The pressure data showed higher sensitivity (MRP 59%, MSP 59.1%, BVP 27.6%, BVU 36.5%) and accuracy (MRP 63.3%, MSP 66%, BVP 39.9%, BVU 48.3%) than the sensory data despite comparable specificity (MRP 80.6%, MSP 93.1%, BVP 88.9%, BVU 95.1%) (table 4). AUC calculation (ARM global 0.876) evidenced that the pressure parameter (AUC MSP 0.825 > AUC MRP 0.746) had a better discriminatory power than the sensory parameter (AUC BVU 0.665 > AUC BVP 0.574). This was seen in both sexes with higher discriminatory power of ARM in females than in males (accuracy: females 89.3%, males 78.3%). The discriminatory power of ARM and each single parameter rose with increasing severity of FI (ARM > pressure parameters > sensory parameters; fig. 3).

Discussion

The present study was performed to evaluate the discriminatory power of ARM in a huge cohort of patients with FI and controls. The main results are: FI patients showed significantly lower sphincter resting (MRP) and

Table 3. Results of ARM in patients with FI and healthy controls (mean ± SD values)

	MRP, mm Hg	MSP, mm Hg	BVP, ml	BVU, ml
Controls	68.3 ± 1.7	192.3 ± 5.9	30.0 ± 1.1	105.9 ± 2.8
FI patients	50.1 ± 1.0*	112.6 ± 2.7*	38.5 ± 1.2*	80.4 ± 2.1[#]
Grade I	56.2 ± 1.9	125.7 ± 5.4	37.4 ± 2.0	82.2 ± 3.6
Grade II	49.7 ± 1.5	113.2 ± 4.0	38.4 ± 1.6	81.5 ± 2.7
Grade III	44.8 ± 2.2	96.4 ± 4.8	39.0 ± 2.7	76.6 ± 5.8
Wexner score 3–6	55.9 ± 2.0	126.4 ± 5.7	37.1 ± 2.0	83.3 ± 3.7
Wexner score 7–10	53.2 ± 2.6	119.4 ± 7.3	35.9 ± 2.3	86.6 ± 5.5
Wexner score 11–13	48.4 ± 1.8	111.0 ± 4.7	39.3 ± 2.0	79.7 ± 3.1
Wexner score 14–16	46.5 ± 3.8	92.1 ± 7.2	37.6 ± 3.8	82.8 ± 8.4
Wexner score 17–20	43.9 ± 2.7	98.6 ± 6.3	39.8 ± 3.7	73.5 ± 7.6

* $p < 0.001$; [#] $p = 0.007$.

Table 4. Sensitivity, specificity and accuracy of ARM in FI

	Sensitivity %	Specificity %	Accuracy %
FI patients	91.4	63.2	85.8
Grade I	85.6	63.2	74.7
Grade II	93.0	63.2	82.7
Grade III	94.0	63.2	78.1
Wexner score 3–6	84.6	63.2	78.7
Wexner score 7–10	86.5	63.2	82.1
Wexner score 11–13	95.5	63.2	85.7
Wexner score 14–16	91.1	63.2	83.1
Wexner score 17–20	95.5	63.2	86.3

squeeze pressure (MSP) as well as urge threshold (BVU) and a significantly higher perception threshold (BVP) than controls. Deterioration of ARM parameters increased with FI severity. The pressure parameters were pathologic in more than half of the FI patients, while the sensory parameters were pathologic in only about one fourth (BVP) and one third (BVU), respectively. Altogether, ARM was pathologic (≥1 pathologic value) in nearly all FI patients (91.4%). Thus, ARM demonstrated an excellent sensitivity and accuracy (85.8%), but had only a moderate specificity (63.2%). The sensitivity of ARM rose with increasing severity of FI.

Many studies have dealt with ARM in FI patients. However, only Thekkinkattil et al. [7] had a comparable high number of controls and FI patients, which seems mandatory due to the known influence of sex and age on the ARM parameter [5]. Notwithstanding, we can confirm that MRP and MSP are significantly lower in FI than in continent people [3, 7–34]. Thus, the ARM pressure parameters seem to be appropriate to quantify the sphincter function in FI patients.

The intrarectal balloon volume eliciting urge threshold was also significantly smaller in FI patients confirming previous studies with low numbers of patients and/or controls [12, 23–25, 27, 29]. Besides a decreased compliance, this parameter is influenced by subjective feelings. Thus, the rectum might have become hypersensitive to protect the patient for leakage in the case of a weak sphincter. The data that perception threshold is also decreased in FI patients could not be confirmed [12, 24, 35]. We and others observed an increased intrarectal BVP demonstrating an impaired sensation at least in some FI patients [8–10, 16, 36]. This impaired sensation may be the result of an anatomic or pathophysiologic (flaccid wall tension/decreased compliance) megarectum or a rectal afferent pathway disorder [37].

Only few studies are reported dealing with the influence of the FI severity on the ARM parameter. Bordeianou et al. [38] observed a correlation between MRP and severity, while Osterberg et al. [22] found a correlation between MSP and severity. No correlation between severity and the pressure values was reported by Penninckx et al. [24]. Concerning the sensory parameters, one study observed an inverse correlation with severity [24], while another study did not see any correlation [39]. However, all these studies are biased by small patient numbers. We were able to demonstrate in our huge cohort that both pressure parameters and the urge threshold decreased significantly with increasing FI severity, while only a small non-significant increase was observed in perception threshold in higher grades of FI.

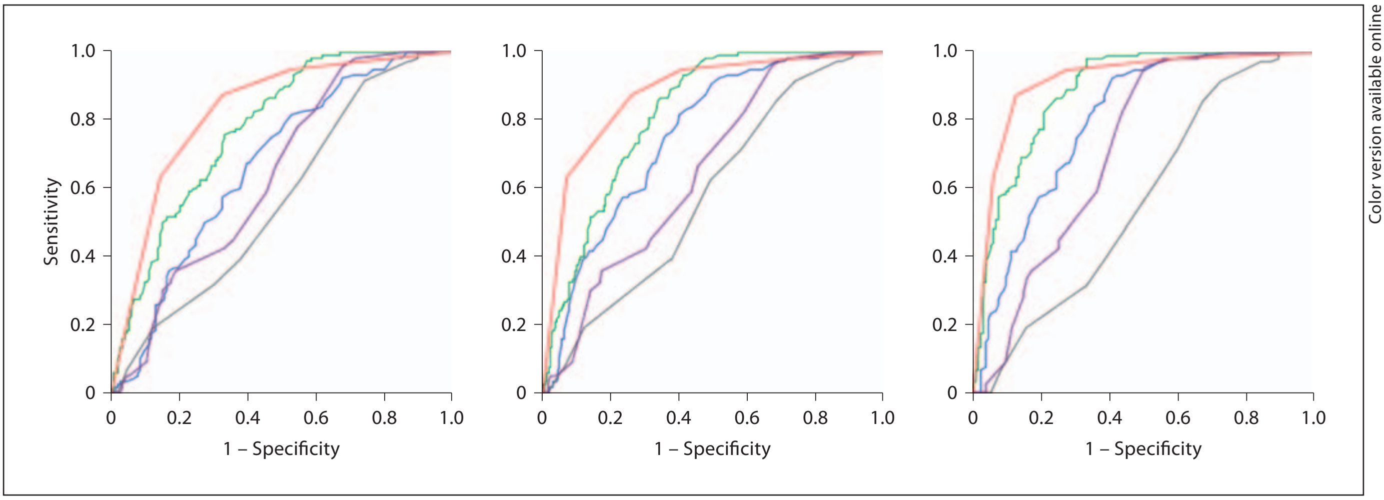

Fig. 3. AUC graph for ARM in patients with FI Parks grades I–III. Graphs represent (from left to right) FI for gas (I), liquid stool (II), and solid stool (III), and the lines in each graph ARM (at least one pathological parameter), MSP, MRP, BVU, and BVP.

The amount of pathological ARM parameters in FI patients differ considerably in the literature. The data ranges from 0% [31] to 92% [40] for MRP, from 14% [9, 21] to 100% [41] for MSP, from 0% [39] to 47% [9] for perception threshold, and from 0% [36, 39] to 47.5% [24] for urge threshold. The main reason for these enormous data ranges seems to be the low number of patients and/or controls in these studies. Due to our huge data cohort, the results of the present study (MRP 59.0%, MSP 59.2%, BVP 27.6%, BVU 36.5%) provide appropriate estimates about the amount of pathological results of ARM which can be expected in patients with FI. Irrespective of the reported amount of pathological results, all datasets show uniformly that pathological pressure values are seen more often in FI patients than pathological results of the sensory parameters [4, 12, 39, 40, 42]. The percentage of pathologic pressure parameters rose steadily with increasing severity of FI in our patients (data not shown), while nearly equal percentages of pathologic sensory parameters were seen in all FI grades (except for BVU in grade III FI patients).

Combining all single ARM parameters, a pathological result of ARM was seen in nearly all FI patients (9 out of 10). A comparison with the literature is difficult since many studies have measured only pressure, but have not analyzed anorectal sensory function. The reported range of FI patients with a pathological sphincter pressure is 32–88% with only one study observing a value below 50% [3, 15, 28, 35, 43–45]. In the two other studies that also integrated the results of sensory measurement [24, 46], ARM showed a pathological result in FI patients in 96 and 98% respectively, comparable to the 94.1% observed in the present study. The percentage of pathological ARM was slightly higher in females than in males in our study. Whether this result is merely by chance or represents a better accuracy of ARM in females is unknown.

Regarding the effect of severity of FI on the percentage of pathological ARM, there are no valid data in the literature. Hiltunen [15] reported an increased percentage of pathological pressure values in grade III FI compared to grade I/II while no effect was found in the study of Saad et al. [47]. However, the latter study has to be criticized due to the very small number of patients in every group. Due to the huge dataset of the present study, we could demonstrate a rise in the percentage of pathological ARM with increasing severity of FI. Yet, the rise was small since already 85.6% of patients with grade I FI had a pathological ARM.

The high number of healthy controls and of FI patients enabled ROC analysis for determination of an optimal cut-off between continent and incontinent people to obtain the highest accuracy of ARM and ARM parameters respectively. The accuracy of ARM amounted to 85.8% with a sensitivity of 91.4% and a specificity of 62.5%. The sensitivity of ARM increases with severity of FI, while the accuracy in the higher grades of FI was only marginally higher. Bielfeldt et al. [9] reported a comparable sensitivity of 87% and a better specificity of 83%. However, besides resting and squeeze pressure and perception and urge threshold, their data included also pain threshold, rectoanal inhibitory reflex, and anodermal sensation.

In contrast to the accuracy of the 'final result' of ARM, the single ARM parameters demonstrated a much lesser sensitivity, but a much higher specificity in our evaluation. This is in agreement with the literature. The reported sensitivities range between 50 and 81% for MRP, 46 and 73% for MSP, and 43 and 67% for the sensory thresholds, while the ranges for specificity spans from 59 to 98% for MRP, from 67 to 100% for MSP, and from 33 to 93% for perception and urge [9, 12, 14, 21, 30, 34, 47]. For comparison of the absolute values, it has to be kept in mind that all the studies presented involved far fewer patients and controls than the present study. In addition, one cannot expect that the sensitivity of each single parameter is as high as the global judgment of ARM, as the pathophysiology of an individual FI patient can be highly different. For example, postpartal incontinence due to a rupture of the external sphincter muscle will mainly decrease MSP, while mainly a decrease of urge threshold (compliance) will be seen in incontinence after radiochemotherapy and resection of rectal cancer.

As a global index of diagnostic accuracy the AUC was calculated. The closer the calculated value is located to '1' the better is the discrimination between continent people and FI patients, while a value of or near to 0.5 means no discriminatory power. The AUC demonstrated that the discriminatory power was good for ARM (at least on pathological parameters) and, considering the individual parameters, for MSP, moderate for MRP, insufficient for urge threshold, and unavailable for perception threshold. The other sole studies using ROC analysis stated either a good discriminatory power for anal resting pressure (no other parameters were calculated) [34] or, like our study, that MSP is the best single test [3].

Besides demonstrating sufficient power in discriminating between health and incontinence, another critical issue for the clinical value of ARM is whether ARM findings can guide therapy of incontinence and predict the outcome of FI management. This has to be demonstrated in further studies, yet preliminary data point to it. Several studies have shown superiority of ARM compared to the experienced surgeon's finger in detecting sphincter weakness [48–50]. In addition, applying the whole battery of specialized investigations (ARM, sphincter EMG, endoanal ultrasound) is of value in the management of the patients with FI and changes the surgeon's diagnosis and/or therapy plan in about 20% [48]. However, the sole value of ARM cannot be stated out of this study. Biofeedback should be restrained when ARM demonstrates severe sensory impairment [51]. Otherwise, biofeedback seems to be more effective in patients with low squeeze (voluntary) pressure [52]. In contrast, ARM does not seem to be predictive in SNS, however the failure group tended to have a lower resting pressure ($p = 0.06$) [53]. If ARM demonstrates an isolated weak resting pressure, augmentation of a weak or disrupted internal sphincter might be considered [54]. ARM appears also to be predictive for continence/incontinence after perineal operations like surgery for fistula-in-ano [55, 56], ileostomy closure after rectal resection [57] or endorectal ileoanal anastomosis [58].

In conclusion, ARM is done to search for weakness of sphincter muscles and disturbances in anorectal sensation or compliance demonstrating the pathophysiology of FI. Contradictory are the reported statements about the value of ARM concerning discrimination between continent people and incontinent patients. We could demonstrate that sensitivity and accuracy of a single ARM parameter is only moderate for the pressure data and poor for the sensory data. In contrast to the single parameters, ARM demonstrated an excellent sensitivity, a moderate specificity, and a convincing accuracy. Therefore, the discriminatory power of ARM in the evaluation of FI patients is sufficiently high to justify its use in clinical routine.

References

1 Whitehead W, Borrud L, Goode P, Meikle S, Mueller E, Tuteja A, Weinstein M, Ye W, Pelvic Floor Disorders Network: Fecal Incontinence in US adults: epidemiology and risk factors. Gastroenterology 2009;137:512–517.
2 Bartlett L, Nowak M, Ho Y: Impact of fecal incontinence on quality of life. World J Gastroenterol 2009;15:3276–3282.
3 Felt-Bersma R, Klinkenberg-Knol E, Meuwissen S: Anorectal function investigations in incontinent and continent patients. Differences and discriminatory value. Dis Colon Rectum 1990;33:479–485.
4 Sun W, Donnelly T, Read N: Utility of a combined test of anorectal manometry, electromyography, and sensation in determining the mechanism of 'idiopathic' faecal incontinence. Gut 1992;33:807–813.

5 Gundling F, Scalercio N, Seidl H, Schmidt T, Schepp W, Pehl C: Influence of gender and age on the results of anorectal manometry in healthy adults in a large German population. Digestion 2010;81:207–213.
6 Pehl C, Enck P, Franke A, Frieling T, Heitland W, Herold A, Hinninghofen H, Karaus M, Keller J, Krammer H, Kreis M, Kuhlbusch-Zicklam R, Mönnikes H, Münnich U, Schiedeck T, Schmidtmann M: Anorectal manometry. Guidelines of the German Society for Neurogastroenterology. Z Gastroenterol 2007;45:397–417.
7 Thekkinkattil D, Lim M, Stojkovic S, Finan P, Sagar P, Burke D. A classification system for faecal incontinence based on anorectal investigations. Br J Surg 2008;95:222–228.
8 Allen M, Orr C, Robinson M: Anorectal functioning in fecal incontinence. Dig Dis Sci 1988;33:36–40.
9 Bielfeldt K, Enck P, Erckenbrecht J: Sensory and motor function in the maintenance of anal continence. Dis Colon Rectum 1990;33: 674–678.
10 Caruana B, Wald A, Hinds J, Eidelman B: Anorectal sensory and motor function in neurogenic fecal incontinence. Gastroenterology 1991;100:465–470.
11 Ferguson G, Redford J, Barrett J, Kiff E: The appreciation of rectal distention in fecal incontinence. Dis Colon Rectum 1989;32:964–967.
12 Fernández-Fraga X, Azpiroz F, Malagelada J: Significance of pelvic floor muscles in anal incontinence. Gastroenterology 2002;123: 1441–1450.
13 Freys S, Fuchs K, Bussen D, Thiede A: Anorektale Durchzugs- und Vektorvolumen-Manometrie. Zentbl Chir 1996;121:652–658.
14 Hallan P, Marzouk D, Waldron D, Womack N, Williams N: Comparison of digital and manometric assessment of anal sphincter function. Br J Surg 1989;76:973–975.
15 Hiltunen K: Anal manometric findings in patients with anal incontinence. Dis Colon Rectum 1985;28:925–928.
16 Hoffmann B, Timmcke A, Gathright J, Hicks T, Opelka F, Beck D: Fecal seepage and soiling: a problem of rectal sensation. Dis Colon Rectum 1995;38:746–748.
17 Holmberg A, Graf W, Österberg A, Påhlman L: Anorectal manovolumetry in the diagnosis of fecal incontinence. Dis Colon Rectum 1995;38:502–508.
18 Kafka N, Coller J, Barrett R, Murray J, Roberts P, Rusin L, Schoetz D: Pudendal neuropathy is the only parameter differentiating leakage from solid stool incontinence. Dis Colon Rectum 1997;40:1220–1227.
19 Kuijpers H, Scheuer M: Disorders of impaired fecal control: a clinical and manometric study. Dis Colon Rectum 1990;33:207–211.
20 Lewicky-Gaupp C, Hamilton Q, Ashton-Miller J, Huebner M, DeLancey J, Fenner D: Anal sphincter structure and function relationships in aging and fecal incontinence. Am J Obstet Gynecol 2009;5:559,e1–5.
21 Monk D, Mills P, Jeacock J, Deakin M, Cowie A, Kiff E: Combining the strength-durations curve of the external anal sphincter with manometry for the assessment of faecal incontinence. Br J Surg 1998;85:1389–1393.
22 Osterberg A, Graf W, Påhlman L: The longitudinal high-pressure zone profile in patients with fecal incontinence. Am J Gastroenterol 1999;94:2966–2971.
23 Parellada C, Miller A, Williamson M, Johnston D: Paradoxical high anal resting pressures in men with idiopathic fecal seepage. Dis Colon Rectum 1998;41:593–597.
24 Penninckx F, Lestàr B, Kereemans R: Manometric evaluation of incontinent patients. Acta Gastroenterol Belg 1995;58:51–59.
25 Rao S, Ozturk R, Stessman M: Investigation of the pathophysiology of fecal seepage. Am J Gastroenterol 2004;99:1104–1109.
26 Rasmussen O, Christensen B, Sørensen M, Tetzschner T, Christiansen J: Rectal compliance in the assessment of patients with fecal incontinence. Dis Colon Rectum 1990;33: 650–653.
27 Rasmussen O, Sørensen M, Tetzschner T, Christiansen J: Anorectal pressure gradient in patients with anal incontinence. Dis Colon Rectum 1992;35:8–11.
28 Rasmussen O, Sørensen M, Tetzschner T, Christiansen J: Dynamic anal manometry: physiological variations and pathophysiological findings in fecal incontinence. Gastroenterology 1992;103:103–113.
29 Rasmussen O, Rønholt C, Alstrup N, Christiansen J: Anorectal pressure gradient and rectal compliance in fecal incontinence. Int J Colorectal Dis 1998;13:157–159.
30 Raza N, Bielfeldt K: Discriminative value of anorectal manometry in clinical practice. Dig Dis Sci 2009;11:2503–2511.
31 Read N, Harford W, Schmulen A, Read M, Ana C, Fordtran J: A clinical study of patients with fecal incontinence and diarrhea. Gastroenterology 1979;76:747–756.
32 Sentovich S, Rivela L, Blatchford G, Christensen M, Thorson A: Patterns of male fecal incontinence. Dis Colon Rectum 1995;38: 281–285.
33 Siproudhis L, Bellissant E, Juguet F, Allain H, Bretagne J, Gosselin M: Perception of and adaption to rectal isobaric distension in patients with faecal incontinence. Gut 1999;44: 687–692.
34 Stojkovic S, Balfour L, Burke D, Finan P, Sagar P: Role of resting pressure gradient in the investigation of idiopathic fecal incontinence. Dis Colon Rectum 2002;45:668–673.
35 Salvioli B, Bharucha A, Rath-Harvey D, Pemberton J, Phillips S: Rectal compliance, capacity, and rectoanal sensation in fecal incontinence. Am J Gastroenterol 2001;96: 2158–2168.
36 Felt-Bersma R, Sloots C, Poen A, Cuesta MA, Meuwissen S: Rectal compliance as a routine measurement. Dis Colon Rectum 2000;43: 1732–1738.
37 Gladman M, Dvorkin L, Lunniss P, Williams N, Scott S: Rectal hyposensitivity: a disorder of the rectal wall or the afferent pathway? An assessment using the barostat. Am J Gastroenterol 2005;100:106–114.
38 Bordeianou L, Lee K, Rockwood T, Baxter N, Lowry A, Mellgren A, Parker S: Anal resting pressures at manometry correlate with Fecal Incontinence Severity Index and with presence of sphincter defects on ultrasound. Dis Colon Rectum 2008;51:1010–1014.
39 Hill J, Corson R, Brandon H, Redford J, Faragher B, Kiff E: History and examination in the assessment of patients with idiopathic fecal incontinence. Dis Colon Rectum 1994;37: 473–477.
40 Neill M, Parks A, Swash M: Physiological studies of the anal sphincter musculature in faecal incontinence and rectal prolapse. Br J Surg 1981;68:531–536.
41 Fletcher J, Busse R, Riederer S, Hough D, Gluecker T, Harper C, Bharucha A: Magnetic resonance imaging of anatomic and dynamic defects of the pelvic floor in defecatory disorders. Am J Gastroenterol 2003;98: 399–411.
42 Lacima G, Espuña M, Pera M, Puig-Clota M, Quintó L, García-Valdecasas J: Clinical, urodynamic, and manometric findings in women with combined fecal and urinary incontinence. Neurol Urodyn 2002;21:464–469.
43 McHugh S, Diamant N: Effect of age, gender, and parity on anal canal pressures: contribution of impaired anal sphincter function to fecal incontinence. Dig Dis Sci 1987;32:726–736.
44 Rex D, Lappas J: Combined anorectal manometry and defecography in 50 consecutive adults with fecal incontinence. Dis Colon Rectum 1992;35:1040–1045.
45 Siproudhis L, Bellissant E, Pagenault M, Mendler M, Allain H, Bretagne J, Gosselin M: Faecal incontinence with normal anal canal pressures: where is the pitfall? Am J Gastroenterol 1999;94:1556–1563.
46 Rao S, Patel R: How useful are manometric tests of anorectal function in the management of defecation disorders? Am J Gastroenterol 1997;92:469–475.
47 Saad L, Coy C, Fagundes J, Ariyzono M, Shoji N, Góes J: Quantificicação da função esfincteriana pela medida da capacidade de sustentação da pressão de contração voluntária do canal anal. Arq Gastroenterol 2002; 39:233–239.
48 Keating J, Stewart P, Eyers A, Warner D, Bokey E: Are special investigations of value in the management of patients with fecal incontinence? Dis Colon Rectum 1997;40: 896–901.

49 Pehl C, Birkner B, Bittmann W, Cluess C, Emmert H, Fuchs M, Passern J, Wendl B, Schepp W, Heitland W: Fecal incontinence: diagnostic and therapeutic options. Dtsch Arzteblatt 2000;97:A1302–A1308.
50 Eckardt VF, Kanzler G: How reliable is digital examination for the evaluation of anal sphincter tone? Int J Colorectal Dis 1993;8: 95–97.
51 Van Tets W, Kuijpers J, Bleijenberg G: Biofeedback treatment is ineffective in neurogenic fecal incontinence. Dis Colon Rectum 1996;39:992–994.
52 Terra M, Deutekom M, Dobben A, Baeten C, Janssen L, Boeckxstaens G, Engel A, Felt-Bersma R, Slors J, Gerhards M, Bijnen A, Everhardt E, Schouten W, Berghmans B, Bossuyt P, Stoker J: Can the outcome of pelvic-floor rehabilitation in patients with fecal incontinence be predicted? Int J Colorectal Dis 2008;23:503–511.
53 Gallas S, Michot F, Faucheron J, Meurette G, Lehur P, Barth X, Damon H, Mion F, Rullier E, Zerbib F, Sielezneff I, Ouaïssi M, Orsoni P, Desfourneaux V, Siproudhis L, Mathonnet M, Menard J, Leroi A, Club NEMO: Predictive factors for successful sacral nerve stimulation in the treatment of faecal incontinence: results of trial stimulation in 200 patients. Colorectal Dis 2011;13:689–696.
54 Tjandra J, Lim J, Hiscock R, Rajendra P: Injectable silicone biomaterial for fecal incontinence caused by internal anal sphincter dysfunction is effective. Dis Colon Rectum 2004;47:2138–2146.
55 Tsang C, Madoff R, Wong W, Rothenberger D, Finne C, Singer D, Lowry A: Anal sphincter integrity and function influences outcome in rectovaginal fistula repair. Dis Colon Rectum 1998;41:1141–1146.
56 Pescatori M, Maria G, Anastasio G, Rinallo L: Anal manometry improves the outcome of surgery for fistula-in-ano. Dis Colon Rectum 1989;32:588–592.
57 Stadelmaier U, Bittorf B, Meyer M, Hohenberger W, Matzel K: Can continence function after rectal resection be prognostically estimated? Chirurg 2000;71:932–938.
58 Heppel J, Taylor B, Beart R Jr, Dozois R, Kelly K: Predicting outcome after endorectal ileoanal anastomosis. Can J Surg 1983;26:132–134.