5 Differences Between Conventional Anorectal Manometry and High Resolution/High Definition Anorectal Manometry

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5.1 Conventional Anorectal Manometry and Its Limits

During the last 20 years many studies investigated and discussed the usefulness of manometry in studying anorectal function and dysfunctions. Conventional anorectal manometry (ARM) measures anal canal pressures in static and dynamic conditions and is traditionally considered a valuable test for the diagnosis and management of anorectal disorders.

ARM is the best diagnostic tool able to provide a direct assessment of anal sphincter pressure and rectoanal response during squeezing and straining maneuvers. Unfortunately, each motility laboratory performs ARM in a different way with different manners of reporting results and conclusions.

Perfusion catheters are generally employed because solid-state microtransducers, which are more reliable, are considered to be too expensive for routine use. ARM, together with other functional tests, can provide essential information on the anorectal pathophysiology of defecation disturbances such as functional defecation disorders and fecal incontinence (FI).

The biggest pitfall of conventional ARM is the lack of uniformity regarding equipment and technique: indeed no consensus was definitely reached about the optimal method for performing an anorectal manometric assessment using conventional systems [1] and the interpretation of ARM findings can be difficult

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owing to the wide variability of the “normal values” among different laboratories [2]. Moreover, most of the parameters measured by ARM (i.e., anal canal pressure, sensory thresholds, etc.) are influenced not only by sex and age, but also by the protocol used.

Indeed normal anal canal pressures largely vary according to sex and age. In general, pressures are higher in men and younger subjects, but there is a considerable overlap between healthy subjects and patients. In addition, till now, most studies did not include large numbers of healthy subjects, consequently the age and sex-specific normal ranges used by the different motility laboratories are derived from the observation of small groups and they probably should be better standardized on larger samples. Due to these reasons some studies suggest that ARM would be able to offer only little additional utility over digital rectal examination for patients’ management [3]. Moreover, ARM is relatively time consuming and its reliability depends on the operator’s experience. All these problems limit a more widespread perception of its usefulness, and therefore its larger diffusion.

When performing ARM a potential risk of both false positive and false negative results should be considered since both patient’s and catheter’s position can affect objective measurements, especially in water-perfused ARM, where the probe is often repositioned during the different phases of the exam. Moreover pelvic floor abnormalities, such as pelvic floor descent and intra-anal intussusception, able to affect the results, are not reliably detected by ARM.

Despite these problems, the reproducibility of ARM is reported good. Hallan et al. [4] assessed anal sphincter function by digital examination and anal canal manometry in 66 patients and controls. They found a good correlation between digital basal score and maximum basal pressure (Spearman rank correlation coefficient $rs = 0.56$, $p < 0.001$). There were wide ranges of sphincter function on digital and manometric assessment with considerable overlap between patient groups. Another study showed that individual variation of resting pressures measured on two separate days was ≤12% indicating a good correlation between the two evaluations [5].

Quantitative measurements of ARM include resting pressure, automatic functions (e.g., rectoanal inhibitory reflex), and voluntary functions (i.e., squeeze pressure, anal relaxation and rectoanal pressure gradient during simulated defecation). Measurements of voluntary functions, requiring active participation by the patient, can vary with patient understanding of instructions. A recent study [6] showed that maximum squeeze pressure, intrarectal pressure, and rectoanal pressure gradient during the push maneuver were all significantly increased when “enhanced” verbal feedback was given to the patients, compared to the results from the same individuals when only “standard” instructions were provided. Such verbal intervention was able to change manometric findings from locally validated as “pathological” to “normal” in 14/31 patients (45%) with fecal incontinence and 12/39 (31%) with functional defecation disorders (Fig. 5.1). Indeed, an effective explanation of the procedures is required during the entire examination.

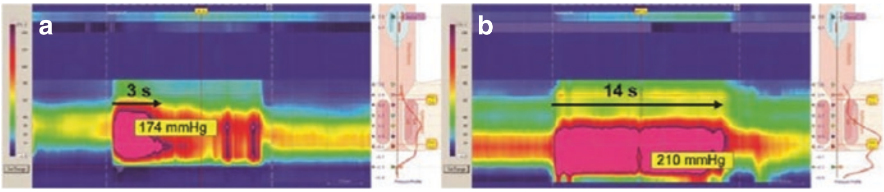

Fig. 5.1 Representative HRAM pressure topography plots of squeeze during standard (**a**) vs enhanced (**b**) instruction and verbal feedback, demonstrating increased pressure and prolongation of squeeze duration (black arrow) (reproduced from Heinrich et al. [6])

5.1.1 Sphincter Resting Pressure

Resting pressure is the result of the activity of the internal anal sphincter (IAS) and the external anal sphincter (EAS). Anal resting pressure is not uniform over the longitudinal extent of the anal canal. Conventional ARM catheters have a limited number of unidirectional sensors (up to eight) which often do not measure pressures over the entire length of the anal canal at the same time; moreover the measurement of resting pressure may be influenced by the ultraslow wave cycling activity [7].

5.1.2 Squeeze Pressure

The squeeze anal pressure measures voluntary contraction of the EAS. The squeeze pressure is lower in women than in men and lower in older than in younger people. Because ARM cannot assess contractile symmetry, it is not useful for identifying contraction of the puborectalis muscle, which only generates forces on the posterior side of the anorectal region; thus it is not able to assess if possible pressure changes are due to EAS or to a puborectalis muscle injury.

5.1.3 Straining Maneuver

During simulated evacuation, patients are asked to expel the manometric probe, typically with the balloon empty and less frequently with the balloon inflated with low air volumes. The assessment of pressure changes during simulated evacuation is limited by the type of recording catheter, the distension of the intrarectal balloon, the body position, the possible displacement of the catheter, and the degree of voluntary participation, because some people find it embarrassing to defecate in the laboratory without the necessary privacy. Finally, about 20% of asymptomatic healthy people undergoing ARM have manometric abnormalities characterizing a straining disorder [8].

5.1.4 Rectoanal Inhibitory Reflex (RAIR)

Rapid rectal distension by inflating the intrarectal balloon elicits an intrinsic reflex, mediated by the myenteric plexus, that relaxes the IAS. The absence of the intrinsic reflex during the rapid rectal distension is typical of the Hirschsprung disease so ARM proved to be a reliable and minimally invasive technique for the diagnosis of this disturbance.

In patients with acquired megarectum, RAIR may be absent because the rectal balloon does not adequately distend the rectum: in this case higher inflation volumes are able to elicit RAIR and therefore should be used in order to distinguish acquired megarectum from Hirschsprung disease.

ARM can also have a role to evaluate the persistance of sympotoms after surgery of Hirschsprung disease, although often it does not give enough information for understanding the cause of a possible persistence of obstructive symptoms [9].

5.1.5 Rectal Compliance and Sensation

Assessing rectal sensation involves the measurement of the volume able to evoke the so-called “first sensation” and subsequently urgency and maximum tolerable volume. The rectal balloons supplied with ARM catheters are usually relatively stiff and moreover their stiffness can vary over time in case of multiuse catheters which are cleaned and reused. For these reasons, rectal compliance and pressure thresholds for rectal sensation sometimes cannot be reliably measured with ARM. Particularly rectal compliance can be reliably assessed only using the barostat which is provided with a long infinitely compliant polyethylene bag [10].

5.1.5.1 Conventional ARM Versus High Resolution Anorectal Manometry

The introduction of 2D high resolution anorectal manometry (HRAM) system, acquiring measurements from at least ten closely spaced pressure sensors across the anal sphincter, removes the need for a pull-through procedure and provides visual feedback to the operator allowing maintenance of a stable catheter position. Both HRAM and 3D high resolution anorectal manometry (HDAM) offer a standardized technique during the examination, evaluating the same parameters for every patient. Unfortunately, we are still far from having a “Chicago classification” for HRAM/HDAM, due to the lack of reliable normal values able to give a real homogeneity to the anorectal manometric reports and making them easily comparable.

Jones et al. [11] reported that HRAM values are highly correlated with water-perfused manometry measurements. In 29 patients resting, squeeze, and relaxation pressures were simultaneously recorded showing the two methods were significantly correlated although anal sphincter pressures recorded by HRAM tended to be higher than those recorded with conventional water-perfused ARM. Furthermore, HRAM provided greater resolution of the intraluminal pressure.

Ambartsumyan et al. studied 30 children with constipation showing that HDAM, compared to ARM, allowed to distinguish the individual contribution of each component of the intra-anal pressure [12]. In addition to these findings, HDAM could have the ability to better detect the normal asymmetry of pressures within the anal canal, with higher pressures in the posterior proximal and anterior distal regions of the sphincter.

A more recent study [13] performed in 14 patients showed that the ARM and HRAM were similar in misuring resting and squeezing pressures. It confeme that the measurement time for HRAM was significantly shorter than the one for conventional water-perfused ARM. Furthermore, some evidence support the hypothesis that pelvic floor abnormalities, not previously identified by conventional ARM, can be detected using HRAM.

5.1.5.2 HDAM Versus HRAM

HDAM utilizes a rigid probe made by 256 pressures sensors arranged in a 16 × 16 grid (i.e., 16 rows spaced 4 mm apart, each containing 16 circumferentially oriented sensors 2.1 mm apart) with an active area of measurement of 6.4 cm. This technology defines the anatomical anal morphology more precisely than HRAM. Manometric data undergo linear interpolation through dedicated software which displays 2D or 3D cylindrical topographical models of the anal canal which can be rotated and viewed from all sides.

Raja et al. [14] studied 231 consecutive patients to investigate the diagnostic utility of HDAM compared to HRAM. HDAM and HRAM studies performed from April 2012 to October 2013 were identified and re-interpreted by two blinded investigators. Disagreements were resolved by a third investigator. Puborectalis muscle (PR) visualization, focal defects of anal canal, and dyssynergy were reported. With HDAM, PR function was visualized in 81% (at rest), 97% (during squeeze), and 73% (during strain). PR was visualized less often at rest in FI than in constipated patients (68 vs. 85%, $p = 0.007$). Focal defects were identified twice as often in FI than in constipated patients (19 vs. 10%, $p = 0.113$). Twenty-nine defects (86% anterior) were visualized on HDAM. Inter-reader agreement between HRAM and HDAM was moderate for PR function ($\kappa = 0.471$), but fair for focal defects ($\kappa = 0.304$). (Figs. 5.2 and 5.3). This study suggests that HDAM provides additional information about structure and function of the anorectum undetectable through HRAM analysis alone.

5.2 Clinical Meaning of HRAM/HDAM

Up to now, the principal indications of HRAM and HDAM are the same of conventional ARM: e.g., the diagnostic workup of FI, chronic constipation, and Hirschsprung disease. They may be also used to improve the results of the pelvic rehabilitation training, assessing patients before the therapy, and/or objectively evaluating them when the rehabilitation course is completed.

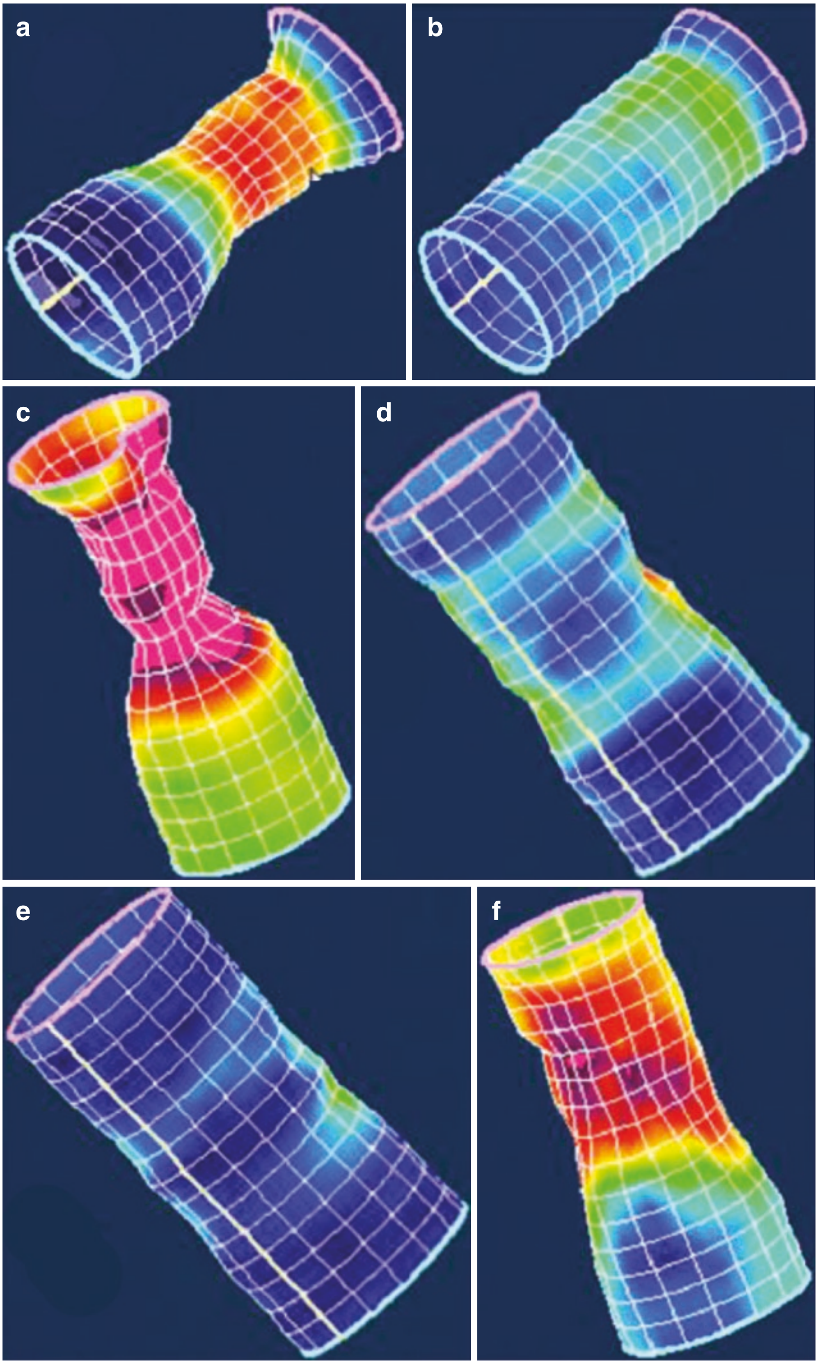

Fig. 5.2 HDAM images. Normal (**a**) and absent puborectalis tone (**b**) at rest. Normal squeeze (**c**) and focal defect at squeeze (**d**). Normal bear down (**e**) and paradoxical contraction (**f**) on bear down (reproduced from Raja et al. [14])

87 2D+/3D+	26 2D–/3D+
44 2D+/3D–	64 2D–/3D–

Fig. 5.3 2 × 2 Table for concordance between 2D and 3D diagnosis of dyssynergia. The + sign indicates the presence of dyssynergia respectively with 2D and 3D analysis (reproduced from Raja et al. [14])

5.2.1 Fecal Incontinence

FI is defined as the recurrent uncontrolled passage of fecal material for at least 3 months and is reported to affect 5–10% of the general population, affecting the quality of life and often leading to surgery [15, 16].

There is general agreement that the anal sphincter mechanism is the most important barrier against leakage of rectal contents [17].

Recent studies showed that anal resting and squeeze pressures measured with ARM and HDAM were lower in incontinent patients than in healthy persons.

Mion et al. conducted a prospective multicenter study in three groups of subjects: healthy asymptomatic controls, patients with FI, and patients with chronic constipation (CC) to evaluate how HDAM could differentiate patients with FI or CC from asymptomatic subjects. To distinguish FI from asymptomatic women, the two most important discriminant variables were: squeeze pressure (AUC of ROC: 0.786) and maximal squeeze pressure (AUC of ROC: 0.777) [18]. Push maneuver results were similar in the three groups, except for the nadir anal pressure that was significantly lower in FI women. Rectal constant defecatory sensation and maximum tolerable volumes were significantly lower in the FI women, compared to asymptomatic and CC women.

HDAM analysis of 24 asymptomatic healthy subjects and 24 patients with FI symptoms was performed; the authors developed and evaluated a robust prediction model to distinguish patients with FI from controls using linear discriminant, quadratic discriminant, and logistic regression analyses. FI severity index scores correlated with low resting pressure ($r = 0.34$) and peak squeeze pressure of the anal canal ($r = 0.28$). The combination of pressure values, anal sphincter area, and reflective symmetry values differentiated FI patients and controls with good accuracy (AUC: 0.96) [13]. Since the anal canal pressure is not symmetric along its length and circumference [19] and HDAM is able to better detect the length and the asymmetry of anal canal pressure [20–22], it appears particularly suitable for studying FI patients.

Finally, in a recent study on healthy women and women with FI, the use of a newly developed parameter, the HRAM contractile integral, increased the sensitivity of detection of anal hypocontractility, from 32% to 55%, compared with ARM measurements of squeeze [23].

5.2.2 Chronic Constipation

CC is a polysymptomatic, multifactorial disorder affecting 15–20% of the general population. It is characterized by symptoms of difficult, infrequent, or incomplete defecation. Lumpy or hard stools, sensation of anorectal obstruction/blockage, and manual maneuvers to facilitate the defecation are frequently reported [24].

A consistent number of patients with CC and irritable bowel syndrome with constipation also report symptoms suggestive of a functional defecation disorder (FDD) [25, 26], which is characterized by a paradoxical contraction or an inadequate relaxation of the pelvic floor muscles and/or inadequate propulsive forces during attempted defecation [27]. From a clinical point of view, FDD is frequently associated with excessive straining, feeling of incomplete evacuation, and digital facilitation of bowel movements [28]. However, symptoms do not consistently identify patients with FDD [29, 30]. Thus, the criteria for FDD must rely on both symptoms and physiological testing. Indeed, to diagnose FDD the Rome IV criteria require features of impaired evacuation in at least two of the following tests: anorectal manometry, rectal balloon expulsion test, barium or magnetic resonance (MR), defecography, and anal surface electromyography [27].

Manometric criteria for FDD include impaired anal relaxation, failure to increase rectal pressure, and a negative rectoanal gradient (i.e., rectal pressure lower than anal pressure) during simulated evacuation. However, Mion et al. [18] observed that many asymptomatic healthy people have a negative rectoanal gradient during evacuation, perhaps due to the left lateral position of the subjects during the procedure. Moreover, unlike normal defecation, during anorectal manometry the urge to defecate induced by rectal distention is not preceded by a normal predefecatory motor pattern associated with anal relaxation. Furthermore, patients may not completely understand the instructions provided during the test or may not be keen to accomplish the task [6, 31, 32].

From a manometric point of view, patients with FDD exhibit one of the following four abnormal defecation patterns [29] (Fig. 5.4):

– In type I the patient can generate adequate propulsive forces (rise in intrarectal pressure ≥40 mmHg) along with paradoxical increase in anal sphincter pressure.

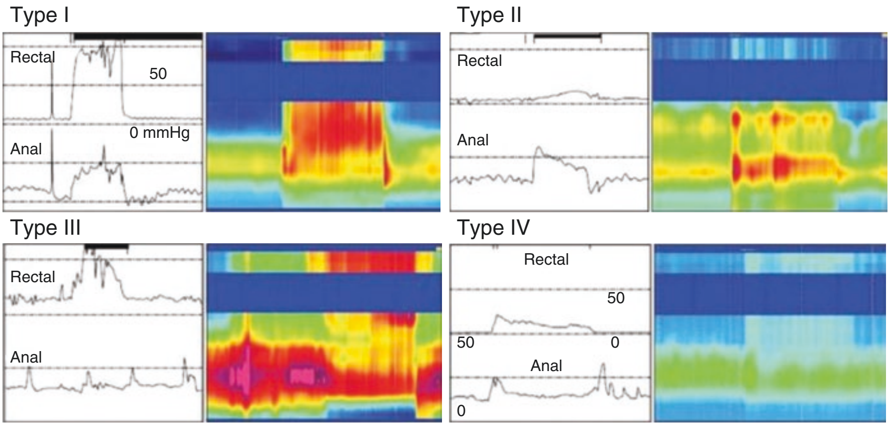

Fig. 5.4 The four types (I–IV) of dyssynergic defecation patterns described in the text are shown using conventional manometry (lines) and HRAM (color topographic plots) (reproduced from Lee et al. [29])

– In type II the patient is unable to generate adequate propulsive forces; additionally there is paradoxical anal contraction.
– In type III the patient can generate adequate propulsive forces, but there is either absent relaxation or inadequate (≤20%) relaxation of anal sphincter.
– In type IV the patient is unable to generate adequate propulsive forces together with an absent or inadequate (≤20%) relaxation of anal sphincter.

Ratuapli et al., by using HRAM in 62 healthy women and 295 women affected by CC, identified three phenotypes (high anal, low rectal, and hybrid) discriminating patients with normal and abnormal balloon expulsion time with 75% sensitivity and 75% specificity, simplifying the previous Rao's classification [30] (Fig. 5.5).

However, several questions exist about the use and the ability of anorectal manometry to diagnose FDD and identify clinical phenotypes: indeed the utility of a negative rectoanal pressure gradient as a marker of FDD is unclear because the gradient values overlap considerably among healthy subjects and constipated patients with and without FDD [33–35].

Another interesting matter of debate is the potential use of HRAM/HDAM in the differential diagnosis between functional and structural abnormalities. A total of 188 consecutive patients with obstructive defecation underwent a full investigation consisting in HRAM and defeco-MR. Compared with patients with dyssynergia on MR imaging, patients with structural pathology, such as rectocele and rectal prolapse, had lower resting and squeeze pressures but a higher rectoanal pressure gradient on HRAM. HRAM diagnostic accuracy for dyssynergia was 82% compared with 77% MR. Interobserver agreement was substantial for HRAM diagnoses. If the data will be confirmed by other studies, these manometric patterns could play a predictive role in identifying patients needing a defecographic study [36].

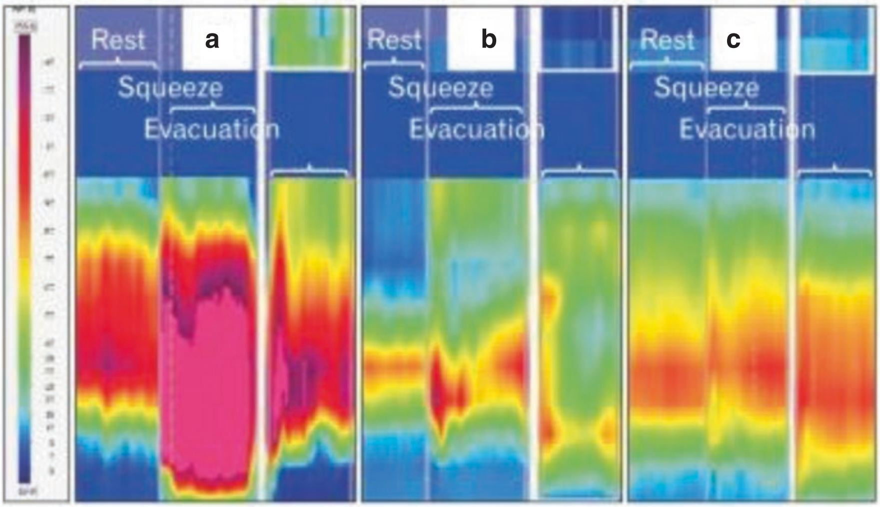

Fig. 5.5 The three defecatory subtypes based on principal components analysis: (**a**) high anal, (**b**) hybrid, and (**c**) low rectal phenotype (reproduced from Ratuapli et al. [30])

5.2.3 Hirschsprung Disease

Hirschsprung disease is characterized by the absence of ganglion cells in the myenteric and submucosal plexus on rectal biopsy.

The absence of the RAIR is known to be a pathognomonic feature of the disease. The absence of RAIR can be explained by the abnormality of the polysynaptic interneurons in the IAS and of the nitrergic inhibitory neurons [37].

The diagnosis is based on the combination of clinical symptoms and results from barium enema, anorectal manometry, and rectal suction biopsy with staining for calretinin or acetylcholinesterase [36–38].

Anorectal manometry has been proved to be a reliable and minimally invasive diagnostic technique: it is a simple screening test in patients with a clinical suspicion of Hirsprung disease. Its most important aim is the differential diagnosis between acquired megacolon and Hirschsprung disease, especially in the ultra-short form of the latter condition.

In infants and children, an absent RAIR has a sensitivity of 91% and a specificity of 94% for the diagnosis of Hirschsprung disease [39]. These figures are slightly but not significantly lower than rectal suction biopsy. When RAIR is present, it excludes an Hirschsprung disease diagnosis.

HRAM is an effective and safe method for the diagnosis in newborns as demonstrated by Tang, who reported a sensitivity of 89% and a specificity of 83% [40].

Wu et al. performed ARM in a group of 24 infants (eight with Hirschsprung disease and 16 without) and HRAM in a group of 21 infants (nine with Hirschsprung disease and 12 without). The authors assessed RAIR adequacy by calculating the sphincter relaxation integral (ASRI) during the HRAM study at pressure cutoff <10, <15, and <20 mmHg (ASRI10, ASRI15, and ASRI20) and investigated their diagnostic utility. They concluded that ASRI10 may be an indicative cutoff for the adequacy of RAIR in infants [41].

Many children with Hirschsprung disease have good surgical results; however, unfortunately, some patients continue to have persistent bowel dysfunction such as constipation and intestinal motility disturbance. The postoperative anorectal manometric evaluation of the patients after surgery provides detailed information about the function of anal canal and rectum. Demirbag et al. evaluated with ARM 18 children after surgery and found an absent RAIR in 14 (77.7%) and an abnormal RAIR in 4 (22.2%). They concluded that the majority of the patients have impaired anorectal motility after surgery but the manometric evaluation did not provide enough information in understanding the causes of symptoms. It is hoped that the new HRAM/HDAM techniques will help to solve this important issue [9].

5.2.4 Pelvic Floor Rehabilitation

Pelvic floor retraining is frequently recommended for defecation disorders. However, the lack of patient's selections and the lack of homogeneity of rehabilitation methods and protocols jeopardize the results causing difficulty in evaluation outcomes [42].

Jodorkovsky et al. retrospectively reviewed 203 patients, who had previously undergone HRAM, in whom manometric results were used for recommending biofeedback as treatment strategy. Biofeedback was ultimately recommended in 119 (58%) patients (80 with CC, 27 with FI, 9 with a combination of CC and FI, and 3 with rectal pain), of whom only 51 actually received therapy. 38 out of 51 underwent at least five sessions of biofeedback, with real life outcome success reported in 66% [43].

Soubra et al. performed HRAM on 25 patients awaiting biofeedback for dyssynergic defecation previously diagnosed through ARM. HRAM pressures tended to be higher than conventional ARM. Although there was high consensus regarding diagnosis of dyssynergia, there was low correlation regarding pattern types. For these reasons, the authors concluded that new diagnostic pressure criteria should be adopted in centers converting to HRAM [44].

5.3 HRAM/HDAM: Potentialities and Perspectives

HRAM and HDAM offer the possibility to have a standardized technique for performing the exam. Moreover, new parameters have been recently studied and developed both in HRAM and HDAM and are being considered for a future introduction in clinical practice.

Without any doubt, the most important gain over conventional ARM is the better capability in studying and understanding the functional anatomy of the sphincter since the distribution of the pressures in the anal canal and the possible asymmetry on the axial and on the circumferential plane are clearly shown [45].

Rezaie et al. studied 39 patients using both endoanal ultrasound (EUS), which is the gold standard for detecting anal sphincter defect, and HDAM. As there was no standard protocol for classifying a sphincter defect using HDAM, they defined sphincter defect as any pressure measurement below 25 mmHg with the canal anal at rest, involving at least 18° of the whole anal circumference (Fig. 5.6) [46].

The authors achieved a sensitivity, specificity, and NPV of 74%, 75%, and 92%, respectively, but a PPV of only 43%. The notable NPV of 92% is promising suggesting that HDAM may be useful in ruling out a sphincter defect helping to better select patients to suggest also EUS.

HRAM could be also used to provide a new classification of FDD as shown by Ratuapli et al. who studied 62 healthy females and 295 females with FDD. They demonstrated that three phenotypes, characterized by (1) high anal pressure at rest and during evacuation ("high anal"), (2) low rectal pressure alone ("low rectal"), and (3) low rectal pressure with impaired anal relaxation during evacuation ("hybrid") were able to discriminate between patients with normal and abnormal prolonged balloon expulsion time (BET) [30].

HDAM could shed new light also on the paradoxical contraction of puborectalis muscle as demonstrated by Xu et al. [47] who evaluated 71 healthy adults and 79 patients with paradoxical puborectalis syndrome (PPS). They found that the pressures were high in the proximal circumferential wall of anorectum in healthy adults and, in contrast, the pressures were low in the proximal circumferential wall of anorectum during simulated defecation in patients with PPS. A characteristic high-pressure area ("boot shaped"), highlighted in the distal posterior wall of the anorectum, was absent in healthy adults.

So, differently from ARM, HDAM could be as important as defecography and electromyography in the diagnosis of PPS.

Moreover HDAM is able to provide additional information about structure and function of the anorectum, which would be unavailable with 2D analysis alone, as shown by Raja et al. who found that the puborectalis tone was absent at rest more often in patients with FI than in those with constipation. Besides, the analysis of 3D images also provided the identification of 29 focal defects not seen with 2D analysis. Furthermore, 3D image analysis allowed the identification of 29 focal defects that had not previously been detected with 2D image analysis [14].

Some new HRAM and HDAM parameters have been recently described and could be used in differentiating patients with dyssynergic defecation and healthy subjects: the anal contractile integral (ACI), the post contraction pressure (PSP), the integrated pressure of the anal relaxation (aIRP), and the sliding speed of the probe during the squeeze in the anal canal (SVAC). In a study involving 40 healthy volunteers (28 women, median age 35 years) and 20 patients with dyssynergic defecation (12 women, median age 46 years), the patients with dyssynergic defecation showed significant different values in comparison with healthy volunteers for each of the

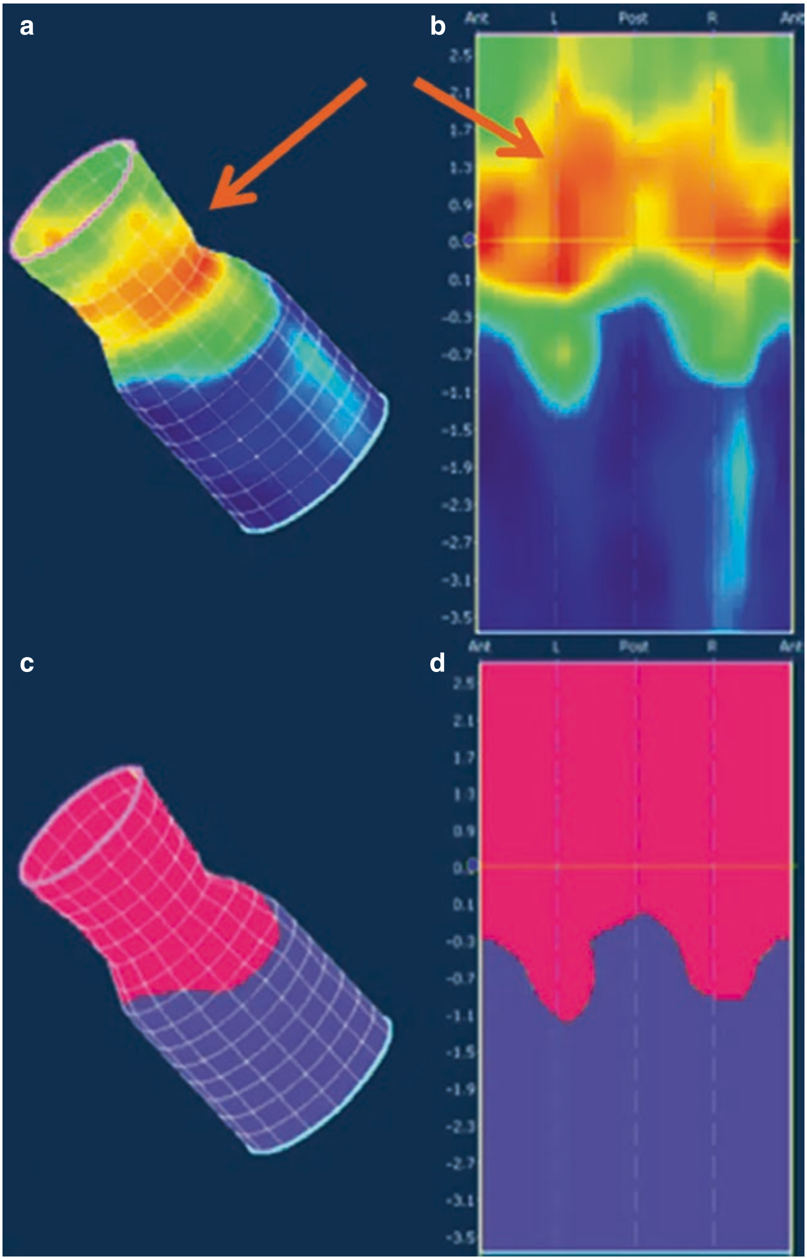

Fig. 5.6 The technique for detection of a sphincter defect using HDAM. An anterior defect while recording resting pressure is shown in (**a**, **b**). The defect becomes more visible when minimum and maximum ranges are set at 24 and 25 mmHg (orange arrows) (**c**, **d**). Using this technique, the extent of the defect was calculated to be 149° by dividing the length of orange arrows by the circumference of the anal canal (reproduced from Rezaie et al. [46])

parameters above described. Up to now, it is too early to state if these parameters will be able to clearly distinguish normal subjects from patients and further studies are mandatory for their validation [48].

Pandolfino et al. in 2008 proposed a novel concept of integrated pressurized volume (IPV), which is calculated by multiplying amplitude, distance, and a certain time period. This new parameter, after further validation studies, could be also used to provide a precise measurement of muscular contractility of the anal canal [49].

Seo et al. identified five regions separated by a distance of 1 cm from the rectum (6 cm from the distal tip of the catheter) to the anus (1 cm from the distal tip of the catheter) (Fig. 5.7). The IPV of each portion and the IPV ratio, which were obtained with and without balloon distention, were compared to determine the value that most precisely predicted the results of the balloon expulsion test. They showed that the ratio of the integrated pressurized volume of the upper 1-cm portion to those of the lower 4-cm portion (IPV14 ratio) with balloon distention was better at predicting balloon expulsion time. They concluded that these novel manometric parameter could be more effective in predicting balloon expulsion time than conventional parameters based on linear waves at certain signal points along the anal canal [50].

Moreover, HRAM and especially HDAM could be useful in the diagnosis of structural anorectal disorders, like the perineum descending syndrome and rectal intussusception, even if further observations on larger samples are needed [46].

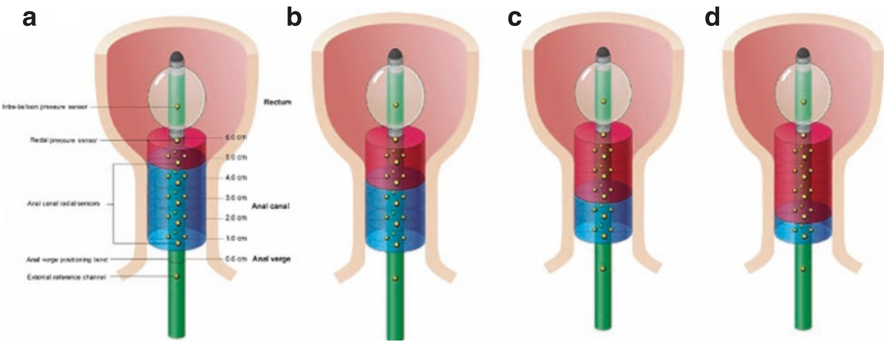

Fig. 5.7 Four categories of integrated pressurized volume (IPV) from the rectum to the anal canal (**a**–**d**). (**a**) The pressure signals obtained during simulated evacuation from the rectum (6 cm from the distal tip of the catheter) to the upper margin of the anal canal (5 cm from the distal tip of the catheter) were considered to belong to the upper 1-cm portion of the anorectal canal (red), whereas those from the upper margin of the anal canal (5 cm from the distal tip of the catheter) to the distal margin of the anal canal (1 cm from distal tip of the catheter) were considered to belong to the lower 4-cm portion of the anorectal canal (blue). The ratio of the upper 1-cm portion to the lower 4-cm portion can be considered as the ratio of the volume of the red-colored portion to that of the blue-colored portion. (**b**) IPVs from the upper 2-cm portion (red) and IPVs from the lower 3-cm portion (blue) (**c**) IPVs from the upper 3-cm portion (red) and IPVs from the lower 2-cm portion (blue) (**d**) IPVs from the upper 4-cm portion (red) and IPVs from the lower 1-cm portion (blue) (reproduced from Seo et al. [50])

Vitton et al., using HDAM in a patient with long history of intractable constipation, found an incomplete anal relaxation during attempted defecation, indicating a pelvic floor dyssynergia and a 9 mm perineal descent on the manometric probe. At the end of the bear down the perineum gained its initial position indicating that the probe had not moved [51]. In this patient also the conventional defecography showed a 9.2 mm perineal descent from the puborectalis line. This first observation was then confirmed by Benezech et al. in 19 female patients with excessive perineal descent diagnosed by defecography. They concluded that HDAM can diagnose excessive perineal descent with the same degree of reliability as defecography [52] (Fig. 5.8).

Also Heinrich et al. supported the hypothesis that HRAM might help to distinguish defecatory disorders due to functional or structural causes. In their study, an elevated intrarectal pressure above a narrow band of high pressure in the anal canal seemed to be associated with rectal intussusceptions [53].

Benezech et al. [54] using HDAM in 26 patients presented with rectal intussusceptions showed that 21 of them had an elevated intrarectal pressure above a narrow band of high pressure in the anal canal during straining, defined as a rectal intussusception as previously described by Heinrich [53]. This additional high-pressure area was located at the superior anterior edge of the probe in 13 patients, at the superior posterior edge in six patients, and at the superior anterior and posterior edge in two patients. (Fig. 5.9). Using these data, the most relevant diagnostic

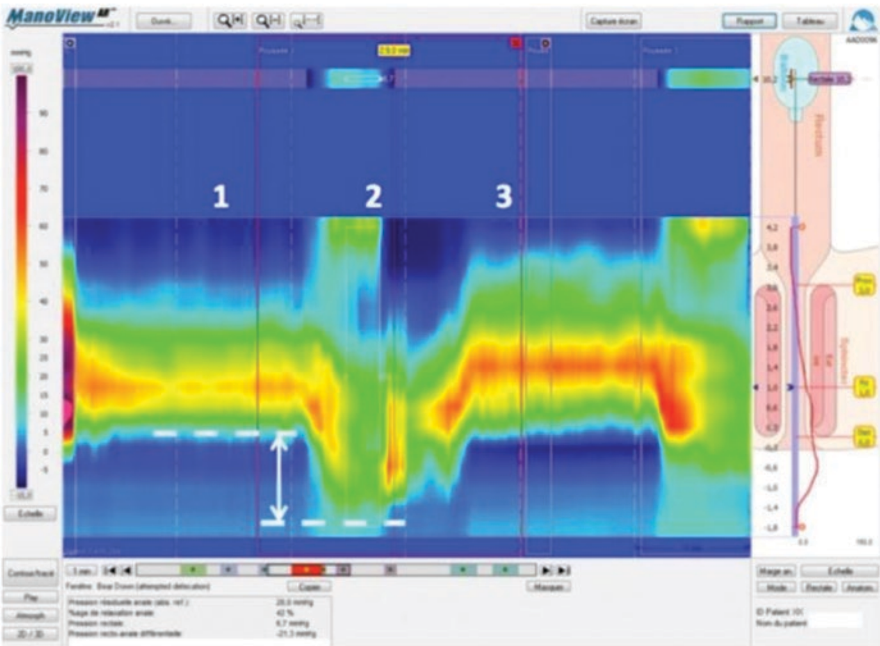

Fig. 5.8 Perineal descent: the row between the two dotted line measures the size of perineal descent (reproduced from Benezech et al. [52])

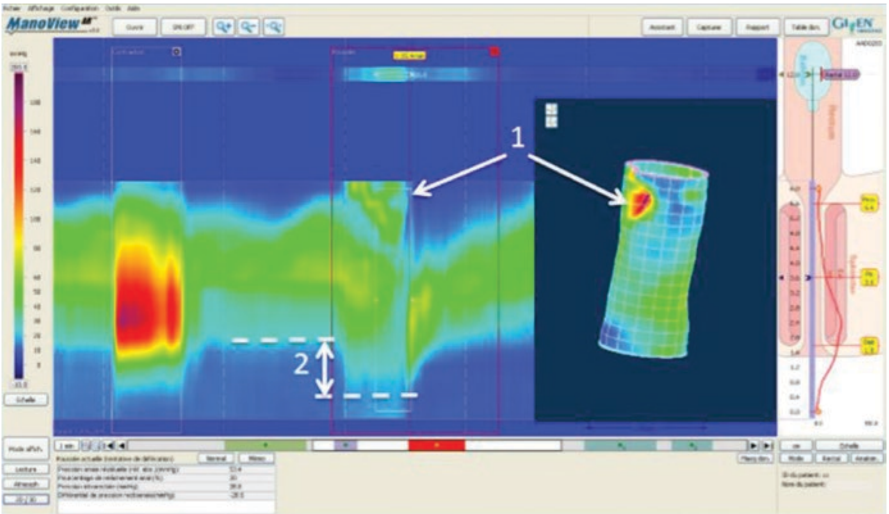

Fig. 5.9 (1) Rectal intussusception is an elevated intrarectal pressure above a narrow band of high pressure in the anal canal during straining; (2) excessive perineal descent (reproduced from Benezech et al. [54])

criterion with the best Yuden Index (0.69) was the association between an anterior additional high-pressure area and a perineal descent, with a positive predictive value of 100%, a negative predictive value of 61.9%, a specificity of 100%, and a sensitivity of 69.2%.

However, up to now, defecography remains the gold standard for the diagnosis of rectal intussusception and the results with HDAM must be compared and integrated with those obtained using conventional X-ray defecography and/or MR defecography [55, 56].

Also Prichard et al. [57] compared HRAM and MR defecography in healthy subjects and in patients with rectal prolapse. Among patients with rectal prolapse, there were two phenotypes, which were characterized by high (PC1) or lower (PC2) anal pressure at rest and squeeze along with higher rectal and anal pressure (PC1) or a higher rectoanal gradient during evacuation (PC2). PC1 and PC2 explained 48% and 31% of the variance, respectively. PC1 was correlated with higher anal pressures at rest and squeeze and higher rectal and anal pressures during evacuation. In contrast, PC2 was inversely correlated with anal pressures at rest and during squeeze; PC2 was correlated with a greater rectoanal pressure gradient during evacuation. In a logistic model, the PC1 score adjusted for age discriminated between controls and rectal prolapse with accuracy of 96%.

Brusciano et al. [58] investigated the correlation between rectal wall thickness (RWT) and rectal pressure (RP), using 3D endorectal ultrasound (3D-EUS) and HRAM, in patients with obstructed defecation syndrome (ODS) caused by internal rectal prolapse. They measured four rectal segments thickness (RWTs) introducing a new parameter, as the total rectal wall volume (TRWV). They found that in ODS patients there was a significant lower TRWV than in healthy volunteers (62.8% with mild and 28% with severe impairment). They also found, as previously reported in other studies that a lower rectoanal gradient was related with constipation symptoms [59, 60].

5.4 Conclusions

In conclusion, HRAM and HDAM are more intuitive and relatively simpler to perform than the ARM. They are very promising for improving the evaluation of functional alterations of the anal canal and the pelvic floor; indeed, they improve the understanding of the anorectal pathophysiology, allowing more precise correlation between anatomy and function. e.g. better evaluating the spontaneous activity of the anal canal, sometimes difficult to assess with the conventional technique.

The standardization of the new HRAM/HDAM parameters, which could add a further diagnostic yield in the study of motor and functional anorectal disorders, will probably require longer time periods. It will be mandatory to study large well-selected groups of patients and healthy subjects different for age, gender, parity and, probably, ethnicity.

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