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Physiologic and radiographic testing in patients with pelvic floor disorders and pelvic organ prolapse

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ABSTRACT

Pelvic floor disorders are common conditions that affects mainly the female population, especially the elderly. Anorectal physiology and imaging tests are important way to assess anal sphincter function and structure of the pelvic floor. Those tests are part of the workup for patients with incontinence, defecatory disorders and pelvic organ prolapse. The most relevant tests will be discussed in this article.

Introduction

Aging in the general population, especially in female patients, has been associated with different symptoms related to disorders of the pelvic floor.[1] In addition, many patients present with sarcopenia and lesions of different pelvic floor structures, related to their obstetrical and surgical history. These lesions can produce a variety of urinary and defecatory symptoms that adversely impact quality of life. To obtain a better evaluation, together with clinical assessment, physiological tests can help to delineate the status, the function and the anatomy of the anorectal muscles and structures of the pelvic floor. [2] These tests can define functional or structural abnormalities and guide the treatment, especially in cases where initial or secondary interventions have failed or were ineffective. In this article, we will discuss the most commonly utilized methods to evaluate anorectal dysfunction. (Table 1)

Anorectal manometry

Anorectal manometry is the most utilized and widely available method to assess sphincter function and consists of recording the intraluminal pressures in the anal canal and rectum, with the patient in the resting position or during requested manouvres, such as squeeze, push or cough.[3] In addition, rectal sensitivity can be assessed during rectal distention with a balloon. Independently of the utilized system and number of channels, manometry allows an objective assessment of internal and external anal sphincter muscle function. The most common indications for manometry include anal incontinence and symptoms of obstructed defecation. In addition, manometry can be utilized in children to rule out the presence of aganglionosis and in many preoperative situations, in patients with rectal prolapse or chronic anal fissures; in patients with an indication for botulinum toxin injection; for legal documentation in patients with recurrent symptoms before or after surgical procedures. (Table 2)

Methods and equipment

There are currently three types of equipment to perform anal manometry: water perfused systems; high resolution systems; and high-definition micro transducers with solid state catheters.[3-6] (Fig. 1)

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Table 1
Physiological and imaging testing.

Test	Purpose	Message
Anorectal Manometry	Assess internal and external anal sphincter muscle function Rectoanal-inibitory reflex (RAIR), rectal sensitivity and compliance Asymmetry and fatigue index	Resting pressure = function of the internal anal sphincter Squeeze pressure = function of the external anal sphincter Loss of the reflex typically in Hirschsprung patients Asymmetric sphincter in the presence of defects
Balloon expulsion test	Additional evaluation for patients with symptoms of obstructed defecation	The inability to expel the balloon is an indication of anismus
EMG of the pelvic floor	Judgment of the Motor Unit Potentials (MUP) Interference pattern	Loss or alteration or signs of denervation or re-innervation; Malfunction of muscle groups (e.g. anismus)
Pudendal Nerve Terminal Motor Latency (PNTML)	Function of the nerve supplying the pelvic floor	Useful for prognosis, if surgery is planned
Endoanal ultrasound	Evaluation of sphincter muscles and other anorectal structures	Asymmetric or absent muscle images correlates with sphincter gaps
Colonic Transit time	Evaluation of the pattern of evacuation and demonstration of retention of the markers	Diffuse spread of radiopaque markers typically for STC Collection of markers in small pelvis as sign for ODS
Cinedefecography	Evaluation of the dynamic of evacuation after filling the rectum with a barium paste	Evaluation of rectocele, enterocele, internal prolapse, perineal descent,anorectal angle
(MRI) – Defecography	Functional judgment of pelvic floor and the internal organs and their mobility	Structural substrate (e.g. rectocele) or only functional disorder (e.g. anismus)

Table 2
Indications for anorectal manometry.

Anal incontinence
Double incontinence
Dissynergic constipation
Mucosal and Complete rectal prolapse
Aganglionosis or Hirschsprung Disease
Chronic anal fissure with hypertonia
Encopresis
Complex anorectal fistulae
LAR syndrome
Anal and pelvic pain

Water perfused systems are the least costly and most widely available systems. Early devices utilized 4 or 6 channels and more modern systems have 8 channels. High resolution manometry can also be performed with a water perfused system, with 24 channels. Following the development of the esophageal manometry systems, more sophisticated and expensive anorectal systems were developed in recent years, such as high-definition manometry, with 256 channels and a solid-state catheter.

A critical difference between the water perfused and the high-resolution systems is the way the exams are presented to the examiner. In the former, the graphic presentation of pressures is seen in each channel as a line that will change according to the status of the sphincter, whereas in the high-resolution systems, the visual aspect of resting and contraction of the muscles is presented as a scale of colors. The “cold” colors (blue and green) represent low pressures. Red and yellow represents higher pressures. (Fig. 2) High resolution manometry also provides continuous and dynamic mapping of anorectal pressures, including pressures in the rectum, allowing a more detailed interpretation of the data.

Manometry with water perfused systems can be performed by a continuous or stationary pull-through technique, whereas using high

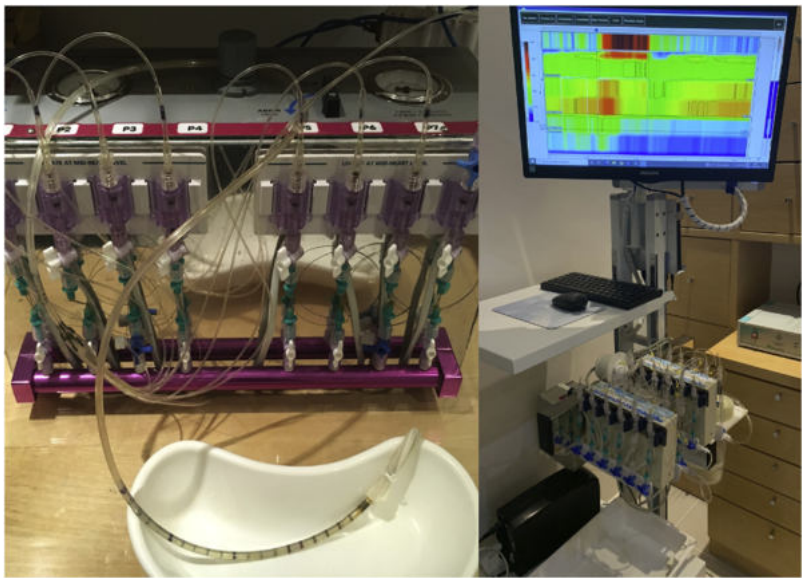

Fig. 1. Anorectal manometry (a) 8 channel water perfused system with radial cathether (Dynamed,Ltda,Brazil); (b) High resolution 24 channel system (Dynamed,Ltda,Brazil).

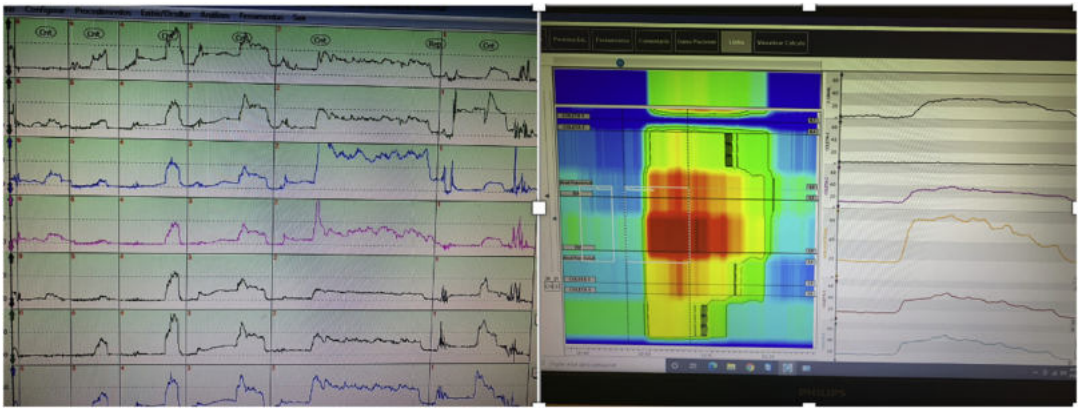

Fig. 2. (a) Conventional and (b) high-resolution manometry.

resolution and high-definition systems the catheter is maintained at the same position during the entire examination. Independent of the utilized system, anorectal manometry will allow evaluation of several parameters, included in Table 3.

Rectal sensitivity measurement is an important evaluation, usually assessed by insufflating the balloon and observing the response of the patient to the distension. Patients with IBS and diarrhea, fecal urgency and reduced rectal capacity or a "rigid" and non-compliant rectum usually present with rectal hypersensitivity. Whereas in constipated patients the response to distention needs greater volumes and rectal hyposensitivity is seen. Anorectal manometry is particularly useful in patients with anal incontinence and suspicion of neurogenic or traumatic etiology.[7] The demonstration of low resting and squeeze pressures is usually seen in patients with neurogenic incontinence. In this case, variation between resting and squeeze pressures is not seen and the recto-anal inhibitory reflex may be difficult to demonstrate. In patients with anterior obstetric injury, the resting pressures can be normal, but the patients have a hypotonic external sphincter and attempt to hold the contraction can clearly demonstrate the fatigue of the muscle. In those cases where there is a muscle defect, sphincter asymmetry is also demonstrated.

Patients are prepared with an enema 2 hours prior to examination and positioned in the left lateral decubitus or Sims's position. Before introducing the catheter, it is important to reset the system to zero before starting the exam. The catheter is then positioned with the perfused channels inside the anal canal and rectum, and recording of resting and squeeze pressures is obtained. Resting and squeeze pressures correspond to the function of the internal and external anal sphincter, respectively.

Because there is no standardized method to perform anorectal manometry, each institution has developed its own methods.[8] This is one of the reasons that comparison of data between different publications is difficult. Therefore, with the development of high-resolution systems in 2007 and because of the lack of consistency between protocols a proposed protocol for performing anorectal manometry was made by the International Anorectal Physiology Working Group (IAPWG) termed the "London Protocol".[9]

Table 3
Parameters evaluated by anorectal manometry.

Mean and maximal resting pressures
Mean and maximal squeeze pressures
Fatigue index
Asymmetry index
Recto anal inhibitory reflex
Cough reflex
Evaluation of dyssinergic evacuation
Rectal sensitivity or rectal threshold
Capacity and compliance

The protocol has the potential to reduce interobserver variability, as long as the following sequence is followed: resting, squeeze two times, endurance squeeze, push two times, cough two times, reflex, and volumetric evaluation.

High resolution systems were developed to facilitate evaluation, reduce examining time, and make comparisons between centers more reliable. Because the catheters have an increased number of channels, the pressures are measured in a bigger area of the anal canal, with more detailed and sensitive results. However, there is a lack of well designed randomized or controlled studies that confirm superiority of high-resolution systems over the conventional water perfused ones. In addition, there is still great variation in the studies comparing conventional and high-definition anorectal manometry.

Independent of the system, anorectal manometry is an objective way to assess sphincter function in incontinent patients, especially for those that have failed conservative and physiotherapy and are candidates for neuromodulation. In patients with dyssynergia, high-definition manometry is often able to discriminate between the four subtypes of dyssnergic defecation.[10] Recent technique refinements have facilitated more exact diagnosis, which helps select the best treatment option. In addition, high-definition manometry has largely replaced electromyography for mapping and detection of a dyssnergic sphincter.

Balloon expulsion test(BET)

This is a simple and inexpensive test that can be performed at the conclusion of anorectal manometry, using the same catheter, filled with 50-60 cc of liquid.[11]

Ideally, the patients should be able to expel the balloon in a sitting position after 1-5 minutes of effort. It is an additional evaluation for patients with symptoms of obstructed defecation and should be correlated with anorectal manometry, electromyography (EMG) and other dynamic imaging tests.[12]

Electromyography(EMG) and pudendal nerve terminal latency (PNTML)

EMG and PNTML are the most frequently utilized neurophysiological tests that can help to elucidate the pathophysiology of symptoms in patients with anorectal dysfunction.[13,14] These tests are complementary to anorectal manometry and imaging of the pelvic floor as they can demonstrate muscle denervation and quantitatively estimate muscle reinnervation as well as the level of motor neuron excitability. They were utilized in the past to more accurately identify patients with neurogenic incontinence and neurogenic bladder, constipation, pelvic pain, and sexual disorders in both male and female.

EMG has been considered to be an important method for evaluation of the external anal sphincter and the puborectalis muscle, as well as the assessment of the electrical activity during voluntary contraction and straining. PNTML consists of transrectal stimulation of bilateral pudendal nerves with the patient in the left lateral decubitus position. The relationship between pudendal neuropathy and poor function after sphincteroplasty has been controversial but in general considered a predictor, especially when bilateral neuropathy could be demonstrated.[14] However, it has also been clearly demonstrated that neuropathy should not necessarily preclude a sphincter repair when anatomical deformity is one of the reasons for fecal incontinence.

Because they are usually performed by neurophysiologists and not always available, needle EMG has slowly being abandoned. Besides little availability, patients' intolerance to EMG needles being placed in the perianal region was another reason for the replacement of these tests by other ways of sphincter mapping such as endoanal ultrasound or surface EMG.

Surface EMG may still have a role in the management of pelvic floor disorders, and is still commonly utilized by physiotherapists for biofeedback therapy.[15]

Endoanal ultrasonography

Endoanal ultrasonography was developed for evaluation of the anal sphincter muscles and other anorectal structures, providing anatomic detail in patients with fecal incontinence, anal fistulas, and other anorectal pathologies. [16] The development of high-resolution transducers, with high frequencies and three-dimensional configuration, has also enabled the evaluation of the pelvic floor structures in both a static and dynamic way.[17,18]

Ultrasonographic images are described as hyper-echogenic, hypo-echogenic or mixed. The finding of hyper-echogenicity implies denser tissues, muscles, and ligaments, and is visualized as whitish images on the display screen. Examples of hyper- and hypo-echoic tissues are the external and internal anal sphincter (IAS) muscles, respectively.

Endoanal ultrasonography has been considered one of the main tests to evaluate anal incontinence because it is relatively painless, simple, easy-to-perform method that provides excellent imaging of the entire sphincter musculature, including the IAS. (Fig. 3). The sensitivity of ultrasonography to detect sphincter defects is almost 100% in most studies.[19,20] In comparison with magnetic resonance imaging, ultrasound has superior sensitivity for the detection of internal anal sphincter defects, an equivalent sensitivity for the detection of external anal sphincter defects and is less sensitive for the evaluation of atrophy of this muscle.

Colonic transit time

Colonic transit time is utilized to evaluate patients with functional constipation.[21] Although there are many methods to assess colonic transit, the simplest one is the single-capsule technique, where twenty-four radiopaque markers are administered to the patient as a single capsule (Sitzmarks-Konsyl Pharmaceuticals, Fort Worth, TX, USA) and a plain anterior-posterior (AP) abdominal radiograph is performed after 5 days. In a patient with normal transit, fewer than 20% (usually fewer than 5) of the markers remain in the colon. When a patient retains more than 5 markers, the distribution of the markers is important. In patients with colonic inertia the markers are usually spread out through the colon whereas in patients with outlet obstruction the markers are usually concentrated in the rectosigmoid. (Fig. 4) The main advantage of this technique is its ease of administration, tolerability, and reduced radiation exposure; however, it does not permit exact quantification of transit time nor does it assess segmental transit time. Also, it is important to counsel the patient to stop all laxatives 48 hours prior to the study. Some clinicians recommend a radiograph on day 1, to ensure that the patient took the capsule, as there have been reports of Munchausen's syndrome where the patient delays ingestion of the capsule until later.

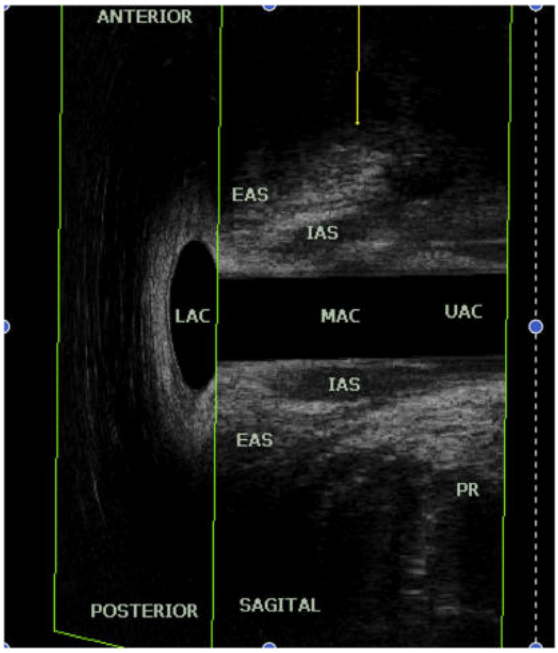

Fig. 3. Endoanal tridimensional ultrasound showing the low, mid and upper anal canal in sagittal view, with internal anal sphincter (IAS), external anal sphincter (EAS) and puborectalis (PR).

Cinedefecography

This is the primary test to evaluation the dynamics of evacuation. It is utilized for patents with symptoms of obstructed defecation. Some centers have substituted dynamic magnetic resonance defecography (MRD). However, MRD is typically performed with the patient supine, which does not replicate normal defecation. Standard fluoroscopic defecography has the patient on a commode to eliminate a barium paste, and thus makes the evaluation more physiological and may be helpful in demonstrating the presence of intussusception, rectoceles, sigmoidoceles and anismus.

Magnetic resonance

Magnetic Resonance Imaging (MRI) is a widely utilized method for evaluating the pelvic floor. Static MRI provides details of the multicompartmental anatomy of the pelvic floor (Fig. 4), while dynamic MRI, also called MR defecography (MRD), demonstrates the dynamic interaction between the three pelvic compartments and reveals relevant pelvic floor abnormalities as well as defecation disorders.[22,23] For evaluation of the pelvic floor, MRI combines high-resolution images with a soft tissue contrast, which makes it possible to assess multiple disorders affecting the pelvic floor in one examination.[24,25] The standard protocol includes patient preparation, consisting of rectal and bowel cleansing and positioning the patient in the supine position and with the knees slightly elevated. The MRD should be performed in a 1.5T or 3T MRI, with a phased array coil with a protocol that should include static and dynamic sequences, whereas dynamic means imaging during squeezing, Valsalva, and evacuation. Our protocol is summarized in Table 3. Fig. 10 and Table 4.

The indications for MRD includes the assessment of patients with rectoceles, cul-de-sac hernias, intussusception, spastic pelvic floor

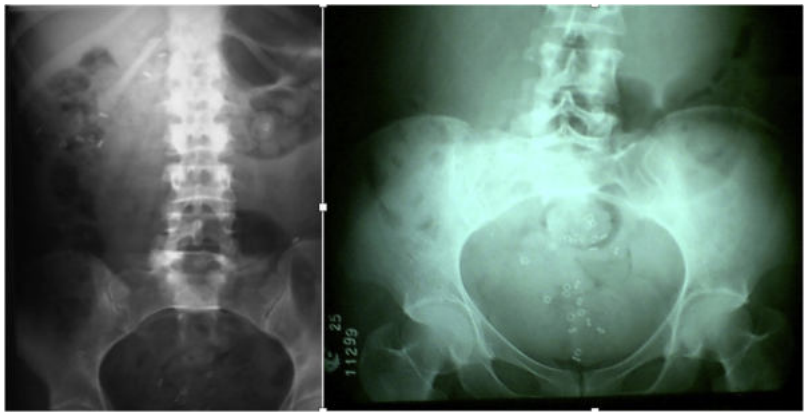

Fig. 4. Colonic transit study in a patient with (a) colonic inertia and (b) outlet obstruction.

and fecal incontinence. In addition, it can assess multicompartmental dysfunction, such as multicompartmental prolapses, those who have undergone surgery and who have progressed to postoperative repair failure, and those who have overlapping clinical conditions that limit physical assessment.[26]

Rectocele

Rectocele is defined as a bulging of the rectal wall beyond its normal limits. Anterior rectoceles are common, especially in women, related to a rectovaginal fascial defect and seen in clinical examination as a protrusion of the rectum into the posterior vagina. Patients usually complain of vaginal pressure, a feeling of incomplete evacuation and other symptoms of obstructed defecation. Rectocele may be associated with rectal descent, intussusception or prolapse. It's important to quantify the anteroposterior diameter of the rectocele (Fig. 5), which should be measured from the most anterior aspect of the rectal protrusion to the expected margin of the normal rectal wall; and if there is complete or partial emptying of the rectocele, as measured by fraction of contrast retention. Posterior rectoceles are less common, related to an anococcygeal ligament defect, and are usually silent clinically.[22,27]

Cul-de-sac-hernia

The cul-de-sac is a normal caudal extension of the peritoneal cavity, between the rectum and the vagina (Fig. 6). A cul-de-sac hernia occurs when the peritoneal sac projects more than one-third beyond the proximal vagina, and reflects injury in supportive ligaments, rectovaginal fascia and levator ani muscles. Patients submitted to hysterectomy are particularly susceptible. It is referred to as a peritoneocele if it contains only peritoneal fat, enterocele if peritoneal fat is accompanied by small bowel loops, sigmoidocele or cecocele if it contains sigmoid or cecal colon, respectively. It may manifest as a posterior vaginal bulging, distinct from rectocele; or cause extrinsic compression and potentially obstruct the vagina, the rectum

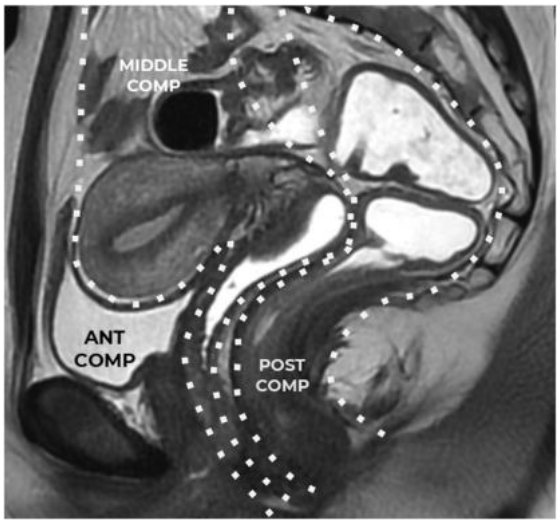

Fig. 5. Pelvic compartments. Sagittal MRI T2WI shows multicompartmental anatomy of the pelvic floor.

or both. MRD is useful in distinguishing these conditions and identifying other associated abnormalities. There is no widely agreed upon indication for corrective operation. The latest consensus is simply to carefully describe the contents of the sac, how far the hernia projects, the relationship with the apex, middle of vaginal or pelvic floor, if there is a protrusion into the vagina or rectum and if the hernia obstructs rectal emptying, as a way of assisting the surgeon's decision.[22,28]

Intussusception and Rectal prolapse

These entities are defined as invagination of the wall of the rectum through the rectum or anal canal, involving the mucosal layer or

Table 4
Defecography imaging protocol.

Study phase	Sequence	Plane	FOV (cm)	Slice thickness	Anguluation	Time of eco
Rest	T2 TSE/FSE 2D	Sagital	22 × 22	3-4 mm	Midsagittal	3-4 min
		Axial	35 × 35		Perpendicular to anorectum	
		Coronal	35 × 35		Parallel to anorectum	
Squeeze	FIESTA/Cine TrueFISP/BFFE	Sagital	35 × 35	8 mm	Middsagittal parallel to anorectum	Squeeze 18s
Valsalva						Valsalva 18s
Defecation 3x						Defecation 40-60s (3x)
Defecation (optional)	FIESTA/Cine TrueFISP/BFFE	Coronal	35 × 35	8 mm	Midcoronal parallel to anorectum	40-60s

Note: TSE/FSE = Turbo/fast spin echo; TrueFISP = true fast imaging with steady state precession; BFFE = balanced fast field echo.

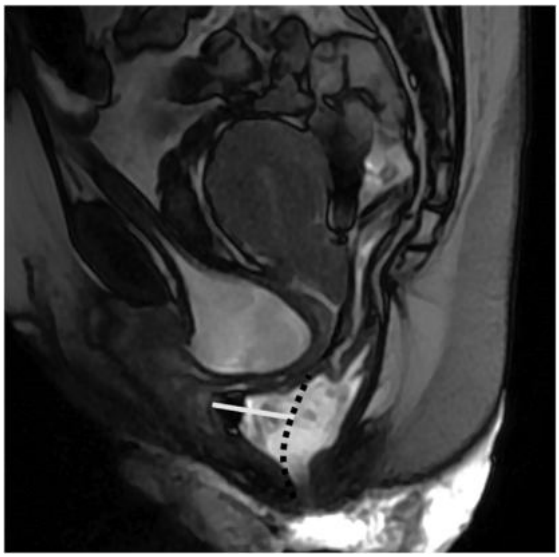

Fig. 6. Retocele. Sagittal MRI T2WI shows anterior rectocele. Anteroposterior diameter (grey line) is measured from the most anterior aspect of the rectal protrusion to the expected margin of the normal rectal wall (dashed black line).

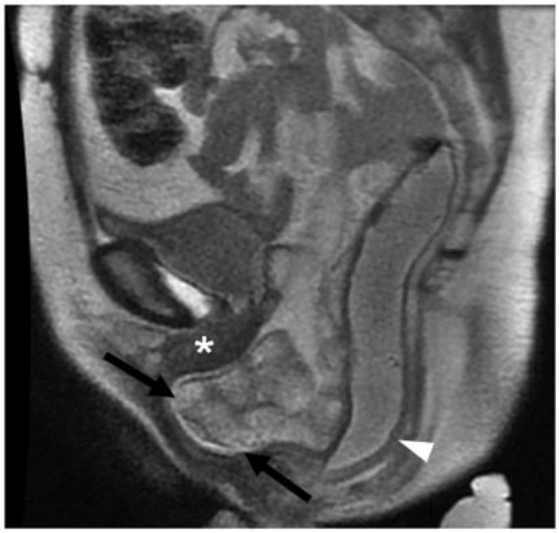

Fig. 7. Cul-de-sac hernia. Sagittal MRI T2WI shows elevator hiatus enlargement, vaginal vault prolapse (white asterisk), rectocele (white arrow head) and peritoneocele (black arrows).

the entire parietal thickness (muscle and mucosa), (Fig. 7). It is necessary to report the distance of the parietal inversion from the anorectal junction and classify the invagination as intrarectal, intra-anal and extra-anal (prolapse). Clinically, invaginations are manifested by obstructive symptoms and may be associated with constipation, pelvic floor dyssynergia, and irritable bowel syndrome.

Spastic Pelvic Floor

Spastic pelvic floor syndrome, also known as pelvic floor dyssynergia or anismus, is failure of puborectalis muscle relaxation during defecation resulting in paradoxical contraction. Patients have symptoms of incomplete or obstructed defecation and anal pain. The following abnormalities are detected on MRD: the unsatisfactory descent of the pelvic floor during the straining phase of defecation, failure to open the anal canal and increase the anorectal angle (Fig. 8). Besides that, the puborectalis muscle may become hypertrophic and decrease the anorectal angle (paradoxical contraction). This pathology is commonly associated with anterior rectocele.[29]

Fecal incontinence

Fecal incontinence (FI) is a multifactorial condition, and several causes may coexist in the same patient; thus, for a more effective treatment, investigation requires careful assessment, not only focused on the sphincter, but also on other associated conditions.

Due to its high tissue resolution, MRD can accurately identify anal canal pathologies, mainly related to sphincter injuries. In addition, MRD can diagnose underlying functional abnormalities. Studies using MRD in patients with FI have found some alternative diagnosis as intussusception, anterior rectocele, enterocele and pelvic floor descent. It's beyond our goals to establish a causal link between these findings and the origin of FI, but the identification of these conditions may directly influence the choice of treatment.[30]

Lesions of the anal sphincter and sphincter atrophy (Fig. 9) are relatively common conditions in patients who have fecal incontinence. Sphincter defects are visible as a discontinuity of the sphincter signal, usually associated with scarring (tissue more hypointense than the musculature), which determine architectural distortion of the sphincter muscle. The atrophic sphincter has accentuated thinning of its muscle fibers or even replacement of the fibers by fat, without expressive thinning.[30]

Although the latest consensus suggests ignoring the Valsalva phase and proceeding directly to a defecation phase; we believe that the Valsalva is often useful in identifying spontaneous loss of contrast media, associated with FI.

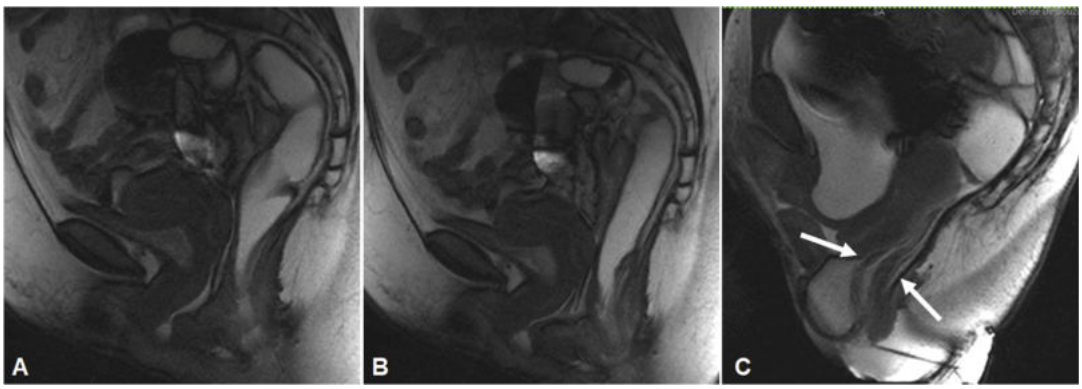

Fig. 8. Intussusception. Sagittal MRI T2WI images in the three phases of evacuation shows invagination of the wall of the rectum through the rectum, involving the mucosal layer, compatible with intrarectal invagination. Intussusception is accentuated in the third phase of evacuation (white arrows), showing the importance of repeating this maneuver during defecography. There is anterior rectocele associated.

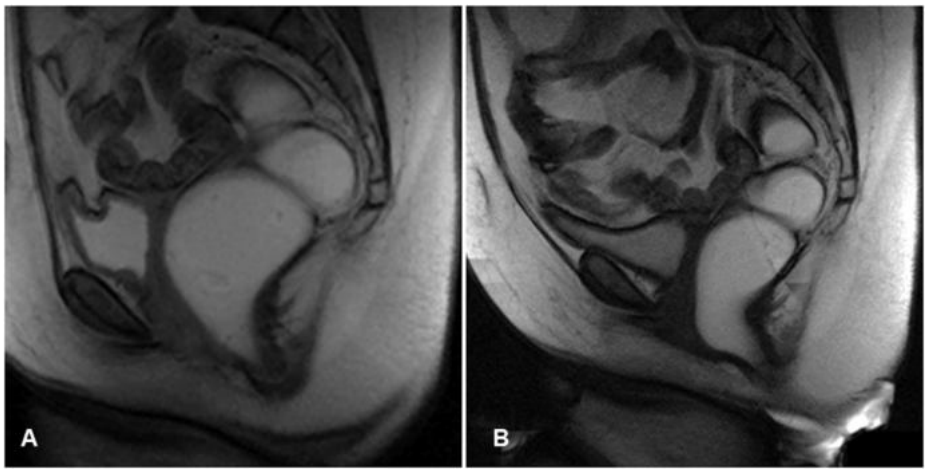

Fig. 9. Spastic pelvic floor syndrome. Rest (A) and Evacuation (B) Sagittal MRI T2WI shows unsatisfactory decency of the pelvic floor during evacuation, with failure to open the anal canal and increase the anorectal angle.

Fig. 10. Fecal incontinence. Coronal (A) and Sagittal (B) MRI T2WI shows bilateral atrophy of the levator ani, with fibrosis on the right (white arrow) in a patient with fecal incontinence for solids.

Conclusion

In conclusion, specialized anorectal testing can help to delineate the pathophysiology of pelvic floor and anorectal dysfunction. These tests can define functional or structural abnormalities and help to select treatment, modalities, especially in cases where initial or secondary interventions have failed or were ineffective.

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