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ORIGINAL ARTICLE

Dynamic MRI defecography vs. entero-colpo-cysto-defecography in the evaluation of midline pelvic floor hernias in female pelvic floor disorders

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Abstract
Purpose The aim of this study was to compare the diagnostic efficacy of dynamic MR defecography (MR-D) with entero-colpo-cysto-defecography (ECCD) in the assessment of midline pelvic floor hernias (MPH) in female pelvic floor disorders.
Methods From August 2004 to August 2010, 3,006 female patients who required ECCD for the evaluation of pelvic floor disorders were enrolled in this study. All the 1,160 patients with ECCD findings of MPH were asked to undergo MR-D; 1,142 accepted to undergo MR-D and constituted the object of analysis. This study was approved by the Institutional Ethical Committee. All the patients gave their written informed consent to take part in the study.
Results Overall, the prevalence of MPH at ECCD was higher if compared with that at MR-D. Concerning the hernia content, there were significantly more enteroceles and sigmoidoceles on ECCD than on MR-D, whereas, in relation to the hernia development modalities, the prevalence of elytroceles, edroceles, and Douglas' hernias at ECCD was significantly higher than that at MR-D. In spite of a 100% specificity, the sensibility of MR-D in the detection of an omentocele, sigmoidocele, and enterocele was, respectively, 95%, 82%, and 65%, showing an inferior diagnostic capacity if compared with that of ECCD.
Conclusion MR-D shows lower sensitivity than ECCD in the detection of MPH development. The less-invasive MR-D may have a role in a better evaluation of the entire pelvic anatomy and pelvic organ interaction especially in patients with multicompartmental defects, planned for surgery.

Keywords Pelvic floor disorders · Entero-colpo-cysto-defecography · Dynamic MR defecography · Midline pelvic floor hernias

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Introduction

Pelvic floor disorders represent a common clinical problem that afflicts women three to seven times more often than men [1] and have a negative impact on quality of life [2, 3]. They comprise a wide variety of clinical conditions, including urinary incontinence, sensory and emptying abnormalities of the lower urinary tract, fecal incontinence, defecatory dysfunction, chronic pelvic pain syndromes, and pelvic organ prolapse [1, 2]. The pelvic floor disorders may be associated, with an incidence ranging from 18% to 45% [4], to the so-called midline pelvic floor sagittal hernias (MPH) that represent the herniation of the peritoneum and/or peritoneal viscera in the Douglas', Retzius', and retro-rectal spaces.

Although anamnestic and physical examination represents the first approach in the evaluation of the patients with pelvic floor dysfunction, the diagnostic limitation of the pelvic examination alone has led to the need to use

more direct and comprehensive diagnostic methods [5–8]. These include: fluoroscopic and radiographic investigation, ultrasound (US), and more recently, MRI. [3, 9–11]. Even if the entero-colpo-cysto-defecography (ECCD) is considered the gold standard for the evaluation of the patients with pelvic floor disorders and diagnosis of MPH [12–14], the role of dynamic MR defecography (MR-D) is an object of debate.

The aim of this study was to compare the diagnostic efficacy of MR-D with ECCD in the assessment of midline pelvic floor sagittal hernias in female pelvic floor disorders.

Patients and methods

From August 2004 to August 2010, female patients who required ECCD for the evaluation of pelvic floor disorders were introduced in a prospective database, investigated about their clinical history, and considered for the enrollment in this study. All the patients with ECCD findings of MPH were asked to undergo MR-D.

Imaging technique

Entero-colpo-cysto-defecography

No bowel preparation was used for ECCD [15]. To obtain small-bowel contrast, 1 h before the exam, 200 mL of barium sulfate 60% *p/v* was administered to each patient. Through a catheter inserted in the bladder, 400 cc of iodine contrast medium (Ultravist, Bayer Schering Pharma, Berlin, Germany) was injected until the patient felt a sensation of fullness. The patient was placed in the left lateral decubitus position, after which 200 cc of barium paste (Prontobario Esofago 113%, barium paste, Bracco, Milan, Italy) was introduced into the rectum. During injector removal, the anal canal was also contrasted. The vagina was contrasted with 25 ml of barium paste. The fluoroscopic table was then tilted upright 90°, and the patient was seated on a radiolucent commode. An anteroposterior radiograph was taken with the patient at rest; after that, five lateral radiographs were taken at rest, during squeezing, pushing, evacuation, and after evacuation.

Dynamic MR defecography

On the same day, an MR-D was performed. All MR-D imaging studies were performed on 1.5-T closed magnet (Magnetom Symphony, Siemens, Germany). All patients were supine imaged with a body-phased-array receiver coil. To ensure an adequate bladder filling, all patients were invited to drink 500–700 ml of water 10–15 min before the examination. The rectum and vagina were filled with 200 mL and about 25–30 mL [16], respectively, of a mixture of ultrasonographic gel (Ultragel, G.P.S., Bologna, Italy) and gadolinium-diethylenetriamine pentaacetic acid [5]. After an initial localizer in three different planes, the study protocol included TSE T2-W axial (matrix, 181×256; slices, 25; thickness, 5 mm; TR/TE, 6,430/114; flip angle, 180°), TSE T1-W sagittal (matrix, 181×256; slices, 25; thickness, 5 mm; TR/TE, 846/11; flip angle, 150°) sequences, and functional dynamic sequences TRUFISP T2-W sagittal, during squeezing, pushing, and evacuation (matrix, 181×256; slices, 1; thickness, 8 mm; TR/TE, 3.75/1.6; flip angle, 80°). The MR-D images so obtained then are assembled in cineview in postprocessing. Examination time took about 30 min to complete.

Image analysis

All personal information was removed from the radiological images. The diagnosis and measurement were then independently performed by two of the authors (S.C. and R. G.) with 20 years of experience; in case of disagreement, the final diagnosis was made in consensus. The line extending from the most inferior portion of the symphysis pubis to the tangent of the sacrococcygeal joint (pubococcygeal line, PCL) acted as a reference line for both ECCD and MR-D. The diagnosis of descent of the bladder, vagina, and rectum was based on measurement of the vertical distance between the PCL and the bladder base, the vaginal vault, and the anorectal junction, respectively.

According to Yang's classification [12], the limits of normal descent with maximal strain are 1.0 cm below the PCL for the bladder base, 1.0 cm above for the vaginal cuff or lower end of the cervix, and 2.5 cm below for the rectal area. The rectocele was defined as an out-pouching of the anterior rectal wall occurring during evacuation or straining [17–19].

The MPH detected by ECCD and MR-D were classified, basing on the content, into enterocele, omentocele, and sigmoidocele, whereas, according to the hernia development, they were distinct as elytrocele, edrocele, retrorectal, and Douglas' and Retzius' hernias [8]. Enterocele, sigmoidocele, and omentocele represent the herniation below the proximal (apical) one third of the vagina of the peritoneal sac containing ileal loops, part of the sigmoid, or peritoneal fat, respectively [9, 20–22]. If the small bowel, the peritoneal fat, or the sigmoid colon entered the Retzius' or Douglas' space, they were identified as Retzius' and Douglas' hernias, respectively; if they entered the vaginal fornix posteriorly, causing a complete eversion of the vaginal wall, an elytrocele was recognized (posterior vaginal hernia) [23] (Fig. 1). In the same way, if they

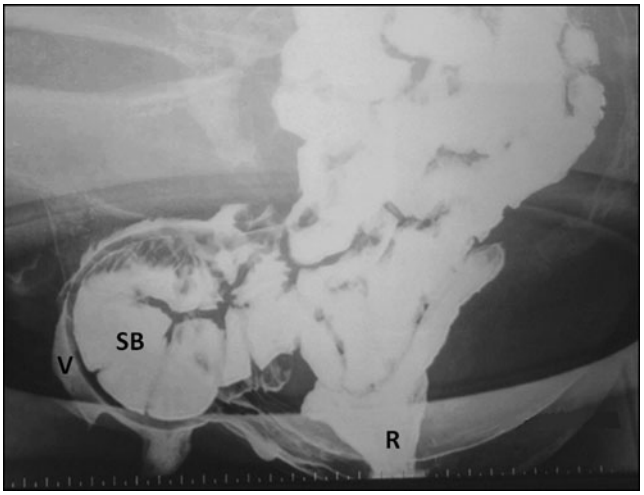

Fig. 1 Elytroceles at ECCD: the small bowel loops enter the vaginal fornix posteriorly with an eversion of the vaginal posterior wall. *V* vagina, *SB* small bowel, *R* rectum

entered the rectum anteriorly, leading to a rectal wall eversion, an edrocele was detected [5, 24–26].

On evaluation of ECCD, the diagnosis of an enterocele/sigmoidocele/omentocele was made if the picture obtained during evacuation compared with that during rest showed an increase in the distance between the vagina and rectum. This expansion should extend below the PCL reference line and show a sagittal diameter of more than 2 cm.

Anyway, the distinction between sigmoidocele, enterocele, and omentocele was made basing on the presence of contrasted small bowel in the expanded recto-vaginal space for the enterocele, on the presence of distinguishable bowel gas bubbles without contrast for the sigmoidocele alone, and on the absence of contrasted small bowel and bowel gas bubbles in the expanded recto-vaginal space, for the omentocele.

On MR-D, the relationship between the lowest point of the peritoneal border line and the PCL was assessed. A descent of parts of the peritoneal content below this line and the identification of herniated contents allowed the distinction in enterocele, sigmoidocele, and omentocele [13]. The hernias detectable only during pushing and evacuation were considered as "functional hernias."

Statistical analysis

Statistical analysis was performed using the program InStat Graph-Pad Prism 5® (San Diego, California, USA). Data are reported as means ± standard deviation and number of patients with percentages in parenthesis. The evaluation of the diagnostic efficacy of the two imaging techniques was carried out comparing the sensitivity and specificity of MR-D vs. ECCD. The percent prevalence of MPH diagnosis of the two imaging techniques was compared by means of a two-site chi-square test. The difference was considered statistically significant for p values less than 0.05.

Ethics

This study was approved by the Institutional Ethical Committee. All the patients gave their written informed consent to take part in the study.

Results

Of 3,006 female patients who had undergone ECCD for the instrumental evaluation of pelvic floor disorder, 1,160 (38.5%) patients showed an MPH at ECCD. Out of these, 1,142 (98.4%) (mean age, 52.47±13.71) accepted to undergo MR-D and constituted the object of analysis. Among the enrolled patients, 722 (63.2%) complained of obstructed defecation syndrome, whereas 371 (32.4%) complained of anal and/or urinary incontinence. Previous surgery was reported by 388 patients (33.9%), including hysterectomy in 299 (77%), stapled transanal rectal resection in 80 (20.6%), and cystopexy in 70 (18%) cases.

At ECCD, an isolated MPH was found in 102 (11%) cases, whereas the MPH was associated with perineal descent in 297 (26%), anterior rectocele in 468 (41%), hysterocele in 367 (33%), cystocele in 194 (17%), and vaginal vault prolapse in 102 (9%) cases. The prevalence of MPH was 40% (388/981) in the patients reporting previous pelvic surgery and, particularly, 51% (299/586) in the patients who had undergone hysterectomy.

Table 1 summarizes the results of both imaging modalities. Overall, the prevalence of MPH at ECCD was higher if compared with that at MR-D, even if only one Retzius' hernia was detected by MR-D alone.

Concerning the hernia content, there were significantly more enteroceles and sigmoidoceles on ECCD than on MR-D, whereas, in relation to the hernia development modalities, the prevalence of elytrocele, edroceles, and Douglas' hernias at ECCD was significantly higher than in MR-D. Interestingly, only one elytrocele and no edrocele were detected by MR-D.

The sensitivity and specificity of MR-D versus ECCD are reported in Table 2. In spite of a 100% specificity, the sensibility of MR-D in the detection of an omentocele, sigmoidocele, and enterocele was, respectively, 95%, 82%, and 65%, showing an inferior diagnostic capacity if compared with ECCD. Interestingly, the only one reported retrorectal hernia, classified as an enterocele at ECCD, was clarified to be a sigmoidocele at MR-D (Fig. 2a, b).

Table 1 Results of both imaging modalities: the prevalence of MPH detected at ECCD was higher if compared with that of MR-D

MR-D vs. ECCD			
Imaging findings	ECCD	MR-D	*P*
Omentoceles	102 (9)	97 (8.5)	0.76
Enteroceles	800 (70)	523 (45.79)	*<0.0001*
Sigmoidoceles	240 (21)	197 (17.2)	*0.02*
Elytroceles	137 (12)	1 (0.09)	*<0.0001*
Retzius' hernias	0 (0)	1 (0.09)	0.31
Douglas' hernias	902 (78.9)	814 (71.2)	*<0.0001*
Edroceles	102 (9)	0 (0)	*<0.0001*
Retrorectal	1 (0.08)	1 (0.08)	1

There were significantly more enteroceles and sigmoidoceles on ECCD than on MR-D, and the prevalence of elytrocele, edroceles, and Douglas' hernias at ECCD was significantly higher than that of MR-D. Interestingly, only one elytrocele and no edrocele was detected by MR-D

Discussion

Pelvic floor disorders represent a significant cause of morbidity and reduction in quality of life that appear to be increasing in frequency during the last few years [27]. The risk factors for pelvic floor dysfunction include pregnancy, multiparity, advanced age, menopause, obesity, connective tissue disorders, smoking, chronic obstructive pulmonary disease, and any other factors that result in a chronic rise in intra-abdominal pressure [6].

The frequent coexistence, in these disorders, of multiple compartment defects [5, 28] suggests a multidisciplinary approach focusing on colorectal, gynecologic, and urologic evaluations and also the employment of panoramic radiological investigations that provides a wide and detailed view of the pelvis [29].

Table 2 The sensitivity and specificity of MR-D versus ECCD are reported

MR-D vs. ECCD		
Imaging findings	Sensitivity (%)	Specificity (%)
Omentoceles	95.1 (97/102)	100 (1,040/1,040)
Enteroceles	65 (523/800)	100 (342/342)
Sigmoidoceles	82 (197/240)	100 (902/902)
Elytroceles	0.7 (1/137)	100 (1,005/1,005)
Retius	N/A	N/A
Douglas	90 (814/902)	100 (240/240)
Edroceles	N/A	N/A
Retrorectal	100 (1/1)	100 (1,141/1,141)

N/A not applicable

In spite of a 100% specificity, the sensibility of MR-D in the detection of an omentocele, sigmoidocele, and enterocele was, respectively, 95%, 82%, and 65%, showing an inferior diagnostic capacity if compared with ECCD

The frequent association between pelvic floor disorders and/or pelvic prolapse and MPH [4] is well known. Concerning this, in this study, the prevalence of MPH ranged from 38% among all the enrolled patients to 51% in the patients reporting previous hysterectomy. These data are in agreement with the available literature and emphasize the role of previous pelvic surgery in the genesis of MPH [4]. The most frequent hernia was enterocele (70%), followed by sigmoidocele (21%), and omentocele (9%). On the other hand, the most frequent hernia development modality was in Douglas' space (78.9%), whereas the Retzius' and retrorectal hernias represented only occasional findings (Fig. 3).

The development of the hernias in the posterior vaginal wall or in the anterior rectal wall was observed in 9% and 12% of cases, respectively. Despite their low prevalence, their detection is important in the planning of the correct therapeutic approach.

The imaging techniques most commonly used for MPH diagnosis and study are fluoroscopic and radiographic investigations, US, and, more recently, MR-D. The defecography, currently considered as the gold standard [7, 12, 13], is a cost-effective procedure, simple to perform, and widely available [20]; however, it is an invasive procedure, especially if it is performed with four contrast that uses ionizing radiation and visualizes only the lumen of the opacified organs. US has the advantage of not using ionizing radiation, but this method has several limitations in evaluating pelvic organs prolapse [10].

Dynamic pelvic evaluation by MR-D was first described by Yang et al. in 1991 [12, 29], who suggested dynamic MR-D as a less-invasive imaging modality that allows a multiplanar and multiparametric evaluation of the three pelvic compartments, also visualizing soft tissue, in a single procedure without exposure to ionizing radiation. After this, several studies were performed to compare the diagnostic efficacy of dynamic MR-D versus that of defecography and/or physical evaluation in a patient with pelvic floor disorders, with variable results [3, 7, 9, 13, 21, 30, 31].

Our study was designed to compare the ECCD, performed with four contrast, with MR-D in the diagnosis of MPH in the female pelvic floor disorders. If compared with analog previous studies, the present study was performed on the largest series of patients.

Substantially, our results showed a higher sensitivity of ECCD in detecting both the content and the development of MPH, if compared with MR-D. Indeed, the prevalence of enterocele, sigmoidocele, edrocele, elytrocele, and Douglas' hernias at ECCD was significantly higher than at MR-D, whereas, regarding omentocele detection, even if the prevalence at ECCD was higher than at MR-D, the difference was not statistically significant.

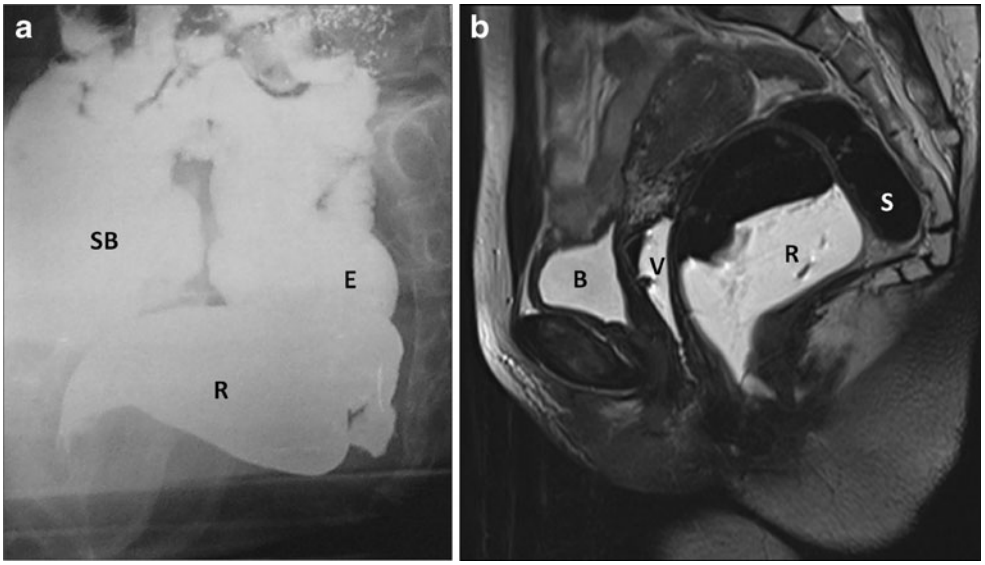

Fig. 2 **a** Retrorectal hernia at ECCD: classified first as an enterocele. *R* rectum, *SB* small bowel, *E* enterocele. **b** Retrorectal hernia at MR-D: the MR-D clarifies the hernia content as a sigmoidocele. *B* bladder, *V* vagina, *R* rectum, *S* sigmoidoceles

These findings, in accordance with other authors [7, 21], emphasize the role of ECCD in the diagnosis of MPH in female pelvic floor disorders, whereas MR-D could be more useful to clarify the intra-pelvic interaction of multiple organ prolapse [30] and to better define the pelvic anatomy and functioning in patients planned for surgery [31, 32]. Concerning this, in our series, MR-D was able to correctly define the large bowel loop content of a retrorectal hernia, previously misdiagnosed as an enterocele at ECCD.

The lower sensitivity of MR-D in the detection of MPH may be related to the supine position of the patients, although it is still a matter of debate if the differences observed between sitting and supine MR-D are clinically relevant [33]. Anyway, apart from the patients' position during the examination, we believe that a complete defecation is pivotal to ensure a completely dynamic evaluation of the pelvic floor diseases. On this subject, Lienemann et al. already reported the importance of repeated straining and rectal emptying for enterocele detection [13] that in supine position could become uncomfortable for the patient. Defecation also plays a role by ensuring that intra-abdominal pressure is adequately elevated. A solution on MR-D is to repeatedly encourage patients to strain maximally or to monitor intra-abdominal pressure [21].

Fig. 3 Retzius hernia at MR-D: the omentum enters the pre-vesical space. *O* omentum, *B* bladder, *U* uterus, *R* rectum

Another significant side in favor of MR-D is the capability of surveying the entire pelvis in a safe and non-invasive manner [3]. This is relevant especially for patients of childbearing age because, in the ECCD, the ovaries are in the primary radiation field, and the ovarian dose from defecography is high, being estimated at 15±5 mSv [34].

In conclusion, MR-D shows lower sensitivity than ECCD in the detection of MPH. The diagnostic efficacy of ECCD is significantly higher than that of MR-D in the detection of both hernia content (enteroceles and sigmoidoceles) and hernia development (Douglas' hernia, elytroceles, and edroceles).

The less-invasive MR-D may have a role in a better evaluation of the entire pelvic anatomy and pelvic organ interaction especially in patients with multicompartmental defects, planned for surgery [35]. The correct diagnosis of these diseases is important to establish the best therapeutic option and to ensure the best therapeutic outcome. Probably, the relatively high rate of repeat surgery may reflect the failure to recognize the full extent of hernias preoperatively, so the preoperative identification of these conditions appears crucial to an appropriate surgical intervention [36–38].

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