

Endometriosis diagnosis: a retrospective study on the use of transvaginal ultrasound, sonovaginography and magnetic resonance imaging

Diagnóstico de Endometriose: uma análise retrospectiva do uso de ecografia transvaginal, sonovaginografia e ressonância magnética pélvica

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Abstract

Objective: To provide estimates of the diagnostic accuracy of transvaginal ultrasound, sonovaginography and magnetic resonance imaging for the diagnosis of ovarian endometriosis and deep endometriosis.

Methods: This was an observational, retrospective study carried out in a Portuguese tertiary center. Consecutive patients who underwent surgical procedures between 2010 and 2023 for diagnosis and treatment of endometriosis were included. The index tests were transvaginal ultrasound, sonovaginography and magnetic resonance imaging. Accuracy of these tests to identify lesions of endometriosis was assessed for different sites, relative to surgical findings. Data was obtained from imaging and surgical reports. Sensitivity, specificity, positive and negative predictive values were calculated for each diagnostic method.

Results: Out of 301 patients who underwent surgery, 195 (64.8%) were evaluated with transvaginal ultrasound, 99 (32.9%) had a sonovaginography performed and 167 (55.5%) were evaluated with magnetic resonance imaging. All but 3 (1.0%) patients had endometriosis confirmed through surgical visualization. The sensitivity and specificity for ovarian endometriosis were 95.2% and 83.1% for transvaginal ultrasound and 91.0% and 80.5% for magnetic resonance imaging, respectively. Regarding deep endometriosis, the sensitivity and specificity were 84.1% and 54.5% for sonovaginography and 90.3% and 60.0% for magnetic resonance imaging, respectively.

Conclusion: Transvaginal ultrasound was highly accurate for the diagnosis of endometriomas and, when used alongside sonovaginography it had important value in the diagnosis of deep endometriosis as well. Both sonovaginography and magnetic resonance imaging showed similar performance in diagnosing deep endometriosis and stand as reliable diagnostic tools.

Keywords: Endometriosis; Diagnosis; Diagnostic imaging; Ultrasonography; Magnetic Resonance Imaging.

Resumo

Objetivo: Obter estimativas da capacidade diagnóstica da ecografia transvaginal, sonovaginografia e ressonância magnética para o diagnóstico de endometriose ovárica e profunda.

Métodos: Este foi um estudo observacional retrospectivo que decorreu num centro terciário português. Foram incluídos pacientes sujeitos a procedimentos cirúrgicos para o diagnóstico e tratamento de endometriose entre 2010 e 2023. A capacidade da ecografia transvaginal, sonovaginografia e ressonância magnética para a identificação de lesões de endometriose foi avaliada para diferentes localizações, tendo por referência os achados cirúrgicos. Os dados foram obtidos a partir dos relatos imagiológicos e cirúrgicos. Para cada método diagnóstico foram calculadas as seguintes medidas: sensibilidade, especificidade, valores preditivos positivos e negativos.

Resultados: De 301 doentes submetidos a cirurgia, 195 (64,8%) realizaram ecografia transvaginal, 99 (32,9%) efetuaram sonovaginografia e 167 (55,5%) foram avaliados com ressonância magnética. O diagnóstico de endometriose foi confirmado, através de visualização direta, em todos os pacientes exceto 3 (1,0%). A sensibilidade e especificidade da ecografia transvaginal para o diagnóstico de endometriose ovárica foram 95,2% e 83,1% e da ressonância magnética foram 91,0% e 80,5%, respetivamente. Relativamente ao diagnóstico de endometriose profunda, obtivemos sensibilidade e especificidade de 84,1% e 54,5% para a sonovaginografia e de 90,3% e 60,0% para a ressonância magnética, respetivamente.

Conclusão: A ecografia transvaginal apresentou um desempenho excelente no diagnóstico de endometriomas e, quando usada em conjunto com a sonovaginografia, revelou grande valor para o diagnóstico de endometriose profunda. Tanto a sonovaginografia como a ressonância magnética obtiveram resultados semelhantes para o diagnóstico de endometriose profunda e afirmam-se como métodos de imagem confiáveis.

Palavras-chave: Endometriose; Diagnóstico; Imagiologia diagnóstica; Ultrassonografia; Imagem de Ressonância Magnética.

INTRODUCTION

Endometriosis is a chronic disease characterized by the presence of endometrium-like tissue outside the endometrium, frequently accompanied by an associated inflammatory reaction¹. The exact prevalence of this disease is unknown, but it is thought to affect around 10% of women in their reproductive years².

Endometriosis manifests mainly as three different subtypes: superficial implants in the peritoneum, ovarian endometriosis (endometriomas) and deep-seated infiltration into nearby tissues and pelvic organs (deep infiltrating endometriosis, DE). According to an international working group, DE is defined as “endometrium-like tissue lesions in the abdomen, extending on or under the peritoneal surface; they are usually nodular, able to invade adjacent structures, and associated with fibrosis and disruption of normal anatomy”¹. These subtypes may differ in symptom presentation and diagnostic approach^{1,3}. The clinical manifestations range from dysmenorrhea and deep dyspareunia to dysuria, dyschezia and infertility⁴. No symptom is specific or pathognomonic of endometriosis and its severity does not correlate to the surgical stage of the disease,

which can remain undiagnosed for 8 to 12 years⁵. This delay leads to long-lasting pain, reduced quality of life, psychological stress, and compromised fertility⁶.

Diagnosing endometriosis remains a challenge for clinicians⁷. Laparoscopic observation and biopsy are considered the gold standard for the diagnosis although identifiable lesions may not always be histologically confirmed^{4,5}. Physical examination alone has low diagnostic accuracy, so imaging is widely used to establish a diagnosis and evaluate the extent of the disease as surgery is invasive and costly^{3,4}. Surgical intervention is usually reserved for women with disease non-responsive to medical treatment, infertility and severe disease (interfering with organ function) so noninvasive imaging exams assume a preponderant role⁶.

Transvaginal ultrasonography (TVUS) allows for real-time assessment of the uterus, adnexa and surrounding structures while granting dynamic evaluation of organ mobility hence it is the first-line imaging modality to use when suspecting of endometriosis⁸⁻¹⁰. TVUS detection is greatly dependent on the experience of the operator and the location of the endometriotic lesions, being especially useful in patients with endometriomas or DE^{9,11,12}. Sonovaginography (SVG), introduced by Dessole et al in 2003, is a

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contrast-enhanced transvaginal ultrasound using saline solution or gel to create an acoustic window between the probe and surrounding structures. It is used as an additional tool to identify and characterize DE^{9,13-15}. Magnetic resonance imaging (MRI) is recommended as a further step in the diagnostic workup of endometriosis following an equivocal ultrasonography evaluation and in case of extensive disease¹⁶. Infiltrating lesions are more precisely mapped as it has a larger field of view and high tolerability therefore significantly helping preoperative planning⁹.

The high accuracy of such non-invasive modalities guarantees their use as standard, enabling early diagnosis which in turn facilitates medical treatment and ensures optimal planning for adequate surgical management, anticipating its difficulty and helping determine when a multidisciplinary team is needed^{7,17}.

In this study, we aim to provide estimates of the diagnostic accuracy of these non-invasive imaging methods for the diagnosis of endometriomas and deep endometriosis in patients who had surgical procedures in a tertiary referral center and to compare the performance of these modalities in accurately mapping lesions and assessing their extent.

METHODS

This was an observational, retrospective cohort study carried out in a tertiary center in Portugal and compliant with the STARD (Standards for Reporting of Diagnostic Accuracy) guidelines. The study was approved by the local ethics committee. All patients who underwent surgical procedures (laparoscopy or laparotomy) for diagnosis and treatment of endometriosis between 2010 and 2023 were eligible for inclusion and we reviewed the unit's surgical database to select them. These patients were followed in this hospital and had clinical or imaging suspicion of ovarian or deep endometriosis. We excluded those who had extrapelvic endometriosis or adenomyosis alone.

The archived data about clinical history, transvaginal ultrasound, sonovaginography, magnetic resonance imaging and surgery results were collected from electronic medical records (SClinico and BHealth).

The topography of the endometriotic lesions was obtained from imaging and surgical reports regarding an-

terior compartment involvement (distal ureters and bladder), posterior compartment involvement (uterosacral ligaments; uterine torus, rectovaginal septum and posterior vaginal wall), intestinal involvement (rectum, sigmoid and rectosigmoid transition), and presence of ovarian endometriomas. For each location, data were classified as positive or negative for the detection of endometriosis in every test.

For every patient, the following anamnestic data were collected: age, height and weight, smoking status, age at menarche, parity and gravidity, history of previous surgeries and medical conditions. Clinical symptoms of endometriosis such as dysmenorrhea, dyspareunia or infertility were also documented as well as if the patient was referred due to an incidental imaging finding.

As per this study's retrospective methodology, all those performing imaging studies or surgery had access to clinical information regarding the patient at the time of execution of the respective procedures. Patients underwent each imaging exam as their assistant gynecologist saw appropriate, considering each case. All reports were analyzed, and the relevant findings were adequately noted. Some reports did not provide information on endometriosis findings regarding every topographic location considered in this study. In those cases, we retrieved the available information and missing results for each location were excluded from the analysis. When the report expressed uncertainty regarding the presence of endometriosis in a given location, we considered it a positive finding.

Transvaginal ultrasound and sonovaginography

Transvaginal ultrasound and sonovaginography were mostly performed in the gynecology department by the same two gynecologists, with extensive expertise in US diagnosis of endometriosis; only a minority of patients had an US executed by their doctor within the clinical appointment. During the first years of the study, a Voluson™ 730 (General Electric, USA) transvaginal 5-9 MHz probe was used; from 2021 a Voluson™ S8 (General Electric, USA) was used. No bowel preparation was used before sonography or sonovaginography.

Sonographic assessment was routinely done according to IDEA group consensus since its publication¹¹. Anatomic sites in the anterior and posterior compartments were evaluated for possible endometriotic

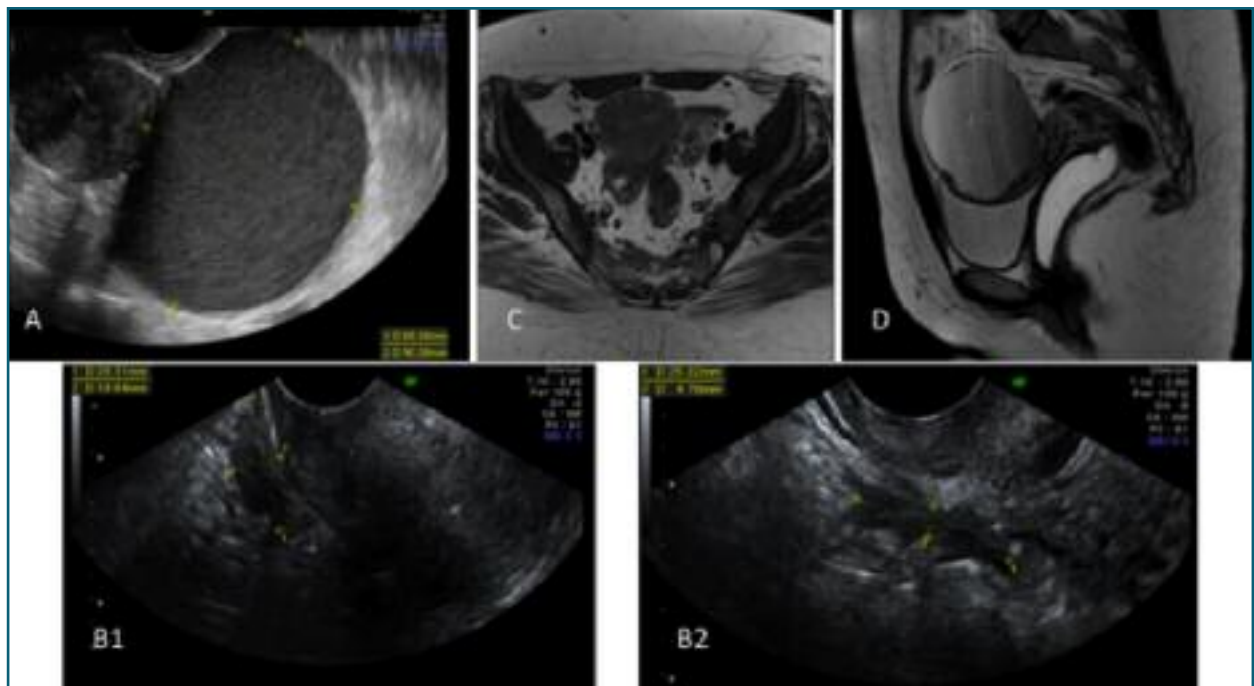


FIGURE 1. Imaging findings of endometriosis.

findings like a hypoechoic thickening, hypoechoic irregular nodules, pouch of Douglas obliteration and pelvic adhesions. Obliteration of the vesicouterine or rectovaginal pouches was assessed by gently pressing the uterus with the probe (anterior and posterior sliding signs). Endometriomas were described according to the International Ovarian Tumor Analysis (IOTA) terminology and typically appear on ultrasound as unilocular, round and with regular margins, fluid-filled cysts with ground glass homogeneous echogenicity (Figure 1A) but can also have atypical features like multiple locules and papillations¹⁸. DE lesions in the anterior compartment were diagnosed when finding hypoechoic lesions extending farther than the bladder serosa or ureter strictures. In the posterior compartment, DE was identified when observing hypoechoic solid nodules with heterogeneous size and margins or hypoechoic thickening of the vagina or intestinal wall (Figure 1B).

Sonovaginography was performed when clinicians deemed it appropriate to better characterize DE lesions. Acoustic window was obtained by placing 50 ml of ultrasound gel in the vagina to distend its walls and enhance visualization of the vaginal walls and fornix,

uterosacral ligaments, pouch of Douglas and rectovaginal septum. Each examination also included a transabdominal ultrasound with the bladder filled in order to better evaluate the presence of any relevant lesion.

Magnetic resonance imaging

Pelvic MRI was performed as per hospital protocol, using hyoscine butylbromide to reduce intestinal peristalsis and contrast if suspecting of an atypical endometrioma in order to exclude potential malignancy. Patients did not undergo any bowel preparation. The protocol also included administration of sterile vaginal ultrasound gel. The majority of the exams were performed using a Siemens MAGNETOM Vida™ device. A minority of the patients had MRI reports from external facilities, but these cases were discussed in group meetings before surgery. From 2020 all cases were reviewed by a multidisciplinary specialized group, including radiologists specialized in pelvic imaging and gynecologists with both ultrasound and surgical experience in dealing with endometriosis.

DE can be detected on MRI by an array of findings ranging from ectopic endometrial nodules to thickened structures, fibrosis or changes to the usual pelvic anatomy;

the implants typically appear as hyperintense areas foci on T1 with fat suppression and hypointense in T2-weighted MR images on the respective locations (Figure 1C). Furthermore, obliteration of pelvic pouches, disappearance of fat tissue planes and ureteral dilation are also signs of the disease. Endometriomas were diagnosed as hyperintense ovarian cysts on T1-weighted images and hypointense on T2W (Figure 1D).

Surgery

All surgical interventions were performed in this hospital by a skilled set of gynecologists, with experience in advanced laparoscopic surgery. This was considered the reference standard for the analysis as it is still considered the gold standard for the diagnosis of endometriosis⁵. Diagnosis of DE was made when at least one of the above-mentioned structures was involved; the location of all suspicious lesions was recorded and removed for histological confirmation. Typical lesions like dark “powder-burn” nodules, implants or cysts with thick content were visually identified on the pelvic structures and considered as DE when extending > 5 mm beneath the peritoneum. Spiculated nodules and thickening of pelvic structures were also evaluated for the presence of the disease. Ovarian endometriomas were identified as blood-filled cysts often adherent to the uterus or surrounding ligaments.

Statistical analysis

Statistical analysis was performed using SPSS version 29. For each diagnostic tool, the sensitivity, specificity, positive predictive value and negative predictive value with their respective 95% confidence interval were calculated for individual and grouped locations. We performed a secondary analysis of diagnostic accuracy, calculating sensitivity and specificity in the group of patients who underwent TVUS complemented with SVG; TVUS versus MRI for endometrioma diagnosis and SVG versus MRI for DE detection. To compare the diagnostic performance of these methods, the McNemar's test was used and a p value <0.05 was considered significant.

RESULTS

Table I presents the demographic data of our population as well as their clinical symptoms and surgical findings.

In total, 301 patients were submitted to surgery due to endometriosis and were included in the analysis. The mean age of our patients was 36.6 years (range 18-61) with a median BMI of 23.9 Kg/m². We found dysmenorrhea to be the most common symptom of our patients (69.0%), followed by deep dyspareunia (44.9%). At least 64 patients (22.9%) had infertility and 40 (13.3%) had undergone previous endometriosis surgery.

Regarding surgeries performed, 285 (94.7%) patients had laparoscopic surgery while the remaining 16 (5.3%) had a laparotomy performed. All but 3 (1.0%) patients had endometriosis confirmed through surgical visualization. Based on surgical records, we found that 180 (59.8%) patients had endometriomas and 207 (68.8%) DE. Both subtypes were present in 90 (29.9%) patients. Regarding temporal trends, 25.2% of surgeries were performed between 2010 and 2014, 35.2% between 2015 and 2019, and 39.5% between 2020 and 2023.

Transvaginal ultrasound

Out of the 301 patients included in this study, 195 (64.8%) were evaluated with TVUS. The diagnostic performance of TVUS in predicting endometriosis in distinct locations is presented in Table II. Regarding ovarian endometriosis, the sensitivity of TVUS for endometriomas was 95.2% (120/126) (95% CI 91.5-99.0) with specificity of 83.1% (49/59) (95% CI 73.5-92.6); however, regarding DE (both anterior and posterior compartment lesions), only 24 out of 124 patients with surgical findings of DE were correctly diagnosed.

Sonovaginography

A total of 99 (32.9%) patients had an SVG performed, and its diagnostic performance is reported in Table II. Regarding overall DE, SVG correctly identified 74 out of 88 patients who had DE diagnosed during surgery. In the anterior compartment, SVG missed DE in 18 patients which resulted in a sensitivity of 14.3% (3/21) (95% CI 0.0-29.3); however, for the posterior compartment, the overall sensitivity was 83.9% (73/87) (95% CI 76.2-91.6). In this compartment, diagnostic sensitivity of endometriosis was highest for uterine torus, rectovaginal septum and posterior vaginal wall at 73.6% (53/72) (95% CI 63.4-83.8) compared to uterosacral ligaments (37.1% (26/70); 95% CI 25.8-48.5) and intestinal endometriosis (36.4% (16/44); 95% CI 22.2-50.6).

TABLE I. DEMOGRAPHIC CHARACTERISTICS, CLINICAL SYMPTOMS AND SURGICAL FINDINGS.

Patient characteristics	N=301
Age, years, M (SD)	36.6 (6.5)
Weight (N=236), Kg, Med [Q1;Q3]	63.0 [56.0;71.0]
Height (N=188), m, Med [Q1;Q3]	1.63 [1.60;1.67]
BMI (N=178), Kg/m ² , Med [Q1;Q3]	23.9 [21.2;26.6]
Age at menarche (N=195), years, M (SD)	12.2 (1.7)
Gravidity (N=279), Med [Q1;Q3]	1 [0;2]
Parity (N=279), Med [Q1;Q3]	0 [0;1]
Smokers (N=146), n (%)	28 (19.2)
Symptoms	
Dysmenorrhea (N=274), n (%)	189 (69.0)
Deep dyspareunia (N=274), n (%)	123 (44.9)
Infertility (N=279), n (%)	64 (22.9)
Previous endometriosis surgery, n (%)	40 (13.3)
Previous abdominal/pelvic surgery (n=281), n (%)	127 (45.2)
Surgical findings	
Ovarian endometriosis, n (%)	180 (59.8)
Right, n (%)	56 (18.6)
Left, n (%)	75 (24.9)
Bilateral, n (%)	49 (16.3)
Deep endometriosis, n (%)	207 (68.8)
Anterior compartment, n (%)	52 (17.3)
Bladder, n (%)	35 (11.6)
Ureters, n (%)	19 (6.3)
Posterior compartment, n (%)	198 (65.8)
Uterosacral ligaments, n (%)	150 (49.8)
Uterine torus, rectovaginal septum and posterior vaginal wall, n (%)	158 (52.5)
Bowel, n (%)	99 (32.9)
Rectum, n (%)	84 (27.9)
Rectosigmoid transition, n (%)	7 (2.3)
Sigmoid colon, n (%)	29 (9.6)

BMI: body mass index

Comparison of TVUS and SVG – SVG as a complement of TVUS

SVG was used as a complement of TVUS when suspecting DE, as was considered pertinent. For that reason, out of 99 patients who performed gel SVG, 94 also had available records of TVUS. In this smaller group, we compared the diagnostic performance of both ultrasound techniques separately and considering their findings together, as that is more resembling of what happens in clinical practice. Our results can be found in Table III. TVUS alone was more sensitive for endometrioma detection reaching a sensitivity of 95.7% (44/46) (95% CI 89.8-100) and specificity of 91.3%

(42/46) (95% CI 83.2-99.5) while SVG alone was more sensitive for the diagnosis of DE achieving a sensitivity of 83.1% (69/83) (95% CI 75.1-91.2) and specificity of 54.5% (6/11) (95% CI 25.1-84.0).

Magnetic resonance imaging

Amongst our population, 167 (55.5%) patients were evaluated with MRI. The diagnostic performance of this imaging study in diagnosing endometriosis in specific pelvic locations is reported in Table IV. For endometrioma detection, MRI showed a sensitivity of 91.0% (61/67) (95% CI 84.2-97.9) and specificity of 80.5% (62/77) (95% CI 71.7-89.4); for DE, MRI correctly

TABLE II. DIAGNOSTIC PERFORMANCE OF TRANSVAGINAL ULTRASOUND AND SONOVAGINOGRAPHY FOR PREOPERATIVE DIAGNOSIS OF ENDOMETRIOSIS.

Site	TP (n)	FP (n)	TN (n)	FN (n)	N	Sensitivity (95% CI) (%)	Specificity (95% CI) (%)	PPV (95% CI) (%)	NPV (95% CI) (%)	Accuracy (95% CI) (%)
TVUS										
<i>Ovarian endometriosis</i>	120	10	49	6	185	95.2 (91.5-99.0)	83.1 (73.5-92.6)	92.3 (87.7-96.9)	89.1 (80.9-97.3)	91.4 (87.3-95.4)
<i>Deep endometriosis</i>	24	1	38	100	163	19.4 (12.4-26.3)	97.4 (92.5-100)	96.0 (88.3-100)	27.5 (20.1-35.0)	38.0 (30.6-45.5)
<i>Anterior compartment</i>	4	1	122	23	150	14.8 (1.4-28.2)	99.2 (97.6-100)	80.0 (44.9-100)	84.1 (78.2-90.1)	84.0 (78.1-89.9)
Bladder	3	1	128	17	149	15.0 (0.0-30.7)	99.2 (97.7-100)	75.0 (32.6-100)	88.3 (83.0-93.5)	87.9 (82.7-93.2)
Ureters	1	1	137	7	146	12.5 (0.0-35.4)	99.3 (97.9-100)	50.0 (0.0-100)	95.1 (91.6-98.7)	94.5 (90.8-98.2)
<i>Posterior compartment</i>	23	1	44	95	163	19.5 (12.3-26.6)	97.8 (93.5-100)	95.8 (87.8-100)	31.7 (23.9-39.4)	41.1 (33.6-48.7)
Uterosacral ligaments	11	0	62	82	155	11.8 (5.3-18.4)	100 (100-100)	100 (100-100)	43.1 (35.0-51.1)	47.1 (39.2-55.0)
Uterine torus, rectovaginal septum and posterior vaginal wall	17	3	62	75	157	18.5 (10.6-26.4)	95.4 (90.3-100)	85.0 (69.4-100)	45.3 (36.9-53.6)	50.3 (42.5-58.1)
Bowel	6	1	99	48	154	11.1 (2.7-19.5)	99.0 (97.1-100)	85.7 (59.8-100)	67.3 (59.8-74.9)	68.2 (60.8-75.5)
SVG										
<i>Deep endometriosis</i>	74	5	6	14	99	84.1 (76.5-91.7)	54.5 (25.1-84.0)	93.7 (88.3-99.0)	30.0 (9.9-50.1)	80.8 (73.1-88.6)
<i>Anterior compartment</i>	3	3	73	18	97	14.3 (0.0-29.3)	96.1 (91.7-100)	50.0 (10.0-90.0)	80.2 (72.0-88.4)	78.4 (70.2-86.6)
Bladder	2	3	78	13	96	13.3 (0.0-30.5)	96.3 (92.2-100)	40.0 (0.0-82.9)	85.7 (78.5-92.9)	83.3 (75.9-90.8)
Ureters	0	2	85	7	94	0.0 (0.0-0.0)	97.7 (94.6-100)	0.0 (0.0-0.0)	92.4 (87.0-97.8)	90.4 (84.5-96.4)
<i>Posterior compartment</i>	73	6	6	14	99	83.9 (76.2-91.6)	50.0 (21.7-78.3)	92.4 (86.6-98.3)	30.0 (9.9-50.1)	79.8 (71.9-87.7)
Uterosacral ligaments	26	6	19	44	95	37.1 (25.8-48.5)	76.0 (59.3-92.7)	81.3 (67.7-94.8)	30.2 (18.8-41.5)	47.4 (37.3-57.4)
Uterine torus, rectovaginal septum and posterior vaginal wall	53	15	10	19	97	73.6 (63.4-83.8)	40.0 (20.8-59.2)	77.9 (68.1-87.8)	34.5 (17.2-51.8)	64.9 (55.5-74.4)
Bowel	16	5	49	28	98	36.4 (22.2-50.6)	90.7 (83.0-98.5)	76.2 (58.0-94.4)	63.6 (52.9-74.4)	66.3 (57.0-75.7)

TP: true positive; FP: false positive; TN: true negative; FN: false negative; PPV: positive predictive value; NPV: negative predictive value

TABLE III. DIAGNOSTIC PERFORMANCE OF TVUS, SVG AND TVUS+SVG FOR PREOPERATIVE DIAGNOSIS OF ENDOMETRIOSIS.

Site		TVUS	SVG	p	TVUS+SVG
<i>Ovarian endometriosis</i>	Sens	95.7 (89.8-100)	78.3 (66.3-90.2)	0.002	95.7 (89.8-100)
	Spec	91.3 (83.2-99.5)	95.7 (89.8-100)		91.3 (83.2-99.5)
<i>Deep endometriosis</i>	Sens	3.6 (0.0-7.6)	83.1 (75.1-91.2)	<0.001	83.1 (75.1-91.2)
	Spec	90.9 (73.9-100)	54.5 (25.1-84.0)		54.5 (25.1-84.0)
<i>Anterior compartment</i>	Sens	0.0 (0.0-0.0)	10.5 (0.0-24.3)	0.125	10.5 (0.0-24.3)
	Spec	98.6 (96.0-100)	95.9 (91.5-100)		95.9 (91.5-100)
Bladder	Sens	0.0 (0.0-0.0)	7.1 (0.0-20.6)	0.250	7.1 (0.0-20.6)
	Spec	98.7 (96.3-100)	96.2 (92.0-100)		96.2 (92.0-100)
Ureters	Sens	0.0 (0.0-0.0)	0.0 (0.0-0.0)	1.000	0.0 (0.0-0.0)
	Spec	98.8 (96.5-100)	97.6 (94.4-100)		97.6 (94.4-100)
<i>Posterior compartment</i>	Sens	3.7 (0.0-7.7)	82.9 (74.8-91.1)	<0.001	82.9 (74.8-91.1)
	Spec	91.7 (76.0-100)	50.0 (21.7-78.3)		50.0 (21.7-78.3)
Uterosacral ligaments	Sens	1.5 (0.0-4.4)	37.3 (25.7-48.9)	<0.001	37.3 (25.7-48.9)
	Spec	100 (100-100)	76.0 (59.3-92.7)		76.0 (59.3-92.7)
Uterine torus, rectovaginal septum and posterior vaginal wall	Sens	4.4 (0.0-9.3)	72.1 (61.4-82.7)	<0.001	72.1 (61.4-82.7)
	Spec	96.0 (88.3-100)	40.0 (20.8-59.2)		40.0 (20.8-59.2)
Bowel	Sens	2.4 (0.0-7.2)	34.1 (19.6-48.7)	<0.001	34.1 (19.6-48.7)
	Spec	100 (100-100)	90.4 (82.4-98.4)		90.4 (82.4-98.4)

Data reported as % (95% CI). Sens: Sensitivity; Spec: Specificity

diagnosed 131 patients with a sensitivity of 90.3% (131/145) (95% CI 85.5-95.2) and specificity of 60.0% (9/15) (95% CI 35.2-84.8). MRI had lower sensitivity and higher specificity in the anterior compartment in contrast to the posterior compartment.

Ovarian Endometriosis – Comparison of TVUS and MRI

In an effort to compare the performance of TVUS and MRI in diagnosing ovarian endometriosis, we analyzed the 91 patients who had both exams performed preoperatively. In this group, 51 (56.0%) patients had ovarian endometriomas according to surgery. We found that they performed similarly as sensitivity and specificity were 90.2% (46/51) (95% CI 82.0-98.4) and 87.5 % (35/40) (95% CI 77.3-97.8) for TVUS and 94.1% (48/51) (95% CI 87.7-100) and 77.5% (31/40) for MRI (95% CI 64.6-90.4), respectively (Table V).

Deep Endometriosis – Comparison of SVG and MRI

In the same way, for comparison of the diagnostic ac-

curacy of SVG and MRI in identifying DE lesions, we analyzed the patients who undertook both these tests prior to surgery. Out of 49 patients, all except for 2 (4.1%) had DE upon surgical evaluation. Lesions were observed in the posterior compartment of all the patients and 12 (24.5%) of them had simultaneous findings of DE in the anterior compartment. In Table V we summarize the diagnostic performance of SVG and MRI in this group of patients.

In both exams, each patient without DE was classified as having it on the posterior compartment and for this reason, specificity for this location was 0.0%. Considering overall DE, MRI and SVG performed similarly. Only for the detection of lesions on the uterosacral ligaments, MRI appeared to be slightly more sensitive with 63.4% (26/41) (95% CI 48.7-78.2) compared to 31.7% (13/41) (95% CI 17.5-46.0) when using SVG.

DISCUSSION

In this study, we analyzed the diagnostic accuracy of

TABLE IV. DIAGNOSTIC PERFORMANCE OF MAGNETIC RESONANCE IMAGING FOR PREOPERATIVE DIAGNOSIS OF ENDOMETRIOSIS.

Site	TP (n)	FP (n)	TN (n)	FN (n)	N	Sensitivity (95% CI) (%)	Specificity (95% CI) (%)	PPV (95% CI) (%)	NPV (95% CI) (%)	Accuracy (95% CI) (%)
Ovarian endometriosis	61	15	62	6	144	91.0 (84.2-97.9)	80.5 (71.7-89.4)	80.3 (71.3-89.2)	91.2 (84.4-97.9)	85.4 (79.7-91.2)
Deep endometriosis	131	6	9	14	160	90.3 (85.5-95.2)	60.0 (35.2-84.8)	95.6 (92.2-99.1)	39.1 (19.2-59.1)	87.5 (82.4-92.6)
Anterior compartment	20	5	101	12	138	62.5 (45.7-79.3)	95.3 (91.3-99.3)	80.0 (64.3-95.7)	89.4 (83.7-95.1)	87.7 (82.2-93.2)
Bladder	15	5	108	8	136	65.2 (45.8-84.7)	95.6 (91.8-99.4)	75.0 (56.0-94.0)	93.1 (88.5-97.7)	90.4 (85.5-95.4)
Ureters	3	3	118	8	132	27.3 (1.0-53.6)	97.5 (94.8-100)	50.0 (10.0-90.0)	93.7 (89.4-97.9)	91.7 (87.0-96.4)
Posterior compartment	127	9	9	15	160	89.4 (84.4-94.5)	50.0 (26.9-73.1)	93.4 (89.2-97.6)	37.5 (18.1-56.9)	85.0 (79.5-90.5)
Uterosacral ligaments	68	11	31	28	138	70.8 (61.7-79.9)	73.8 (60.5-87.1)	86.1 (78.4-93.7)	52.5 (39.8-65.3)	71.7 (64.2-79.3)
Uterine torus, rectovaginal septum and posterior vaginal wall	101	21	19	15	156	87.1 (81.0-93.2)	47.5 (32.0-63.0)	82.8 (76.1-89.5)	55.9 (39.2-72.6)	76.9 (70.3-83.5)
Bowel	50	3	65	23	143	66.7 (56.0-77.3)	95.6 (90.7-100)	94.3 (88.1-100)	72.2 (63.0-81.5)	80.4 (73.9-86.9)

TP: true positive; FP: false positive; TN: true negative; FN: false negative; PPV: positive predictive value; NPV: negative predictive value

TVUS, SVG and MRI, three widely used imaging exams for the diagnosis of endometriosis. Their diagnostic performance varies across published literature as these are all dependent on operator or interpreter experience.

TVUS and pelvic MRI were highly accurate for the diagnosis of ovarian endometriosis. Our results align with those from a recent systematic review which reported a sensitivity of 70.86-96% and specificity of 71-96% for TVUS as well as a sensitivity of 76.9-94% and specificity of 71-93.9% for MRI¹⁹. Even though our study was retrospective, our ultrasound results for endometrioma detection also match those from a recent multi-center prospective study, strengthening our findings²⁰. Regarding DE detection using TVUS, our results for its diagnostic sensitivity are lower than reported in the mentioned studies which we attribute to their more robust prospective methodology. Furthermore, as this center regularly uses SVG for DE assessment, TVUS reports may be less descriptive for these kinds of lesions. We attribute this lower-than-expected result to these factors, as well as to others such as the lengthy data collection period. Over the past decade, substantial research and innovation have driven major advances in imaging technology and more standardised reporting practices. In the future, it would be interesting to investigate the extent to which these developments, such as IDEA group consensus adoption, since its publication may have impacted diagnostic acuity of TVUS over time in

TABLE V. DIAGNOSTIC PERFORMANCE OF TVUS AND MRI FOR PREOPERATIVE DIAGNOSIS OF OVARIAN ENDOMETRIOSIS AND DIAGNOSTIC PERFORMANCE OF SVG AND MRI FOR PREOPERATIVE DIAGNOSIS OF DEEP ENDOMETRIOSIS.

Site		TVUS	MRI	p
<i>Ovarian endometriosis (N=91)</i>	Sens	90.2 (82.0-98.4)	94.1 (87.7-100)	0.146
	Spec	87.5 (77.3-97.8)	77.5 (64.6-90.4)	
		SVG	RM	
<i>Deep endometriosis (N=49)</i>	Sens	89.4 (80.6-98.2)	85.1 (74.9-95.3)	0.774
	Spec	0 (0.0-0.0)	0.0 (0.0-0.0)	
<i>Anterior compartment</i>	Sens	16.7 (0.0-37.8)	50.0 (21.7-78.3)	0.453
	Spec	94.6 (87.3-100)	97.3 (92.1-100)	
Bladder	Sens	10.0 (0.0-28.6)	50.0 (19.0-81.0)	0.219
	Spec	94.9 (88.0-100)	94.9 (88.0-100)	
Ureters	Sens	0 (0.0-0.0)	0.0 (0.0-0.0)	0.500
	Spec	95.5 (89.3-100)	100 (100-100)	
<i>Posterior compartment</i>	Sens	89.4 (80.6-98.2)	85.1 (74.9-95.3)	0.774
	Spec	0 (0.0-0.0)	0.0 (0.0-0.0)	
Uterosacral ligaments	Sens	31.7 (17.5-46.0)	63.4 (48.7-78.2)	0.043
	Spec	57.1 (20.5-93.8)	85.7 (59.8-100)	
Uterine torus, rectovaginal septum and posterior vaginal wall	Sens	73.7 (59.7-87.7)	78.9 (66.0-91.9)	1.000
	Spec	10.0 (0.0-28.6)	20.0 (0.0-44.8)	
Bowel	Sens	50.0 (30.8-69.2)	69.2 (51.5-87.0)	1.000
	Spec	82.6 (67.1-98.1)	100 (100-100)	

Data reported as % (95% CI). Sens: Sensitivity; Spec: Specificity

our centre. As with any operator-dependent imaging exam we are also always conditioned by possible technical errors, which can introduce variability. Nonetheless, the specificity of TVUS for DE detection was high, suggesting that a positive result is highly indicative of DE but a negative finding does not exclude it, in line with the most recent ESHRE guidelines for diagnostic imaging⁴.

SVG showed good diagnostic accuracy for overall DE although, when considering specific sites, it was lower than what is described in the literature¹⁵. Barra et al obtained a sensitivity of 89.4% and specificity of 79.4% for posterior DE using gel SVG while our sensitivity was 83.9% and specificity of 50.0% for the same location²¹. Our lack of specificity seems to be mainly driven by higher false positive rates for endometriosis in the uterine torus, rectovaginal septum and posterior vaginal wall. Even though we have a good detection rate for overall lesions, this lack of specificity means that there is still an opportunity to improve with this

diagnostic tool. Based on our comparison of the diagnostic accuracy of TVUS and SVG, we do believe we can conclude that, by performing these exams simultaneously as a routine, our rates of detection of ovarian endometriosis (sensitivity 95.7% (95%CI 89.8-100) and specificity 91.3% (95%CI 83.2-99.5)) and DE (sensitivity 83.1% (95%CI 75.1-91.2) and specificity 54.5% (95%CI 25.1-84.0)) are reassuring for our patients.

For overall DE diagnosis by MRI, we obtained a sensitivity of 90.3% (95%CI 85.5-95.2) and specificity of 60.0% (95%CI 35.2-84.8) which is quite comparable to what Nisenblat et al reported of overall sensitivity of 94% (95%CI 90-97) and specificity of 77% (95%CI 44-100%)¹⁷. Similarly to SVG, our specificity was worse particularly due to higher false positive rates for the uterine torus, rectovaginal septum and posterior vaginal wall. When focusing on specific locations, we obtained slightly worse results than those described in the literature^{8,17,22}. This suggests that while MRI shows

an adequate overall accuracy for diagnosing DE, there is room for optimizing its performance at specific site detection of lesions to help achieve a more precise mapping of the disease.

Regarding the anterior compartment, the lower prevalence of disease limits the interpretation of our results. Reassuringly, the high specificity found in both SVG and MRI, allows us to be confident when disease is diagnosed in these exams.

In the direct comparison between SVG and MRI, results were quite similar. However, for disease in the uterosacral ligaments, MRI seems to have a higher sensitivity with similar specificity to SVG. This means that, in cases with high clinical suspicion of disease in this location, MRI seems to have an important role.

Ultrasound has several advantages to MRI, such as being a dynamic, innocuous and cost-effective exam. As such, its role as a first-line modality for screening and diagnosis of endometriosis is well established¹⁰. TVUS serves a purpose beyond being a diagnostic test, as it can help to understand the extent and site of lesions by taking into consideration real-time tenderness and mobility of the structures, giving an idea about the existence of adhesions and obliteration of the pelvic pouches⁷. However, it relies extensively on the operator's experience and its images cannot be adequately reviewed after the examination by other clinicians. Furthermore, TVUS may be refused or impossible to perform in some patients. On the other hand, MRI provides accurate identification of endometriotic lesions, particularly in the posterior compartment and some major benefits of its use are the simultaneous multiple plane assessment and its capability to allow the retrospective review of images, which is most useful for preoperative workup⁹. Moreover, it allows the examination of organs and regions not accessible to the ultrasound probe.

We identify several limitations in this study. Firstly, we have limitations inherent to the retrospective design of the study and the use of medical records, thus our results rely on the quality and quantity of information recorded. Additionally, the time interval between performing the different tests was not considered. This could result in the disease progressing while patients were undergoing various imaging exams or awaiting surgery, leading to an underestimation of the results. Despite the fact that visual inspection of lesions

during surgery is not fully specific, we also did not consider histopathology as an additional reference standard, as our reports did not have sufficient quality, even though the specimens were adequately marked during surgery. The use of the same operators for both TVUS and SVG reduces inter-operator variability but may introduce incorporation bias when both exams are performed by the same clinician. By contrast, the limited number of scans performed by other clinicians could also contribute to discrepancies in findings. Besides, even though the majority of the TVUS and SVG were performed by the same 2 ultrasonographers, not all MRIs were performed by the same radiologists; however, from 2020, even the exams performed outside of the hospital could be reviewed by a multidisciplinary team, minimizing this limitation. Furthermore, clinicians were not blinded to the patient's clinical history, which can introduce heterogeneity in our data although it better reflects day-to-day practice. Lastly, this study may be subject to patient selection bias as it only includes women who underwent surgery for endometriosis diagnosis and treatment.

Finally, some key strengths of our study are its large sample of patients from 14 years of clinical care in a center with an experienced team in dealing with diagnosing and treating this disease. The imaging exams performed in this hospital are standardly described to ensure a complete and comprehensive evaluation and surgeries were performed mainly by the same team.

In conclusion, our results suggest that TVUS is highly accurate for the diagnosis of ovarian endometriosis and remains the cornerstone imaging modality for this condition. Both SVG and MRI showed similar performance in diagnosing deep endometriosis and stand as reliable diagnostic tools. Lesions in the uterosacral ligaments were best identified by MRI, making it an important auxiliary exam. Rather than being equivalent modalities, SVG and MRI should be viewed as complementary techniques that enhance our understanding of deep lesions and help us optimize surgical planning.

REFERENCES

1. Tomassetti C, Johnson NP, Petrozza J, Abrao MS, Einarsson JJ, Horne AW, et al. An international terminology for endometriosis, 2021(). *Hum Reprod Open*. 2021;2021(4):hoab029.

2. Shafir AL, Farland LV, Shah DK, Harris HR, Kvaskoff M, Zondervan K, et al. Risk for and consequences of endometriosis: A critical epidemiologic review. *Best Pract Res Clin Obstet Gynaecol.* 2018;51:1-15.
3. Allaire C, Bedaiwy MA, Yong PJ. Diagnosis and management of endometriosis. *Cmaj.* 2023;195(10):E363-e71.
4. Becker CM, Bokor A, Heikinheimo O, Horne A, Jansen F, Kiesel L, et al. ESHRE guideline: endometriosis. *Hum Reprod Open.* 2022;2022(2):hoac009.
5. Kiesel L, Sourouni M. Diagnosis of endometriosis in the 21st century. *Climacteric.* 2019;22(3):296-302.
6. Zondervan KT, Becker CM, Missmer SA. Endometriosis. *N Engl J Med.* 2020;382(13):1244-56.
7. Pascoal E, Wessels JM, Aas-Eng MK, Abrao MS, Condous G, Jurkovic D, et al. Strengths and limitations of diagnostic tools for endometriosis and relevance in diagnostic test accuracy research. *Ultrasound Obstet Gynecol.* 2022;60(3):309-27.
8. Guerriero S, Saba L, Pascual MA, Ajossa S, Rodriguez I, Mais V, et al. Transvaginal ultrasound vs magnetic resonance imaging for diagnosing deep infiltrating endometriosis: systematic review and meta-analysis. *Ultrasound Obstet Gynecol.* 2018;51(5):586-95.
9. Quesada J, Härmä K, Reid S, Rao T, Lo G, Yang N, et al. Endometriosis: A multimodal imaging review. *Eur J Radiol.* 2023;158:110610.
10. Piketty M, Chopin N, Dousset B, Millischer-Bellaische AE, Roseau G, Leconte M, et al. Preoperative work-up for patients with deeply infiltrating endometriosis: transvaginal ultrasonography must definitely be the first-line imaging examination. *Hum Reprod.* 2009;24(3):602-7.
11. Guerriero S, Condous G, van den Bosch T, Valentin L, Leone FP, Van Schoubroeck D, et al. Systematic approach to sonographic evaluation of the pelvis in women with suspected endometriosis, including terms, definitions and measurements: a consensus opinion from the International Deep Endometriosis Analysis (IDEA) group. *Ultrasound Obstet Gynecol.* 2016;48(3):318-32.
12. Daniilidis A, Grigoriadis G, Dalakoura D, D'Alterio MN, Angioni S, Roman H. Transvaginal Ultrasound in the Diagnosis and Assessment of Endometriosis-An Overview: How, Why, and When. *Diagnostics (Basel).* 2022;12(12).
13. Dessole S, Farina M, Rubattu G, Cosmi E, Ambrosini G, Nardelli GB. Sonovaginography is a new technique for assessing rectovaginal endometriosis. *Fertil Steril.* 2003;79(4):1023-7.
14. Reid S, Lu C, Hardy N, Casikar I, Reid G, Cario G, et al. Office gel sonovaginography for the prediction of posterior deep infiltrating endometriosis: a multicenter prospective observational study. *Ultrasound Obstet Gynecol.* 2014;44(6):710-8.
15. Arezzo F, Cormio G, La Forgia D, Kawosha AA, Mongelli M, Putino C, et al. The Application of Sonovaginography for Implementing Ultrasound Assessment of Endometriosis and Other Gynaecological Diseases. *Diagnostics (Basel).* 2022;12(4).
16. Bazot M, Bharwani N, Huchon C, Kinkel K, Cunha TM, Guerra A, et al. European society of urogenital radiology (ESUR) guidelines: MR imaging of pelvic endometriosis. *Eur Radiol.* 2017;27(7):2765-75.
17. Nisenblat V, Bossuyt PM, Farquhar C, Johnson N, Hull ML. Imaging modalities for the non-invasive diagnosis of endometriosis. *Cochrane Database Syst Rev.* 2016;2(2):Cd009591.
18. Timmerman D, Valentin L, Bourne TH, Collins WP, Verrelst H, Vergote I. Terms, definitions and measurements to describe the sonographic features of adnexal tumors: a consensus opinion from the International Ovarian Tumor Analysis (IOTA) Group. *Ultrasound Obstet Gynecol.* 2000;16(5):500-5.
19. Bauic A, Coroleuc C, Coroleuc C, Comandău D, Matasariu R, Manu A, et al. Transvaginal Ultrasound vs. Magnetic Resonance Imaging (MRI) Value in Endometriosis Diagnosis. *Diagnostics (Basel).* 2022;12(7).
20. Leonardi M, Uzuner C, Mestdagh W, Lu C, Guerriero S, Zajick M, et al. Diagnostic accuracy of transvaginal ultrasound for detection of endometriosis using International Deep Endometriosis Analysis (IDEA) approach: prospective international pilot study. *Ultrasound Obstet Gynecol.* 2022;60(3):404-13.
21. Barra F, Leone Roberti Maggiore U, Evangelisti G, Scala C, Alessandri F, Vellone VG, et al. A prospective study comparing rectal water contrast-transvaginal ultrasonography with sonovaginography for the diagnosis of deep posterior endometriosis. *Acta Obstet Gynecol Scand.* 2021;100(9):1700-11.
22. Indrielle-Kelly T, Frühauf F, Fanta M, Burgetova A, Lavu D, Dunder P, et al. Diagnostic Accuracy of Ultrasound and MRI in the Mapping of Deep Pelvic Endometriosis Using the International Deep Endometriosis Analysis (IDEA) Consensus. *Biomed Res Int.* 2020;2020:3583989.

AUTHOR CONTRIBUTIONS

Eva Paiva: Conceptualization, Investigation, Methodology, Project administration, Visualisation, Writing – original draft. Ana Mafalda da Costa Castro Neves: Resources, Validation, Writing – review & editing. Pedro Viana Pinto: Conceptualization, Investigation, Methodology, Project administration, Visualization, Writing – original draft. Ana Margarida Póvoa: Resources, Validation, Writing – review & editing. Andreia Teixeira: Resources, Validation, Writing – review & editing.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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