Can Enhanced Techniques Improve the Diagnostic Accuracy of Transvaginal Sonography and Magnetic Resonance Imaging for Rectosigmoid Endometriosis? A Systematic Review and Meta-analysis

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Abstract

Objective: Our aim was to perform a systematic review and meta-analysis of the most commonly used examinations for rectosigmoid lesions of deeply infiltrating endometriosis, transvaginal sonography (TVS) and magnetic resonance imaging (MRI), to compare their diagnostic accuracy and enhanced or non-enhanced techniques.

Methods: A systematic search was performed until March 2018 without time or language restrictions. Eligibility criteria included studies that compared the accuracy of TVS and MRI for diagnosis of rectosigmoid endometriosis. The quality of the studies was assessed by means of Quality Assessment of Diagnostic Accuracy Studies-2 and Preferred Reporting Items for Systematic Reviews and Meta-Analyses recommendations. Bivariate and hierarchical analysis were performed. The difference in the accuracy of TVS and MRI was tested, and heterogeneity was addressed by means of meta-regression, sensitivity, or subgroup analysis.

Results: A total of 1754 studies were screened; 105 studies were eligible, and 11 studies were included in the meta-analysis. Overall pooled sensitivity, specificity, and area under the receiver operating characteristic curve were 0.80, 0.94, and 0.95, respectively. The measures for MRI were 0.82, 0.94, and 0.95, respectively. There was no statistical difference between the accuracy values of TVS and MRI ($P = 0.90$). The use of bowel preparation and vaginal contrast could enhance the accuracy of MRI. Along with rectosigmoid prevalence, bowel and vaginal contrast explained a significant proportion of the statistical heterogeneity.

Conclusions: Both TVS and MRI showed high diagnostic accuracy for rectosigmoid deeply infiltrating endometriosis lesions. There is no strong evidence suggesting that the two diagnostic methods might differ in specificity or sensitivity, but enhanced techniques may increase the accuracy measures.

Key Words: Endometriosis, systematic review, meta-analysis, ultrasound, magnetic resonance

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Résumé

Objectif : L'objectif était de réaliser une revue systématique et une méta-analyse des examens les plus couramment utilisés pour diagnostiquer les lésions rectosigmoïdiennes d'une infiltration endométriosique profonde, soit l'échographie transvaginale (ETV) et l'imagerie par résonance magnétique (IRM), afin de comparer leur exactitude diagnostique et leur utilisation avec ou sans produit de contraste.

Méthodologie : Une recherche systématique a été réalisée jusqu'à mars 2018, sans restriction de temps ni de langue. Les critères d'admissibilité comprenaient les études comparant l'exactitude de l'ETV et de l'IRM pour diagnostiquer l'endométriose rectosigmoïdienne. On a évalué la qualité des études au moyen de l'outil QUADAS-2 (*Quality Assessment of Diagnostic Accuracy Studies-2*) et des recommandations PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*). Des analyses bivariées et hiérarchiques ont été réalisées. On a ensuite examiné la différence de l'exactitude entre l'ETV et l'IRM, puis on a traité l'hétérogénéité au moyen d'analyses de méta-régression, de sensibilité ou de sous-groupe.

Résultats : Au total, 1 754 études ont été recensées; 105 étaient admissibles, et 11 ont fait partie de la méta-analyse. La mise en commun globale de la sensibilité, de la spécificité et de l'aire sous la courbe ROC (*receiver operating characteristic*) était respectivement de 0,80, 0,94 et 0,95. Les mesures pour l'IRM étaient respectivement de 0,82, 0,94 et 0,95. On n'a observé aucune différence statistique entre les valeurs d'exactitude de l'ETV et de l'IRM (P = 0,90). La préparation du côlon et le produit de contraste vaginal peuvent amplifier l'exactitude de l'IRM. Parallèlement à la prévalence des lésions rectosigmoïdes, l'utilisation de produit de contraste colique et vaginal explique une partie importante de l'hétérogénéité statistique.

Conclusions : L'ETV et l'IRM ont toutes deux montré une grande exactitude dans le diagnostic de lésions rectosigmoïdiennes d'une infiltration endométriosique profonde. On ne relève aucune donnée probante solide indiquant que les deux méthodes diagnostiques pourraient présenter des différences relatives à la spécificité ou à la sensibilité, mais l'utilisation de produit de contraste peut améliorer les mesures d'exactitude.

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INTRODUCTION

Endometriosis affects up to 10% of reproductive-age women, and its symptoms can have a negative impact on various aspects of women's lives. Pain from deeply infiltrating endometriosis (DIE) constitutes a challenge for both patients and gynaecologists in determining whether to pursue medical or surgical treatment.[1]

Accurate identification of the location and extension of lesions is important for surgical treatment, especially in women with bowel and rectal involvement, which may require resection of an intestinal segment. Complete removal of the lesions improves patients' quality of life; however, this procedure must be performed by an experienced multidisciplinary surgical staff because of possible complications.[1]

The accuracy of preoperative testing plays an important role in developing strategies for expectant or surgical treatment, and several imaging methods have been used for this purpose. Magnetic resonance imaging (MRI) of the pelvis and transvaginal sonography (TVS) are widely accessible and exhibit adequate accuracy.[2,3]

Usually, TVS accesses the lower intestinal lesions at the rectum, sigmoid colon, and rectosigmoid transition.[4] The accuracy of TVS varies widely,[5] and its precision may increase with the use of enhanced techniques, such as bowel preparation,[3,6] rectal[7] or vaginal contrast agents,[8] tenderness-guided technique,[9] and three-dimensional imaging.[5,9] Conversely, measures of the accuracy of MRI have exhibited little variation,[10] and similar resources may be used to enhance test precision.[7,11] In the ideal situation, both TVS and MRI would be performed during the preoperative assessment of DIE to plan the rectosigmoid surgery thoroughly[12]; however, clinical practitioners and surgeons have little opportunity to do so in either the private or the public setting. Test cost-effectiveness has yet to be better addressed.[7,11] Furthermore, some technical, economic, and health care conditions may determine access to MRI or TVS. Availability of these imaging modalities can also be influenced by their required learning curve: up to 75 scans[13] for DIE diagnosis by TVS and an estimated at 24 months[14] for MRI. Thus, the operator's aptitude may affect the accuracy of TVS and MRI.

Although not all patients undergo surgery, the diagnostic gold standard of DIE is intraoperative and histological confirmation of disease. Nevertheless, some investigators[2,8] advocate considering cul-de-sac obliteration at laparoscopy for DIE, regardless of whether surgical resection has been performed.

Some systematic reviews have been conducted on the accuracy of TVS and MRI for rectosigmoid lesions; however, considerable controversy persists regarding the use of enhanced techniques, especially in the case of lesions located at the rectum and sigmoid bowel.[5,10,15–17] Available evidence does not clarify the role of vaginal and bowel contrast media and preparation, nor does it fully explore the causes of the heterogeneity found in the previous analyses.[5,10,15–17] It is necessary to demonstrate whether there is a difference in the accuracy of these two methods and between their enhancing techniques to recommend the use of the most precise method, or alternatively, to determine whether their accuracy is similar and they can be used interchangeably.

Therefore, the aim of the present review was to perform a systematic analysis and meta-analysis comparing the

accuracy of TVS and MRI and their enhancing techniques for the diagnosis of rectosigmoid endometriosis.

MATERIALS AND METHODS

A systematic searched was performed for studies comparing the accuracy of TVS and MRI for the diagnosis of DIE affecting the rectum or rectosigmoid area in the same population.

Protocol and Registration

This systematic review was prospectively registered at PROSPERO (identification number: CRD42015025557) and followed the criteria recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[18,19] The criteria for selection, data extraction, assessment of quality, and possible factors of heterogeneity were pre-defined.

Eligibility Criteria

Study design

Studies, either of prospective or retrospective design, were eligible if index tests were carried out before the reference standard. Case-control, pilot, or experimental studies, chapters in books, comments, letters to editors, reviews, or case reports were excluded. Inclusion and exclusion criteria are presented in online Table 1.

Participants

The research question for the present systematic review concerned studies that included women of reproductive age with clinical suspicion of rectosigmoid DIE and who underwent both TVS and MRI as preoperative diagnostic tests.

Index tests

TVS and MRI of the pelvis were considered as "index tests" and should have been performed before the reference standard. Differences within tests related to the use of enhanced techniques (such as bowel preparation, enema, bowel or vaginal water, or gel contrast medium) were taken into consideration for further evaluation by subgroup analysis. Regarding TVS evaluation, other technologies besides two-dimensional TVS were not included because of disparities of imaging quality.

Reference standard

Surgical and histological findings were the "reference standard" for a rectosigmoid endometriosis diagnosis. Studies in which surgery was not performed were excluded. Time elapsed between index tests and the reference standard was registered but was not considered an exclusion criterion because of the lagging evolution of the disease.[16]

Target condition and outcome

The target condition was DIE located at the rectum or rectosigmoid area. Although "bowel endometriosis" is an expression commonly used to address those locations, lesions located higher than the rectosigmoid transition can hardly be detected with many imaging tests and did not fall within the scope of our investigation.

Electronic Searches

A systematic search was conducted from May 24, 2015 to June 9, 2015, and it was updated from February 16, 2018 to March 4, 2018, using Medline (PubMed), Cochrane, and EMBASE, as well as secondary databases (online Table 2). A manual search was performed on selected studies and references from prior reviews. The search had no restrictions regarding time period, language, or study size.

Search strategy

The search strategy included Medical Subject Headings (MeSH) or Descriptors for Health Sciences (DECS) terms and corresponding derivatives and synonyms. The strategy used for the Medline (PubMed) database is presented in online Figure 1.

Selection criteria

Terms such as "deeply infiltrating endometriosis," "rectal endometriosis," "rectosigmoid endometriosis," "bowel endometriosis," or "intestinal endometriosis" were used to specify the outcome location.

Selection

The selection and assessment of the quality of the studies were independently performed by two investigators (A.M.G.P. and V.S.C.B.) and were updated (A.M.G.P. and M.S.R.C.) until April 8, 2018 with Rayyan software.[20]

Data extraction

Whenever the same research center or investigators were found to have published two or more studies, we sought to establish whether the same population sample had been used through analysis of the reported data or by directly contacting the authors; in such circumstances, the most recent and complete studies were included.[2,7,9,21,22] These investigators were also contacted in case of lack of reported data. The variables considered for data extraction are presented in Table 1 and online Table 3.

Table 1. Characteristics of the eligible studies

Studies (first author)	Year of publication	Country of origin	Study design	Sample size, n	Mean or median age	Recto-sigmoid DIE, %	TVS technique	MRI technique
Abrão	2007	Brazil	Prospective	104	33.8	51.9	B	V
Alborzi	2018	Iran	Prospective	317	31	16,4	B	V
Andrade[a]	2014	Portugal	Retrospective	124*	34	30.8	V	B
Bazot	2009	France	Retrospective	92	31.8	68.5	N	B
Carbognin	2006	Italy	Prospective	32	33	50	B	B
Cazalis	2012	France	Retrospective	25	35.4	76	N	B
Guerriero	2018	Italy	Prospective	159	33	41,5	V	B
Maggiore	2017	Italy	Prospective	286	31.9	52.8	B	B
Mangler [a]	2013	Germany	Prospective	79*	34	60.8	N	N
Saccardi	2012	Italy	Prospective	54	32.3	11.1	V	V
Vimercati	2012	Italy	Prospective	90	34.3	20	N	B

[a] Studies with smaller number of participants in group MRI; the data correspond to the participants in group TVS.

B: bowel preparation/contrast; DIE: deep infiltrating endometriosis; MRI: magnetic resonance imaging; N: no contrast or preparation; TVS: transvaginal sonography; V: vaginal contrast.

Risk of Bias Assessment

Risk of bias of the included studies was evaluated by the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) and was addressed independently by two authors (A.M.G.P. and E.M.C.).[23]

Statistical Analysis

We applied both the bivariate and the hierarchical summary receiver-operating characteristic (HSROC) models to obtain pooled accuracy measures along with their 95% confidence intervals (CIs). Summary ROC curves presented the 95% confidence regions as well as prediction regions around the summary point. The heterogeneity of the pooled sensitivity and specificity measures was assessed by means of Cochran's Q test (P_Q), in which $P < 0.10$ was indicative of heterogeneity. In addition, the I^2 statistic was used; values greater than 50% were considered to represent high heterogeneity. Funnel plots and Deeks' test were used to assess small-study biases.

Covariables were considered for additional analysis through meta-regression, subgroup, and sensitivity analyses because they could represent sources of statistical heterogeneity. Differences between the examinations were tested by means of bivariate analysis as recommended by the Cochrane handbook for meta-analysis for accuracy data.[24]

Bivariate analysis, hierarchical models, and summary ROC curves were performed using the Stata (data analysis and statistical software) version 12.0 (StataCorp, College Station, TX). To conduct bivariate comparison, subgroup analysis, and meta-regression, we used R for Windows software version 3.2.2 (The R Project for Statistical Computing, Vienna, Austria).

Overall Quality of the Body of Evidence

Analysis of the level of evidence was performed according to the Grading of Recommendations Assessment, Development and Evaluation (GRADE) criteria.[25]

RESULTS

Results of the Search

The systematic search retrieved 1754 articles, of which 301 were duplicates and were excluded. Figure 1 depicts the flow chart of study selection.

Included Studies

Included studies[2,3,6,7–9,11,21,22,26,27] were published between 2006 and 2018, and their sample size ranged from 25 to 317 participants. Summarized characteristics of the studies are described in Table 1.

Risk of Bias in Included Studies

The methodological quality of the primary studies is depicted in Figures 2 and 3.

Accuracy of Transvaginal Sonography

The bivariate model revealed a summary sensitivity of 0.80 (95% CI 0.62–0.91), and the summary specificity was 0.94 (95% CI 0.87–0.97), with strong evidence of statistical heterogeneity in both measures ($I^2 = 94.6\%$ with $P < 0.001$ and $I^2 = 89.9\%$ with $P < 0.001$ of Cochran's Q test,

Figure 1. Study flow chart.

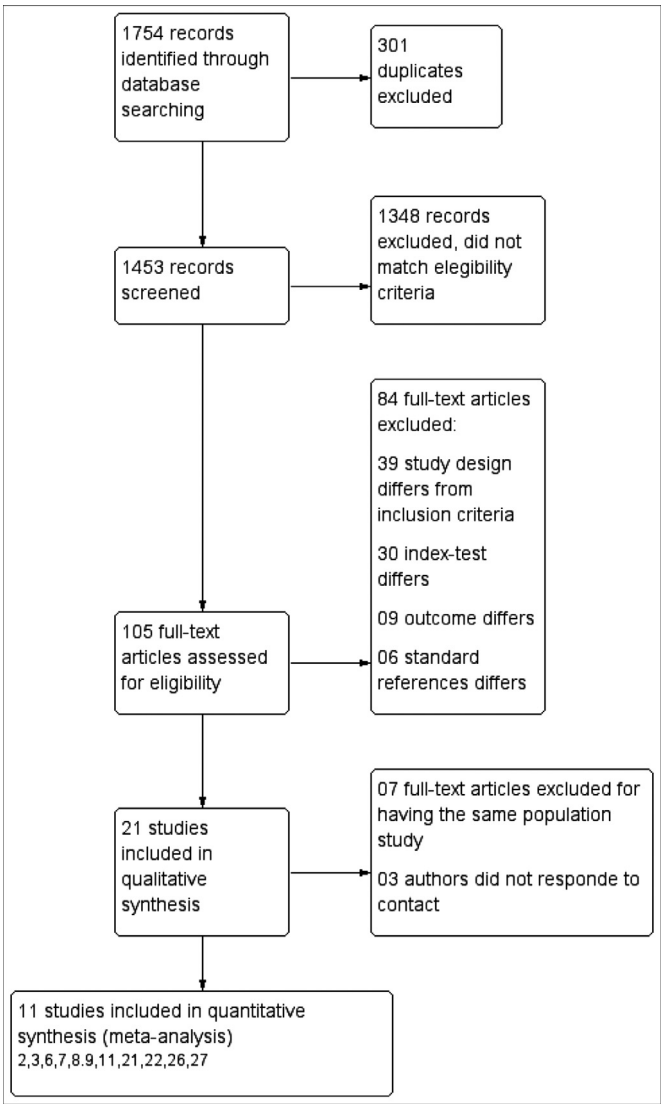
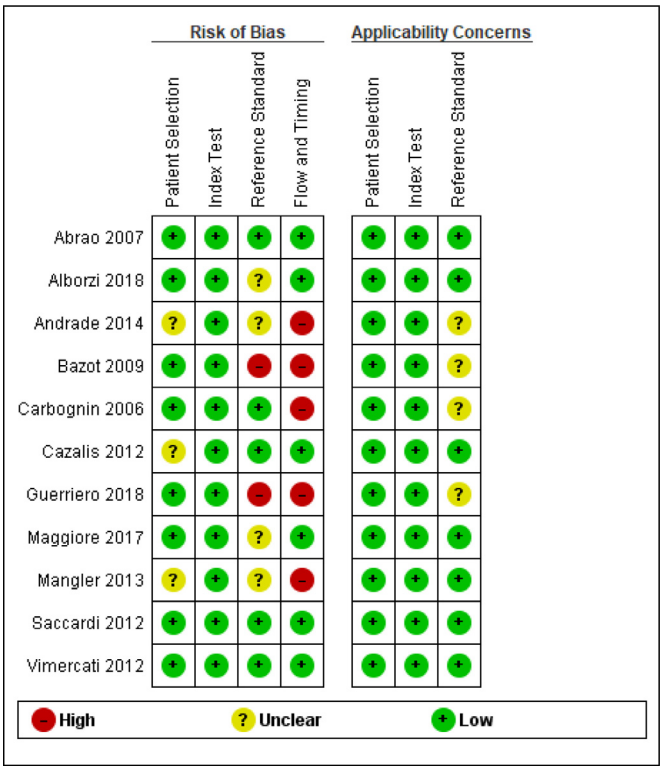


Figure 2. Summary of methodological assessment: QUADAS-2.



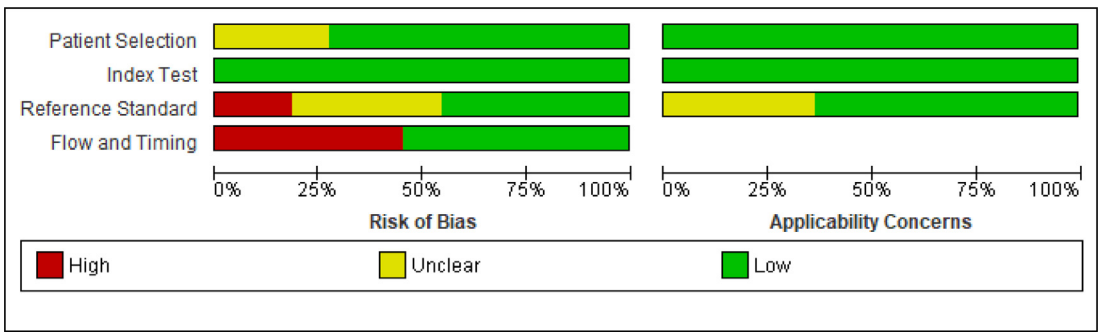
QUADAS-2, Quality Assessment of Diagnostic Accuracy Studies-2.

respectively). The area under the ROC curve (AUROC) was 0.95 (95% CI 0.93−0.97), the positive likelihood ratio (LR) was 13.7 (95% CI 5.5−34.2), and the negative LR was 0.21 (95% CI 0.10−0.44). A forest plot with the primary studies' sensitivity and specificity distribution for TVS is presented in Figure 4, and the HSROC curve for TVS is shown in Figure 5.

Accuracy of Magnetic Resonance Imaging

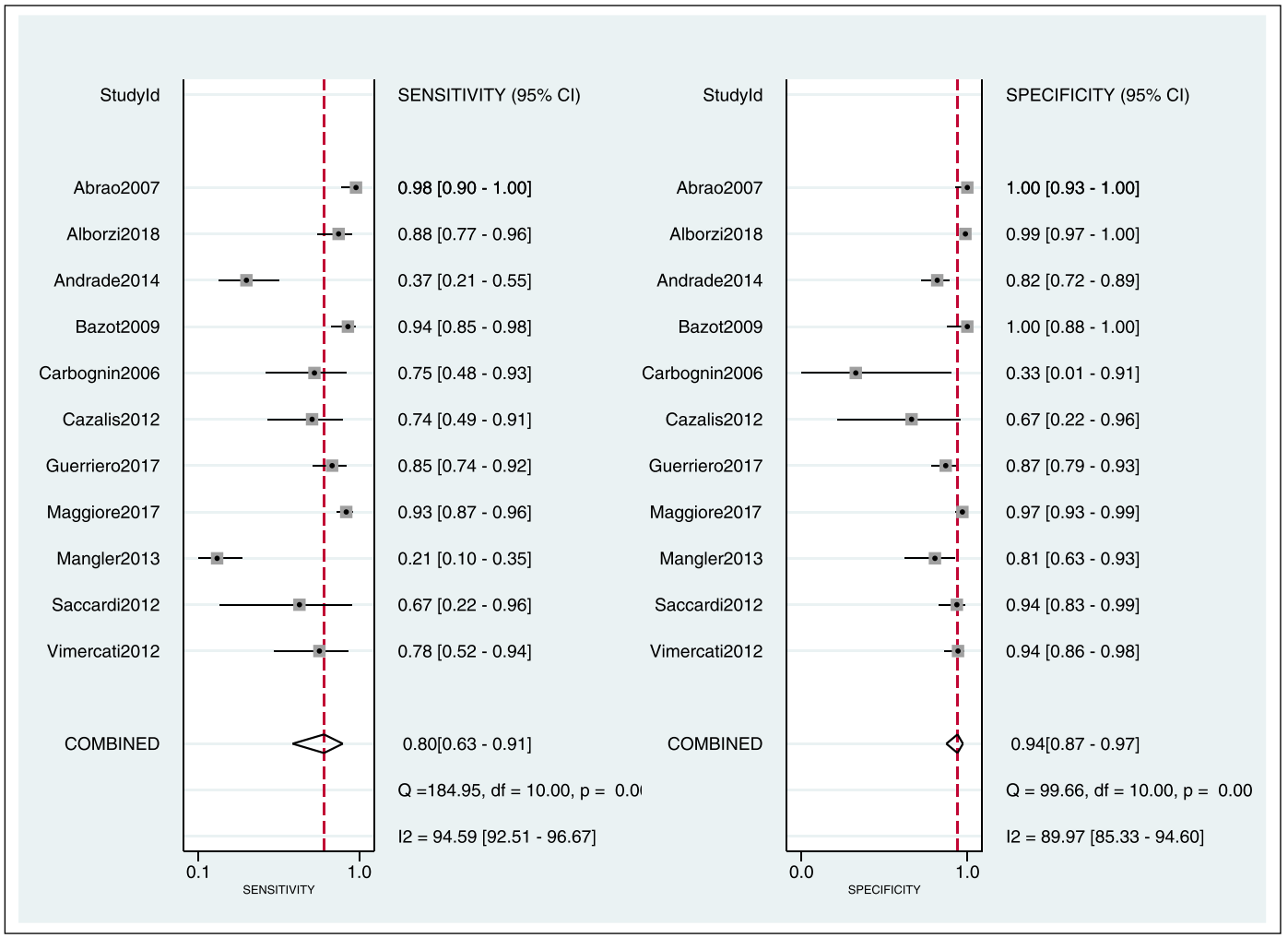
Similar results were found for the summary sensitivity of MRI (0.82; 95% CI 0.68−0.91; $I^2 = 89.4\%$, $P < 0.001$) and the summary specificity of MRI (0.94; 95% CI 0.86−0.97; $I^2 = 91.4\%$, $P < 0.001$), the AUROC curve (0.95; 95% CI 0.93−0.97), the positive LR (13.1; 95% CI 5.3−32.5), and the negative LR (0.19; 95% CI 0.10−0.38). The forest plots

Figure 3. Risk of bias and applicability of primary studies according to QUADAS-2.



QUADAS-2, Quality Assessment of Diagnostic Accuracy Studies-2.

Figure 4. Forest plot of accuracy measures of transvaginal sonography.



of the accuracy estimates for MRI and the HSROC curve for MRI are presented in Figures 6 and 7.

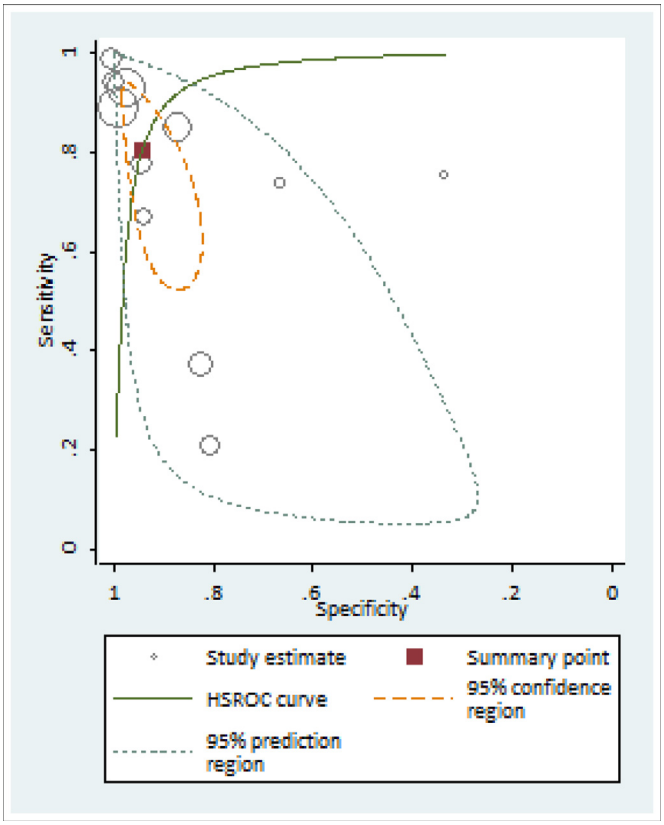
Difference in Accuracy Between Transvaginal Sonography and Magnetic Resonance Imaging

Hierarchical analysis provided coincidental AUROC curves with overlapping confidence intervals for both imaging examinations. Comparative analysis through a bivariate model did not detect any significant difference between the accuracy values of TVS and those of MRI ($P = 0.90$), or when sensitivity ($P = 0.83$) and specificity ($P = 0.89$) were analyzed separately. Direct comparison between MRI and TVS with bowel preparation or contrast media showed the same lack of difference, but the accuracy of MRI with vaginal contrast was significantly better than TVS using vaginal gel or contrast (Table 2), mainly because of the statistical difference in specificities.

Subgroup Analysis

Enhanced and non-enhanced techniques were also compared for each index test separately. The accuracy of resonance diverged, presenting greater sensitivity of bowel preparation or contrast and better vaginal contrast specificity. A statistically significant difference was not found among the techniques for preparation or use of contrast media by the rectal or vaginal route at TVS, but the sensitivity of the bowel preparation group was 24% greater than the vaginal contrast technique and 20% greater than the subgroup without any enhanced technique (Table 2). Further comparisons using bivariate analysis observed better specificity of MRI with vaginal gel or contrast over TVS with the same enhancing method (Table 2), significantly greater specificity of MRI without bowel preparation over TVS without the same technique, and greater sensitivity of TVS with bowel preparation or contrast over MRI without the same technique (Table 3). In addition, other differences

Figure 5. Hierarchical summary receiver-operating characteristic curve for transvaginal sonography and corresponding studies.



HSROC: hierarchical summary receiver-operating characteristic.

were observed favouring MRI bowel preparation sensitivity over TVS without any type of enhanced technique (14%) and TVS with bowel preparation or contrast over MRI without any preparation or with vaginal contrast (19.6%) (Table 3).

Meta-regression Assessments

The statistical heterogeneity initially found was further investigated by means of subgroup analysis and meta-regression. Table 4 shows that the heterogeneity of the accuracy values for both MRI and TVS decreased when bowel preparation and vaginal contrast were considered in some subgroups. Variables such as prevalence of bowel endometriosis, the use of enhanced techniques (bowel and vaginal contrast) for MRI, and number and mean age of study participants might have been sources of heterogeneity (Table 5).

Publication Bias

Deeks' test did not find evidence of any asymmetry in the distribution for either TVS ($P = 0.30$) or MRI ($P = 0.14$), a finding suggesting lack of publication bias (online Figures 2 and 3).

Quality of the Evidence (GRADE)

The criteria assessed in the present diagnostic accuracy meta-analysis were evaluated according to the GRADE approach for quality of evidence (online Table 4), and the quality of the evidence was "very low" for both diagnostic methods, mostly because of the risk of bias, inconsistency, and imprecision.

DISCUSSION

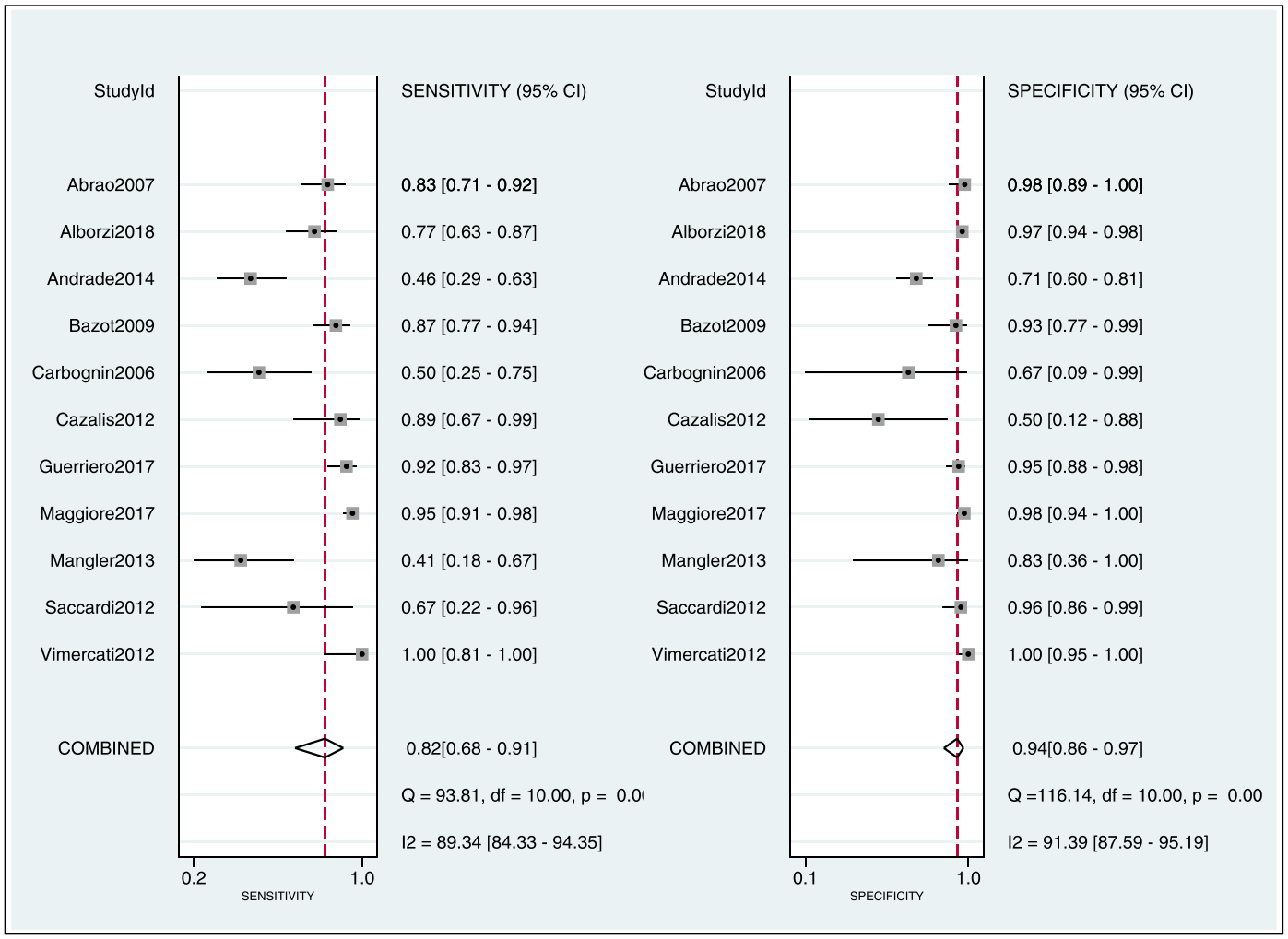
Summary accuracy measures exhibited similar results for TVS and MRI, respectively. The imprecision of the sensitivity measures was noticeable because their CIs showed considerable amplitude for both examinations (TVS, 62%−91%; and MRI, 67%−91%) and reflected the variability found in the primary studies (0.21−0.98 for TVS and 0.41−1.00 for MRI). In contrast, the imprecision of the specificity measures was less. Similar great imprecision was reported by previous reviews for TVS accuracy[5,15−17] and MRI accuracy.[10,16,17]

Pooled accuracy measures of TVS (sensitivity, 80.4%; and specificity, 94.1%) and MRI (sensitivity, 82.0%; and specificity, 93.8%) were similar, and a statistically significant difference was not found between both examinations. Moreover, significant heterogeneity was found for both accuracy measures. Although statistical heterogeneity is frequent in meta-analysis of accuracy studies, several factors such as enhanced techniques used to improve the quality of imaging may have contributed to the heterogeneity found, as shown by the subgroup analysis.

These findings suggest that any type of bowel contrast or preparation for MRI was responsible for some of the heterogeneity found, along with the lack of this technique for TVS, and the use of vaginal contrast for both imaging examinations. In addition, the application of any health-related technique has its own learning curve, leading to the possible contribution of operator aptitude to non-explained heterogeneity.[5,13,14]

From the studies that conducted comparative analysis, the study by Abrão et al. was the only one to observe statistical difference favouring the specificity of TVS.[2,3,9,11,27] Direct comparison between subgroups with bowel-enhanced techniques did not find a statistical difference, but use of vaginal contrast with MRI was significantly more accurate. A clinical difference of 24% greater than the vaginal

Figure 6. Forest plot of accuracy measures of magnetic resonance imaging.



contrast group and 20% greater than the subgroup without any enhanced technique was observed at TVS comparison.

The absence of a statistically significant difference between TVS and MRI corroborates the current lack of recommendation of any specific preparation technique.[4,28] Conversely, Saccardi et al. found better accuracy measures of the vaginal gel contrast while comparing it with the simple TVS technique.[8] Moreover, some authors[3,7] have reached impressive accuracy measures when using bowel preparation for TVS. The use of some of these techniques may still play a role in the accuracy of TVS.[16]

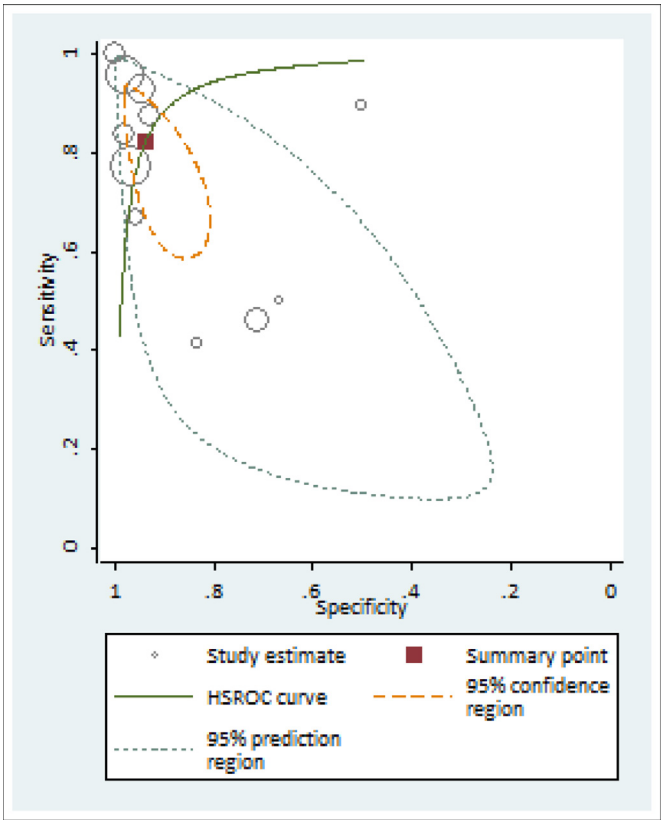
Enhanced techniques may also be applied to MRI, and exploration of these methods resulted in a heterogeneity explanation for both sensitivity and specificity measures. Some data suggest improvement in resonance images after rectal or vaginal opacification,[17] and our meta-analysis observed increased values in MRI accuracy with both enhanced techniques.[10,16]

Direct comparisons among different techniques suggested better accuracy of bowel contrast when compared with the simple technique for both examinations. However, economic and technical issues, differences in geographical areas, distinctions between social and cultural demographics, and health care or insurance characteristics may determine access to either MRI or TVS and their enhanced techniques.

Limitations

Most of the studies reviewed found a high prevalence of intestinal endometriosis, and this could represent a selection bias leading to a decrease in negative findings.[5,10,16,17] This can result from surgical indications directed to highly suspicious cases. Hence, the validity of those studies is limited to tertiary centers specialized in that condition. Randomized diagnostic trials would equalize negative findings, although they could put women without suspicion of DIE at surgical risk with low benefit of compensation.

Figure 7. Hierarchical summary receiver-operating characteristic curve for magnetic resonance imaging and corresponding studies.



HSROC: hierarchical summary receiver-operating characteristic.

QUADAS-2 evaluation of whether the reference standard results were interpreted without knowledge of the index tests results pointed towards another limitation. However, ethical issues regarding blinding surgeons to perform the reference standard are limiting.

Another possible source of bias is the criterion used by some studies to determine DIE on the basis of vaginal cul-de-sac obliteration,[2,8] whereas other studies did not report histological confirmation of rectosigmoid endometriosis.[7,22] Because pouch of Douglas obliteration is a frequent finding of diagnostic tests for DIE,[7] it was not clear whether some of the studies avoided surgical resection of the lesion as a result of technical difficulties but nonetheless, defined the gold standard result as positive despite the absence of histological results.[8,23]

These considerations led us to consider the risk of bias using the GRADE classification as "serious." Inconsistency was also evaluated as "serious" because of wide variation in the results of the accuracy measures reported in the primary studies, despite the overlap of CI, and also because of non-explained heterogeneity. Serious imprecision was considered to reflect wide pooled CIs of sensitivity for both examinations. Deliberation using the GRADE criteria indicated a very low level of evidence, and together with the large prediction intervals found at the HSROC curves, the quality of the evidence suggests that more comparative studies

Table 2. Comparative bivariate analysis of magnetic resonance imaging and transvaginal sonography and their enhanced and non-enhanced techniques

Technique	Number of patients	Sensitivity (95% CI)	Specificity (95% CI)	Comparison of accuracy (*P* value)	Comparison of sensitivity (*P* value)	Comparison of specificity (*P* value)
MRI bowel preparation or contrast[2,6,7,9,11,22,26]	804	83.8 (63.6–93.9)	90.0 (76.6–96.1)	0.594	0.525	0.317
TVS bowel preparation or contrast[3,6,7,21]	739	89.6 (78.2–95.4)	95.5 (67.0–99.6)			
MRI vaginal gel or contrast[3,8,21]	475	79.2 (70.5–85.8)	96.9 (94.2 - 98.1)	0.010[a]	0.424	0.003[a]
TVS vaginal gel or contrast[8,9, 22]	337	65.7 (33.2–88.1)	87.5 (79.8–92.5)			
MRI bowel preparation or contrast[2,6,7,9,11,22,26]	804	83.8 (63.6–93.9)	90.0 (76.6–96.1)	0.012[a]	0.496	0.272
MRI vaginal gel or contrast[3,8,21]	475	79.2 (70.5–85.8)	96.9 (94.2–98.1)			
TVS bowel preparation or contrast[3,6,7,21]	739	89.6 (78.2–95.4)	95.5 (67.0–99.6)	0.105	0.066	0.099
TVS vaginal gel or contrast[8,9, 22]	337	65.7 (33.2–88.1)	87.5 (79.8–92.5)			
TVS bowel preparation or contrast[3,6,7,21]	739	89.6 (78.2–95.4)	95.5 (67.0–99.6)	0.283	0.127	0.543
TVS without any bowel or vaginal contrast[2,11,26,27]	286	69.6 (31.2–92)	89.4 (72.3–96.4)			
TVS vaginal gel or contrast[8,9,22]	337	65.7 (33.2–88.1)	87.5 (79.8–92.5)	0.485	0.921	0.358
TVS without any bowel or vaginal contrast[2,11,26,27]	286	69.6 (31.2–92)	89.4 (72.3–96.4)			

[a] Statistically significant *P* value.

CI: confidence interval; MRI: magnetic resonance imaging; TVS: transvaginal sonography.

Table 3. Comparative bivariate analysis of enhanced and non-enhanced techniques for magnetic resonance imaging and transvaginal sonography

Technique	Number of patients	Sensitivity (95% CI)	Specificity (95% CI)	Comparison of accuracy (*P* value)	Comparison of sensitivity (*P* value)	Comparison of specificity (*P* value)
MRI bowel preparation or contrast[2,6,7,9,11,22,26]	804	83.8 (63.6–93.9)	90.0 (76.6–96.1)	0.072	0.286	0.782
TVS without any bowel or vaginal contrast[2,11,26,27]	286	69.6 (31.2–92)	89.4 (72.3–96.4)			
MRI vaginal gel or contrast[3,8,21]	475	79.2 (70.5–85.8)	96.9 (94.2–98.1)	0.408	0.691	0.226
TVS without any bowel or vaginal contrast[2,11,26,27]	286	69.6 (31.2–92)	89.4 (72.3–96.4)			
MRI without bowel preparation or contrast[3,8,21,27]	499	70.0 (48.8–85.1)	95.5 (89.5–98.2)	0.053	0.975	0.041[a]
TVS without bowel preparation or contrast[2,8,9,11,22,26,27]	623	68.3 (43.7–85.6)	87.1 (81.5–91.2)			
MRI without vaginal gel or contrast[2,6,7,9,11,22,26,27]	828	80.3 (58.7–92.1)	88.3 (74.7–95.1)	0.171	0.989	0.186
TVS without vaginal gel or contrast[2,3,6,9,11,21,26,27]	1025	82.9 (62.2–93.5)	93.0 (82.6–97.4)			
MRI bowel preparation or contrast[2,6,7,9,11,22,26]	804	83.8 (63.6 - 93.9)	90.0 (76.6–96.1)	0.191	0.177	0.770
TVS without bowel preparation or contrast[2,8,9,11,22,26,27]	623	68.3 (43.7–85.6)	87.1 (81.5–91.2)			
MRI without bowel preparation or contrast[3,8,21,27]	499	70.0 (48.8–85.1)	95.5 (89.5–98.2)	0.036[a]	0.037[a]	0.632
TVS bowel preparation or contrast[3,6,7,21]	739	89.6 (78.2–95.4)	95.5 (67.0–99.6)			
MRI vaginal gel or contrast[3,8,21]	475	79.2 (70.5–85.8)	96.9 (94.2–98.1)	0.559	0.679	0.795
TVS without vaginal gel or contrast[2,3,6,9,11,21,26,27]	1025	82.9 (62.2–93.5)	93.0 (82.6–97.4)			
MRI without vaginal gel or contrast[2,6,7,9,11,22,26,27]	828	80.3 (58.7–92.1)	88.3 (74.7–95.1)	0.576	0.414	0.722
TVS vaginal gel or contrast[8,9, 22]	337	65.7 (33.2–88.1)	87.5 (79.8–92.5)			

[a] Statistically significant *P* value.

MRI: magnetic resonance imaging; TVS: transvaginal sonography.

Table 4. Subgroup analysis for statistical heterogeneity by means of enhanced techniques

Enhanced techniques	I^2 test	Cochran's *Q* test (*P* value)
Sensitivity of MRI with bowel preparation or contrast	85.42	0.000
Specificity of MRI with bowel preparation or contrast	70.83	0.000
Sensitivity of MRI without bowel preparation or contrast	12.42	0.005
Specificity of MRI without bowel preparation or contrast[a]	03.46	0.326[a]
Sensitivity of TVS with bowel preparation or contrast[a]	09.97	0.080*
Specificity of TVS with bowel preparation or contrast	61.11	0.000
Sensitivity of TVS without bowel preparation or contrast	90.98	0.000
Specificity of TVS without bowel preparation or contrast	15.87	0.015
Sensitivity of MRI with vaginal contrast[a]	01.30	0.521[a]
Specificity of MRI with vaginal contrast[a]	0.385	0.825[a]
Sensitivity of MRI without vaginal contrast	107.68	0.000
Specificity of MRI without vaginal contrast	70.50	0.000
Sensitivity of TVS with vaginal contrast	21.35	0.000
Specificity of TVS with vaginal contrast[a]	04.27	0.118[a]
Sensitivity of TVS without vaginal contrast	163.69	0.000
Specificity of TVS without vaginal contrast	68.78	0.000
Sensitivity of TVS without any type of vaginal or bowel contrast	66.27	0.000
Specificity of TVS without any type of vaginal or bowel contrast	12.68	0.050

[a] Subgroups with improved statistical heterogeneity.

MRI: magnetic resonance imaging; TVS: transvaginal sonography.

Table 5. Bivariate metaregression analysis

Index test	Predictor factor (variable)	Qui-square test (*P* value)
TVS	Number of patients	0.05
	Patients mean/median age	0.15
	Study prospective design	0.75
	Year of publication	0.44
	Prevalence of rectosigmoid DIE	<0.001
	Bowel preparation or contrast	0.15
	Vaginal contrast	0.58
MRI	Number of patients	0.05
	Patients mean/median age	0.003
	Study prospective design	0.03
	Year of publication	0.58
	Prevalence of rectosigmoid DIE	<0.001
	Bowel preparation or contrast	0.007
	Vaginal contrast	0.01

DIE: deep infiltrating endometriosis; MRI: magnetic resonance imaging; TVS: transvaginal sonography.

need to be performed before stronger recommendations are made.

Implications for Additional Research

Recently, some studies suggested the use of both MRI and TVS to improve the detection of DIE lesions.[12] Although some investigators have advocated that is more affordable,[7,11,17] others[6] have stated that MRI is economically more accessible than laparoscopic surgery, that these two tests are not always concomitantly available in the general practice setting, but that cost-effectiveness should be directly addressed by comparative studies as a primary economic evaluation, as well as a direct comparison among enhanced techniques.

Future comparative studies conducted with similar methods could contribute to the reduction in the prediction interval of the accuracy measures, as well as the imprecision and inconsistency of the final results.[14] Recent consensus addressing techniques used for imaging examinations,[4,28,29] along with report guidelines,[30] could add to the standardization of results registration and surgical procedures, thereby contributing to better transparency of future publications.

CONCLUSION

This review provided a direct comparison of the accuracy of TVS and MRI for rectosigmoid endometriosis, but it was not sufficient to determine the superiority of any specific imaging technique. Although this accuracy equivalence would allow general and specialized gynaecologists to use the most accessible and available image technique to its practice. Still, the place of some enhanced techniques should be considered.

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SUPPLEMENTARY MATERIAL

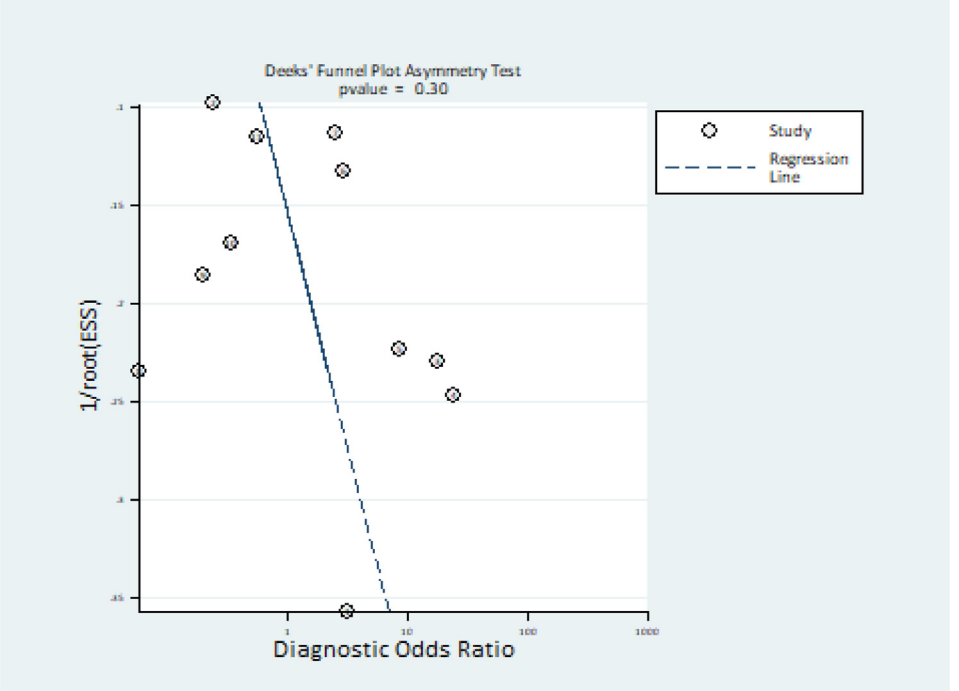
Supplementary Figure 1, Supplementary Figure 2 and Supplementary Figure 3

Supplementary Table 1, Supplementary Table 2, Supplementary Table 3 and Supplementary Table 4.

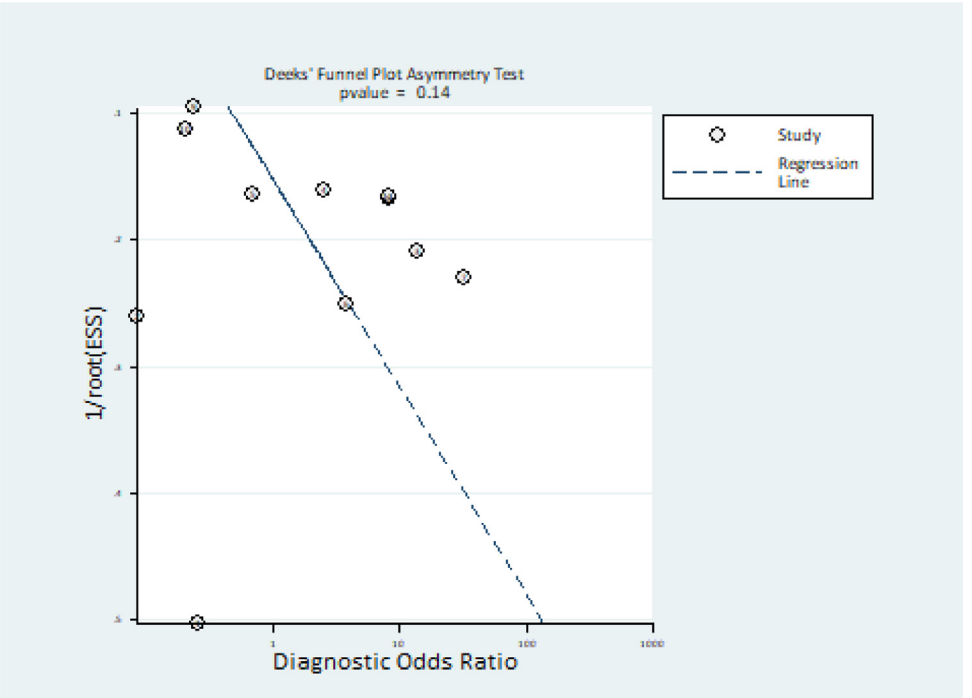
Supplementary Figure 1. Search strategy used for MEDLINE (PubMed)

((("endometriosis"[MeSH Terms] OR "endometriosis"[All Fields]) OR ("endometriosis"[MeSH Terms] OR "endometriosis"[All Fields] OR "endometriose"[All Fields])) AND (("ultrasonography"[Subheading] OR "ultrasonography"[All Fields] OR "ultrasonography"[MeSH Terms]) OR ("ultrasonography"[Subheading] OR "ultrasonography"[All Fields] OR "ultrasound"[All Fields] OR "ultrasonography"[MeSH Terms] OR "ultrasound"[All Fields] OR "ultrasonics"[MeSH Terms] OR "ultrasonics"[All Fields]) OR ("ultrasonography"[MeSH Terms] OR "ultrasonography"[All Fields] OR "sonography"[All Fields]) OR ("ultrasonography"[MeSH Terms] OR "ultrasonography"[All Fields] OR "ultrasonic"[All Fields] OR "ultrasonics"[MeSH Terms] OR "ultrasonics"[All Fields]) OR ("ultrasonography"[Subheading] OR "ultrasonography"[All Fields] OR "echography"[All Fields] OR "ultrasonography"[MeSH Terms] OR "echography"[All Fields]))) AND (("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields]) OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("nMRI"[All Fields] AND "imaging"[All Fields]) OR "nMRI imaging"[All Fields]) OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("imaging"[All Fields] AND "nMRI"[All Fields]) OR "imaging, nMRI"[All Fields]) OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("MRI"[All Fields] AND "scans"[All Fields]) OR "MRI scans"[All Fields]) OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("MRI"[All Fields] AND "scan"[All Fields]) OR "MRI scan"[All Fields]) OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("scan"[All Fields] AND "MRI"[All Fields]) OR "scan, MRI"[All Fields]) OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("scans"[All Fields] AND "MRI"[All Fields]) OR "scans, MRI"[All Fields]))

Supplementary Figure 2. Deeks' funnel plot asymmetry test for publication bias of TVS studies



Supplementary Figure 3. Deeks' funnel plot asymmetry test for publication bias of MRI studies



Supplementary Table 1. Inclusion and exclusion criteria of studies elegibility

	Inclusion criteria	Exclusion criteria
Study Design	Randomized, cross-sectional or observational studies, prospective or retrospective designs	Case-control, pilot or experimental studies, chapters in books, comments and letters to editors, reviews, case reports or case series
Participants	Women reproductive age Clinical suspicion of DIE	previous diagnosis of DIE
Index tests	2D transvaginal sonography Pelvic Magnetic Resonance Imaging	3D images or abdominal sonography If not both exams were executed before the Reference standard
Reference standard	Surgery to excise DIE lesions	
Target condition	DIE at rectum and rectosigmoid sites	Intestinal location not clearly stated
Outcome	TP, FP, FN and TN Accuracy measures	

* TP: True Positive; FP: False Positive; FN: False Negative; TN: True Negative

Supplementary Table 2. Number of studies retrieved from each database and dates of search

Database	Number of Studies
Cochrane Library	31
MEDLINE	581
EMBASE	947
LILACS	54
Scielo	13
Scopus	103
OpenGrey	25
Total	**1,754**

Supplementary Table 3. Characteristics of the eligible studies

Studies (first author)	Year of publication	Country of origin	Study design	Patient selection	Sample size	MRI technique	TVS technique	Histological confirmation
Abrao	2007	Brazil	Prospective	Pelvic endometriosis	104	V	B	Yes
Alborzi	2018	Iran	Prospective	Pelvic endometriosis	317	V	B	Yes
Andrade*	2014	Portugal	Retrospective	DIE	124*	B	V	**
Bazot	2009	France	Retrospective	Pelvic endometriosis	92	B	N	No
Carbognin	2006	Italy	Prospective	Pelvic endometriosis	32	B	B	No
Cazalis	2012	France	Retrospective	Pelvic endometriosis	25	B	N	Yes
Guerriero	2018	Italy	Prospective	DIE	159	B	V	No
Maggiore	2017	Italy	Prospective	DIE	286	B	B	Yes
Mangler *	2013	Germany	Prospective	DIE	79*	N	N	Yes
Saccardi	2012	Italy	Prospective	DIE	54	V	V	Yes
Vimercati	2012	Italy	Prospective	DIE	90	B	N	Yes
Total					1362			

* studies with smaller number of participants in group Magnetic Resonance Imaging, data correspond to the participants in group Transvaginal Sonography

** data not reported

DIE: Deep Infiltrating Endometriosis

V: Vaginal contrast

B: Bowel preparation or contrast

N: No contrast or enhanced technique

Supplementary Table 4. GRADE quality of evidence and summary findings

Summary of findings								
Index test							Pooled accuracy measures (CI)	
TVS							Sensitivity: 80 (62 – 91)	
							Specificity: 94 (87 – 97)	
MRI							Sensitivity: 82 (68 – 91)	
							Specificity: 94 (86 – 97)	
Quality assessment								
Participants (studies)		Study design	Factors that might decrease quality of evidence					Quality of evidence TVS / MRI
TVS	MRI		Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias	
1362 (11 studies)	1303 (11 studies)	Cross-sectional*	Serious	Not serious	Serious	Serious	Not detected	⊕◯◯◯ VERY LOW
								⊕◯◯◯ VERY LOW

* cohort type accuracy study; TVS:Transvaginal Sonography; MRI:Magnetic Resonance Imaging; CI:Confidence Interval