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Original Article

Is training sufficient for ultrasound operators to diagnose deep infiltrating endometriosis and bowel involvement by transvaginal ultrasound?

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ABSTRACT

Objectives. – To assess and compare the diagnostic accuracy of transvaginal ultrasonography (TVUS) by trained or untrained ultrasound operators in deep infiltrating endometriosis (DIE) imaging, for diagnosing DIE and bowel involvement.
Methods. – This was an observational study of patients with clinically suspected DIE operated in a reference center. TVUS was performed pre-operatively by a trained or/and untrained ultrasound operator to search for DIE and rectal involvement. During surgery, DIE was diagnosed according to macroscopic and histological criteria. Sensitivity (Se), specificity (Sp) and c-index were calculated with 95% confidence intervals for trained and untrained operators, if TVUS results were significantly predictive of DIE and rectal involvement at $p < 0.05$.
Results. – 115 patients were included: 100 (87%) had DIE and 34 (29.6%) had bowel involvement. TVUS was performed by a trained ultrasound operator for 70 patients and by an untrained one for 56 patients. When performed by a trained operator, TVUS significantly predicted DIE with a Se of 58% (95% CI, 46–70), a Sp of 87.5% (95% CI, 63–100) and a c-index of 0.73 (95% CI, 0.59–0.87). TVUS performed by an untrained operator was not significantly predictive of DIE ($p = 0.58$).

Rectal involvement was significantly predicted by TVUS performed by a trained operator with a Se of 40% (95% CI, 23–59), a Sp of 93% (95% CI, 86–100) and a c-index of 0.67 (95% CI, 0.56–0.77). None of the untrained ultrasound operators diagnosed a bowel involvement.
Conclusion. – TVUS is not sufficient to diagnose DIE and bowel involvement, in particular when performed by untrained ultrasound operators.

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1. Introduction

Endometriosis is defined as the growth of functional and hormone-dependent endometrial tissue outside the uterine cavity. Deep infiltrating endometriosis (DIE) involves lesions infiltrating the retroperitoneal space by 5 mm or more [1]. It can affect different regions of the pelvis, including the digestive organs. Laparoscopic resection of all DIE lesions significantly reduces pain and improves the patient's quality of life. Thus, the thorough pre-operative evaluation of DIE lesions is essential to define the best therapeutic strategy [2–4].

According to the literature, there is currently no consensus strategy for the pre-operative evaluation of DIE and several imaging techniques may be used. Magnetic resonance imaging (MRI) can detect both uterosacral ligaments (USL) and rectal involvement with good sensitivity (Se) (80–85% and 53–96%, respectively) [5–8]. Rectal endoscopic sonography (RES) is considered the gold standard for diagnosing rectal involvement of DIE lesions, and has a Se of 82–100%. However, the use of these techniques is limited due to their availability and cost.

Transvaginal ultrasound (TVUS) is a non-invasive, cost-effective, well-accepted and accessible test for diagnosing benign gynecological diseases. Signs of DIE on ultrasound, including abnormal hypoechoic linear thickening, nodules or masses with or without regular contours that are visible in particular regions such as the retrocervical area, have been successfully used for diagnosis

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[9]. Furthermore, several teams have described specific signs on TVUS indicative of bowel involvement associated with DIE lesions, and have reported that such an examination can effectively diagnose bowel involvement [10–15]. However, the present role of TVUS in the diagnosis of DIE is disputed. Some authors [8,11,12,14,16] consider that TVUS should be used as the first-line test to diagnose DIE and rectal involvement, whereas others found that this technique has low sensitivity and specificity [13,17,18]. However, few teams have published their results and such studies have been conducted in departments that are highly specialized in DIE employing practitioners who are very skilled in ultrasound imaging [12,15].

The aim of the study was to assess the accuracy of TVUS for diagnosing DIE and bowel involvement, and to compare performance between ultrasound operators who were trained or untrained in DIE imaging.

2. Methods

This was an observational, single-center study conducted at the gynecologic surgery unit of the Poissy-Saint-Germain-en-Laye Hospital. All patients who underwent surgery for clinical suspicion of endometriosis between October 1, 2004 and April 30, 2011 were collected in a prospective database. Patients were included prospectively when they had symptoms advocating endometriosis at pre-operative examination with no obvious pathology. Painful symptoms were chronic pelvic pain of more than six months duration, including severe dysmenorrhea, deep dyspareunia, cyclic pelvic pain and painful defecation, with or without infertility. Patients with a myoma or an ovarian cyst (including endometrioma) of more than 40 mm and those who had previously undergone surgery for the resection of a DIE nodule, or those without an available complete preoperative ultrasound report, were excluded from the study.

Epidemiological, ultrasound, surgical and histological data were collected with a standardized method. The practitioner (A.R.) who collected ultrasound results was blind to surgical findings collected during surgery. The recorded ultrasound data included the number, size, depth of infiltration and localization of DIE nodules, and the number and size of ovarian cysts. Ultrasound operators were blind to the results of other imaging tests at the time of the TVUS. Surgical reports were based on ASRM classification [19] and immediately completed by the surgeon after the intervention in a standardized datasheet. The report described the surgical approach used (laparoscopy or laparotomy), the number, size, depth of infiltration, localization and treatment of DIE nodules, and the number and size of ovarian cysts. Surgeons were trained in endometriosis surgery and aware of the results of imaging tests performed before surgery. DIE was diagnosed according to surgical and histological criteria [20]. A positive surgical diagnosis was based on obvious retroperitoneal infiltration of more than 5 mm, visible nodule or infiltration associated with palpable induration, or visible dark blue nodule of the posterior vaginal fornix [21]. A positive histological diagnosis was based on the presence of endometrial glands and stroma on resected specimens. Digestive DIE was defined as the involvement of the muscularis propria of the digestive wall. Histological tests were performed on the resected specimen if the nodule was resected, and on biopsies if the nodule was not resected. DIE was considered absent if the surgical and/or histological diagnosis was negative as follows: (i) a negative surgical and histological diagnosis; (ii) a negative surgical diagnosis and a positive histological diagnosis, corresponding to peritoneal endometriosis with retroperitoneal infiltration of less than 5 mm; or (iii) a positive surgical diagnosis and a negative histological diagnosis corresponding to retroperitoneal fibrosis without endometriotic lesions (scar tissue from previous intervention, infections, malignant lesions).

All ultrasound operators ($N = 47$) had a national degree in gynecological ultrasound and regularly practiced gynecological ultrasound scans. Forty-six ultrasound operators were classified as untrained in endometriosis imaging based on their replies to a questionnaire about their experience of ultrasound; 28 were radiologists (60.9%), 15 were obstetrician gynecologists (32.6%), two were general practitioners (4.3%), and one was a medical gynecologist (2.2%). One ultrasound operator (J-P.B.) was an obstetrician gynecologist who had practiced gynecologic and obstetrical ultrasound for over 15 years. He was considered trained in endometriosis imaging after having completed these successive steps of training: (i) theoretical training in endometriosis imaging involving courses and conferences given by experts in endometriosis; (ii) surgical training involving practical training with surgeons carrying out surgical interventions for endometriosis; and (iii) self-assessment of skills in real practice. Patients were referred primarily to this trained ultrasound operator for ultrasound when patients did not have TVUS or in cases of missing or non-conform ultrasound procedures. This trained ultrasound operator used a Voluson 730 Expert machine (GE Healthcare Europe, Buc, France) with a 7-MHz transvaginal probe.

Institutional Review Board approval was given for this study. The CEROG (ethical board of research in gynecology and obstetrics) approval number was CEROG-2011-GYN-06-01.

Ordinal variables were compared with the Chi-squared test when the expected numbers were ≥ 5, and Fisher's exact test when they were <5. The Student's t-test was used to compare continuous variables if they were normally distributed. Association between ultrasound and the diagnosis of DIE was studied by the Chi-squared test or Fisher's exact test for ordinal variables for both types of ultrasound operator. The diagnosis of DIE and the diagnosis of digestive involvement were examined separately. If there was a significant association, sensitivity, specificity and the c-index were calculated with 95% confidence intervals (95% CI). The c-index measures the overall predictive information of each of a diagnostic test prediction and is defined as the proportion of all usable patient pairs in which the predictions and outcomes are concordant, which is, for a binary outcome prediction mathematically equivalent to the area under the receiver operating characteristic curve. Differences between trained and untrained ultrasound operators were considered significant if the confidence interval of the c-index of one group did not include that of the other.

3. Results

A total of 175 women underwent surgery at our institution for suspected endometriosis between October 2004 and April 2011. Sixty patients were excluded and 115 patients were included in the study (Fig. 1). There were 110 (95.6%) successful laparoscopic procedures, three laparotomies and two laparoscopies that were converted into a laparotomy. There was no significant difference between patients with DIE and patients without DIE regarding age, body mass index (BMI), desire for pregnancy, and mean delay between ultrasound and surgery. A total of 126 TVUS were performed: 70 (60.9%) by the trained ultrasound operator and 56 (48.7%) by an untrained ultrasound operator. There were no significant differences regarding the general characteristics of the population between these two groups (Table 1). Patients received a single ultrasound by the trained (59/115) or an untrained ultrasound operator (45/115), or received an ultrasound from both successively (11/115).

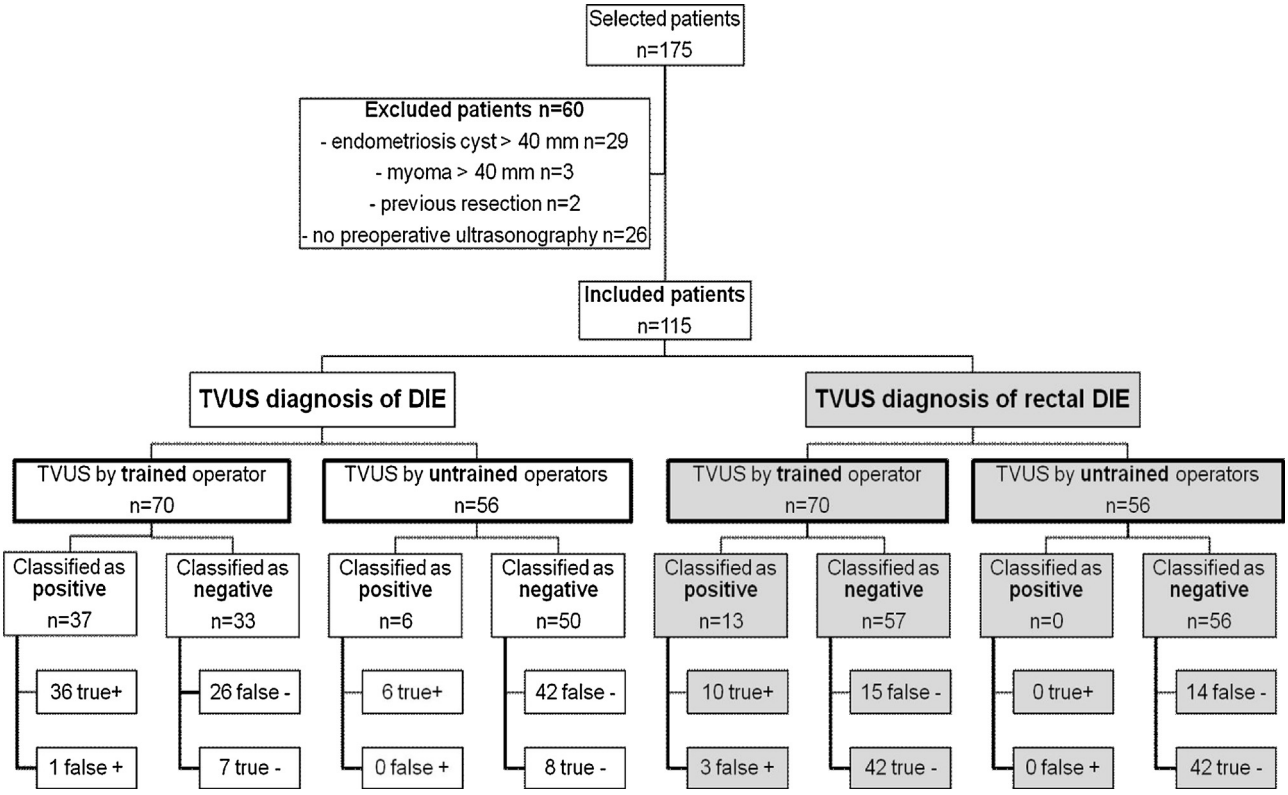

Fig. 1. Flow diagram of the study. *n*, effectives; TVUS, transvaginal ultrasonography; DIE, deep infiltrating endometriosis; true +/−, true positive/negative; false +/−, false positive/negative.

Table 1
Characteristics of the patients of the study.

	Group of the trained operator *N* = 70	Group of untrained operators *N* = 56	Total *N* = 126
Age, years, mean (± 1SD)	34.2 (± 11.2)	33.7 (± 12.5)	34.0 (±11.8)
BMI, mean (± 1SD)	23.0 (± 4.4)	22.0 (± 3.1)	22.6 (± 3.9)
Gravidity, mean (± 1SD)	0.9 (± 1.2)	1.0 (± 1.6)	1.0 (± 1.4)
Parity, mean (± 1SD)	0.6 (± 0.9)	0.6 (± 1.0)	0.6 (± 0.9)
Desire for pregnancy, *n*/N (%)	30/61 (49.2)	20/39 (51.2)	50/100 (50)
Period of infertility, years, mean (± 1SD)	1.5 (± 3.0)	1.3 (± 2.0)	1.4 (± 2.6)
Presence of endometriomas, *n*/N (%)	26/70 (37.1)	27/56 (48.2)	53/126 (42.1)
Presence of DIE, *n*/N (%)[a]	62/70 (88.5)	48/56 (85.7)	110/126 (87.3)
Localization, *n*/N (%)[b]			
Anterior	24/70 (34.3)	14/56 (25)	38/126 (30.2)
With bladder involvement	5/70 (7.1)	3/56 (5.4)	8/126 (6.3)
USL	30/70 (42.9)	32/56 (57.1)	62/126 (49.2)
Vagina	7/70 (10)	2/56 (3.6)	9/126 (7.1)
Digestive involvement	25/70 (35.7)	14/56 (25)	39/126 (30.9)
Number of nodules, *n*/N (%)			
1	26/70 (37.1)	17/56 (30.4)	43/126 (34.1)
2	20/70 (28.6)	22/56 (39.3)	42/126 (33.3)
3	15/70 (21.4)	7/56 (12.5)	22/126 (17.5)
4	1/70 (1.4)	2/56 (3.5)	3/126 (2.4)
Average size of the largest diameter of nodules, mm, mean (± 1SD)	24.1 (± 10.3)	22.5 (± 9.3)	23.4 (± 9.9)
Laparoscopy, *n*/N (%)	65/70 (92.9)	56 (100)	–
Laparotomy, *n*/N (%)	3/70 (4.3)	0 (0)	–
Laparoconversion, *n*/N (%)	2/70 (2.8)	0 (0)	–

No *p*-value were found < 0.05.
SD, standard deviation.
BMI, body mass index.
DIE, deep infiltrating endometriosis.
USL, uterosacral ligaments.
[a] Include patients with anterior DIE.
[b] All patients with anterior DIE also had posterior DIE. So the total of USL, vagina and rectum involvement patients was equal to the number of patients with DIE.

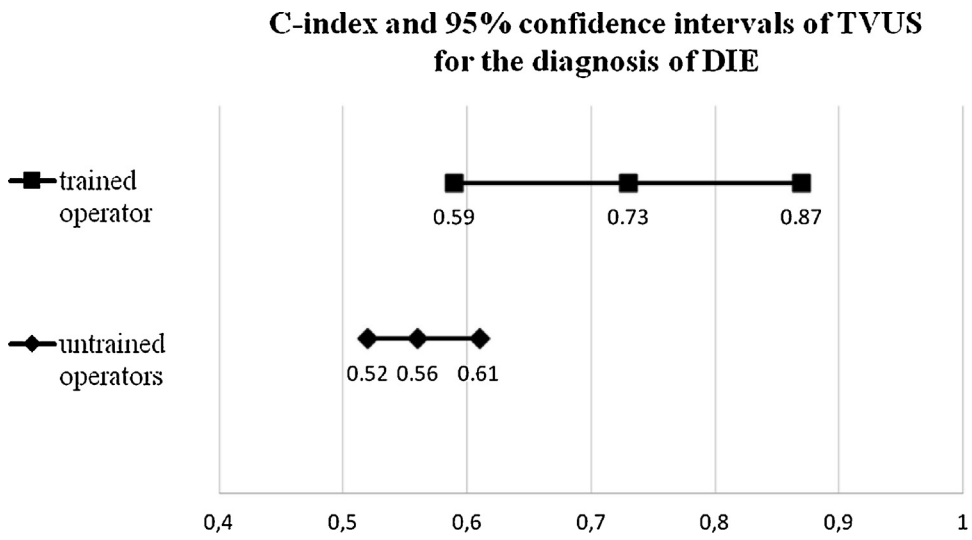

Fig. 2. C-index and 95% confidence intervals of transvaginal ultrasound examination (TVUS) for the diagnosis of deep infiltrating endometriosis (DIE) by trained and untrained ultrasound operators. If the C-index of a test is not within the range of the confidence interval of the other, there is a significant difference between tests.

Fifteen patients did not have deep infiltrating endometriosis: nine had both a negative surgical and histological diagnosis; three had a negative surgical diagnosis and a positive histological diagnosis, corresponding to peritoneal endometriosis with retroperitoneal infiltration of less than 5 mm; and three showed macroscopic aspects of endometriosis but histological diagnosis after complete resection of the lesion was negative, and revealed retroperitoneal fibrosis without endometriotic lesions. Thus, 100 patients (86.9%) had DIE. Thirty-four patients (29.6%) had anterior DIE, including eight patients (7.0%) with detrusor infiltration. All women with anterior DIE lesions also had posterior DIE. Thirty-four patients (29.6%) had digestive involvement, including rectal involvement in 26 cases, involvement of the recto-sigmoid junction in seven cases and sigmoid involvement in two cases. Surgical data including the location, size and number of nodules are described in Table 1. Overall, 186 DIE nodules were observed during surgery. Nodules were removed or left intact in 71.5% and 18.3% of patients, respectively, and the remaining patients underwent an extrafascial hysterectomy (6.5%) or a proctectomy (2.7%).

Overall TVUS (performed by either the trained or an untrained ultrasound operator) significantly predicted the presence of DIE (Fisher's exact test, $p = 0.005$) with a sensitivity of 42.7% [95% CI, 33–52], a specificity of 93.7% [95% CI, 70–100], and a c-index of 0.68 [95% CI, 0.61–0.76]. TVUS results were also significantly predictive of rectal involvement, (Fisher's exact test, $p = 0.004$) with a sensitivity of 22.5% [95% CI, 11–38], a specificity of 95.3% [95% CI, 88–99], and a c-index of 0.59 [95% CI, 0.52–0.66].

TVUS performed by the trained ultrasound operator significantly predicted the presence of DIE (Fisher's exact test, $p = 0.02$) with a sensitivity of 58% [95% CI, 46–70], a specificity of 87.5% [95% CI, 63–100], and a c-index of 0.73 [95% CI, 0.59–0.87]. However, TVUS performed by untrained ultrasound operators did not significantly predict the presence of DIE (Fisher's exact test, $p = 0.58$), sensitivity and specificity were not calculated, and the c-index was 0.56 [0.52–0.61]. The c-index of the untrained ultrasound operators was not within the range of the confidence interval of the trained ultrasound operator; thus, the diagnostic value of TVUS performed by the trained ultrasound operator was significantly higher than that of TVUS performed by an untrained ultrasound operator (Fig. 2).

TVUS performed by the trained ultrasound operator significantly predicted the presence of rectal involvement (Fisher's exact test, $p = 0.001$) with a sensitivity of 40% [95% CI, 23–59], a specificity of 93% [95% CI, 86–100], and a c-index of 0.67 [95% CI, 0.56–0.77]. Untrained ultrasound operators did not diagnose any cases of rectal involvement, although 14 women (25% of their patients) had DIE involving the digestive wall.

4. Discussion

Our study shows that routine TVUS has an insufficient diagnostic accuracy to detect DIE and to diagnose rectal involvement, even when performed by a trained ultrasound operator, experienced in the field of endometriosis. We also demonstrate that the expertise in the field of endometriosis of the ultrasound operator has an important impact on the diagnostic performance of the examination.

Our study is the first one to examine how the level of training of ultrasound operators affects the accuracy of TVUS for the diagnosis of DIE, according to well-defined criteria for training in endometriosis imaging. The gold standard method used here to confirm diagnosis was very strength: all patients had surgery and histological analysis in accordance with CNGOF [23] and ESHRE [20] criteria. Furthermore, all DIE implants were characterized with precision. Indeed, if an implant was not resected, positive surgical diagnosis was based on the appearance of the nodule [21] and biopsies were performed for histological diagnosis. In addition, our exclusion criteria limited potential confounders that might decrease the sensitivity of TVUS for the diagnosis of DIE lesions, such as endometriomas and myomas >40 mm [11].

There are nonetheless several limitations to our study. At first, the prevalence of DIE was very high in our population suggesting the possibility of referral bias [24]. Indeed, 86.9% of patients had posterior DIE and the prevalence of bowel involvement in DIE patients was particularly high (34%) compared to other sample of women operated for DIE. Chapron et al. [22] reported that only 9.9% of DIE lesions infiltrated digestive organs. These figures can at first be explained by the fact that, in our study, the patient inclusion criteria were rather strong and surgical procedures for diagnosis were highly standardized. Nonetheless, it is obvious than those patients who had an abnormal TVUS will have surgery to confirm the diagnosis more frequently than those who had a normal TVUS. Therefore, our population contained a higher proportion of abnormal TVUS than in the population of women having TVUS for chronic pelvic pain. Thus, the 58% sensitivity rate

Table 2
Sensitivities for the diagnosis of any DIE and of rectosigmoid DIE by TVUS in previous published studies.

Authors	*N*	Any DIE	Rectosigmoid DIE
Dessole 2003 [17]	46	43.7	33.3
Bazot 2004 [11]	142	78.5	87.2
Bazot 2007 [12]	81	87.3	92.6
Valenzano Menada 2008 [13]	90	92.8	56.5
Piketty 2009 [16]	134	NA	90.7
Bazot 2009 [8]	92	87.8	93.6
Hudelist 2009 [14]	200	NA	98
Present study	115	42.7	22.5

N, effective of the study.
NA, non available.
DIE, deep infiltrating endometriosis.
TVUS, transvaginal ultrasonography.
USL, uterosacral ligament.

which we have calculated for TVUS might in turn have been artificially increased and the actual diagnostic accuracy of TVUS may be lower than that reported in our study.

Secondly, untrained ultrasound operators performed "first-line" ultrasound scans whereas the trained ultrasound operator performed first or second line scans on those patients who have been referred specifically to them: the indications for TVUS in these patients may be better defined and they probably have more severe endometriosis than patients sent for first-line scans. This may affect the difference of predictive value of TVUS between trained and untrained operators, but we were not able to take this into account in our statistical analysis.

Finally, we assessed the diagnostic accuracy of TVUS by only one trained ultrasound operator, compared with many untrained ultrasound operators. This could have an impact in our result, taking into account inter-operator variability. Untrained ultrasound operators may have various experience of endometriosis imaging. The diagnostic accuracy of TVUS performed by untrained ultrasound operators might have been different if there were fewer operators and with the same experience. Conversely, there are probably different levels of experience for endometriosis imaging. Our results might have been more representative if the diagnostic accuracy had been assessed by several trained operators.

The diagnostic accuracy of TVUS for the diagnosis of DIE, and in particular digestive involvement, has been reported in only a few studies [8,11,12,14–16,25], and the results are heterogeneous (Table 2). Most publications were performed by the same team, Bazot et al. [8,11,12,25] who have a great experience with TVUS and bowel endometriosis. Not surprisingly, the diagnostic accuracy of TVUS, even performed by a trained ultrasound operator, we have found is far lower than that found by Bazot et al. [8,11,12]. Peculiarly, the sensitivity of TVUS for predicting bowel involvement we have found is less than half than those reported by this author. This may be explained by the 70.0% rate of rectal infiltration among DIE patients reported by this author [8,12], versus 34% in our study. It may also relate to differences between the severity of the disease among patients referred to this center, which is well-known for colorectal endometriosis, compared to our center which takes care of various form of the disease. Fortunately, the sensitivity of TVUS reported by Dessole et al. is equivalent to ours [17], even if this study took place in tertiary referral center in which the prevalence of endometriosis is high. Those studies used transvaginal probes of different frequencies, that could modify the diagnostic accuracy of TVUS in diagnosing DIE.

Unlike ours, the previous published studies (Table 2) did not involve procedures carried out by several ultrasound operators and thus measures of inter-observer variability are lacking. Pooling the results of several ultrasound operators would provide a more accurate estimate of diagnostic value of TVUS representative of the population of ultrasound operators available in the everyday-life practice. TVUS, although frequently used as a first-line test for various gynecologic diseases, may thus be inadequate to screen for DIE in routine practice.

The place of TVUS should be discussed alongside the other pelvic imaging examinations to assess the extent of the disease and rectal involvement at pre-operative evaluation. MRI is expensive and less accessible but can map pelvic lesions and extension into deep organs with high sensitivity and specificity [5–8]. Rectal endoscopic sonography (RES) is a good technique to assess rectal infiltration and has a great sensitivity of 82–100% [4–7,18,25–31]. However, it is an invasive test and it only examines the rectum and lower sigmoid [7]. TVUS is frequently used due to its accessibility but its sensitivity is poor, even with a trained ultrasound operator. Our opinion is that TVUS alone is not sufficient to rule out rectal involvement, but it may help to the diagnosis. Its association with several other tests is thus mandatory for adequate pre-operative evaluation.

Different techniques have been described to improve sensitivity of TVUS, but they cannot all be performed easily [10,13,15,17,32–34]. Nevertheless, preparing the digestive tract before TVUS is a simple approach that could improve the sensitivity of TVUS for the diagnosis of rectal infiltration. Prospective studies should be conducted to assess the diagnostic value of these technical modifications.

According to good professional practice it is recommended that "all imaging tests should be performed by operators trained to detect DIE". Our study demonstrates clearly the impact of specialized training to identify endometriosis on ultrasound. The ultrasound operator should thus be aware of the symptoms and clinical signs that prompted the use of an ultrasound scan, should carry out the exam according to a precise protocol and should know the signs on ultrasound to look for [35].

Disclosure of interest

The authors declare that they have no competing interest.

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