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Comparison of three-dimensional rectosonography, rectal endoscopic sonography and magnetic resonance imaging performances in the diagnosis of rectosigmoid endometriosis



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ABSTRACT

Study Objective: Comparison of 3D-rectosonography (3D-RSG), rectal endoscopic sonography (RES), and MRI performances in the diagnosis of rectosigmoid endometriosis using surgery as the Gold Standard.

Design: Monocentric retrospective longitudinal study on diagnostic procedures.

Design classification: Canadian Task Force II-2.

Setting: University Hospital of Lyon Croix-Rousse.

Patients: A total of 37 patients treated surgically for pelvic endometriosis.

Interventions: Expert 3D-RSG (3D Transvaginal sonography with water contrast in the rectum), MRI and RES performed by expert examiners. Sensitivity, specificity, accuracy, positive and negative predictive value, positive and negative likelihood ratios were calculated. Depth, size, and volume of intestinal lesions were also compared to the type of surgery performed (shaving versus segmental resection).

Measurements and main results: Rectosigmoid endometriosis lesion was confirmed by surgery in 31 patients on 37 (84%). Sensitivity, specificity, accuracy, positive and negative predictive value, positive and negative likelihood ratios for 3D-RSG were 94%, 100%, 95%, 100%, 75%, +∞ and 0.06 respectively; for RES 81%, 100%, 84%, 100%, 50%, +∞ and 0.19 respectively; while for MRI 90%, 100%, 92%, 100%, 67%, +∞ and 0.10 respectively. There was no significant difference between the 3 procedures ($p > 0.05$).

Conclusion: 3D-RSG, RES and MRI seem to be 3 effective procedures in the diagnosis of rectosigmoid endometriosis. Their performances seem equivalent.

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1 Introduction

Deep infiltrating endometriosis (DIE) is defined by endometriosis lesions infiltrating the peritoneum for more than 5 mm and/or infiltrating pelvic organs [1]. The rectosigmoid lesions are responsible for severe non-specific symptoms and their surgical management is complex [2]. A comprehensive preoperative imaging evaluation is therefore paramount for both patients and surgeons.

Many imaging procedures are used in the diagnosis and evaluation of intestinal endometriosis such as endovaginal ultrasound, Magnetic Resonance Imaging (MRI), rectal endoscopic

sonography (RES), Virtual Colonoscopy or Entero-MRI [3–9]. Endovaginal ultrasound with intrarectal contrast is a recent ultrasound technique described for the first time by Valenzano Menada et al. in 2008, and which is also known as three-dimensional Rectosonography (3D-RSG) when coupled with several three-dimensional acquisitions [7,10]. Few studies have compared this technique with pelvic MRI and no publication to date has compared it with RES [11,12].

The aim of this study was to evaluate the performances of 3D-RSG, RES and MRI in the preoperative diagnosis of rectosigmoid endometriosis using surgery as the Gold Standard.

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2 Patients and methods

2.1 Study population and ethical considerations

Data from patients who underwent surgery for endometriosis at the Croix-Rousse University Hospital in Lyon (France) between August 2012 and January 2017 were retrospectively collected. Only patients who received a preoperative imaging assessment involving the three complementary exams (3D-RSG, RES and MRI) were included in the study. Patients under 18 years, virgin patients or patients with contraindication to the MRI were excluded. For every patient included in the study, the following data were collected: age, parity, history of pelvic surgery and clinical symptoms. The study was submitted to the SUD-EST II ethics committee, which classified the treatment provided as “usual care” (Reference number: CAL 2013-028-2).

2.2 Rectosonography

Rectosonography examination was performed with a SAM-SUNG UGEO WS80A ultrasound system (SAMSUNG Seoul, South Korea) and a VOLUSON E8 ultrasound system (GE Healthcare Ultrasound, Milwaukee, WI, USA) and was interpreted in real-time by the same experimented operators (GD, PSH, CAP). The operator was informed of the patient's symptoms but was not aware of the results of other imaging reports. A rectal preparation by enema (Normacol[®]) was administered to the patients 2 h and 1 h before the examination. At the beginning of the imaging examination, the patient slowly injected herself 120 mL of water into the rectum. A transvaginal sonography (TVS) was then performed. Intestinal involvement was suspected when a hypoechoic nodule reached the intestinal serosa and infiltrated the muscularis (Fig. 1). Pressure made by the probe when in contact with the lesion often recreated dyspareunia described by patients, helping to orient the operator towards the lesion in real time. Tridimensional acquisitions were used to enhance the characterization of the nodules.

2.3 Rectal endoscopic sonography

RES was performed without anesthesia after colonic preparation by a referent operator in endometriosis (FB). A probe of 7.5–12 MHz was inserted up to the sigmoid colon and was slowly removed until the anal margin, allowing a complete assessment of the rectal wall. The endometriotic nodules appeared as hypoechoic lesions infiltrating the intestinal wall.

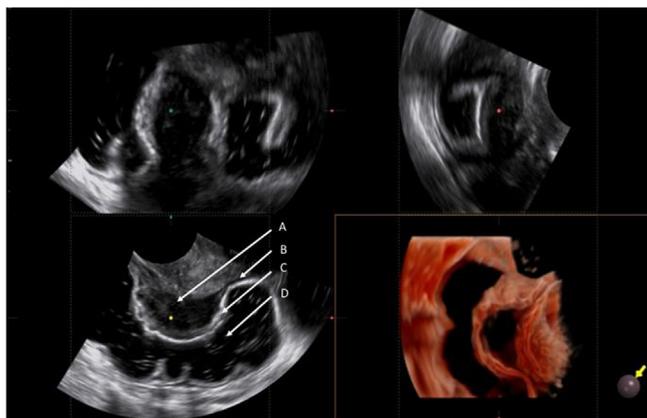


Fig. 1. Rectosigmoid endometriosis nodule in 3D-RSG.

The nodule of endometriosis appears as a hypoechoic lesion (A), which here reaches the normal hypoechoic muscularis (B). The mucosa (C) does not seem involved. The intrarectal contrast in the lumen (D) helps visualize the luminal side of the nodule.

2.4 Pelvic MRI

Pelvic MRI was performed in T1-weighted, T2-weighted and Fat suppression sequences T2 after intestinal preparation and with intravaginal and intrarectal opacification by gel. MRI results were all interpreted by the same radiologist referent in endometriosis (EM). The rectosigmoid endometriosis lesions appeared as hypointense nodules on the intestinal wall with badly limited extensions to adjacent organs.

2.5 Surgical treatment

All patients underwent laparoscopy or laparotomy with surgical indication related to endometriosis at the Croix Rouse University Hospital (Lyon, France). The presence or absence of intestinal lesions was confirmed by the surgeon while exploring the abdominal cavity even if an excision of the intestinal lesion was not systematically performed to respect the patient's will and/or fertility project. The pouch of Douglas was always entered and the endometriosis nodule was always dissected from the USLs that were treated in all cases. When a lesion was confirmed and removed, a pathological analysis was systematically carried-out. The primary outcome measure was “rectosigmoid endometriosis lesion confirmed by surgery”.

The surgical reports were all retrospectively assessed by the same surgeon (AS) following a systematic review process with a previously established reading grid reporting the following elements: presence or absence of a digestive lesion, location, depth, size, volume, type of surgery, presence of other endometriosis lesions. Histological reports were also analyzed according to the same parameters.

2.6 Characteristics of the nodules and prediction of the surgical procedure

The following characteristics of each endometriosis nodule detected by imaging ultrasound were collected: location, depth, size and volume of the intestinal lesion. These data were compared with surgical management items. A risk of surgical resection was then calculated depending on the different characteristics.

2.7 Statistical analysis

All of the patients' data were collected and anonymized using a Microsoft Excel sheet. Sensitivity, specificity, accuracy, positive predictive value (PPV), negative predictive values (NPV), positive likelihood ratios (LR+) and negative likelihood ratios (LR-) were calculated for each imaging method using surgery as the Gold Standard. 95% confidence interval (95%CI) was calculated using Wilson score method without continuity correction. Wilcoxon test was used to compare independent data; Mc Nemar test to compare paired binomial data and the ANOVA test to compare continuous data with qualitative data.

3 Results

3.1 Population and characteristics

Between August 2012 and January 2017, 264 patients underwent surgery for endometriosis at the Croix Rouse University Hospital (Lyon, France). Among these patients, 37 patients matched the inclusion criteria and received a complete preoperative assessment including 3D-RSG, RES and MRI. Patients characteristics are summarized in Table 1.

Table 1
Patient characteristics.

Age ^o :	34.4 (22–46)
Previous surgery for endometriosis	23/37 (62%)
Endometriosis related symptoms*	
Dysmenorrhea	36/37 (97%)
Dyspareunia	28/37 (76%)
Dysuria	10/37 (27%)
Dyschezia	13/37 (35%)
Constipation	21/37 (57%)
Diarrhea	24/37 (65%)
Rectorrhagia	9/37 (24%)
Surgery*	
Digestive lesions confirmed at surgery	31/37 (84%)
Rectum	10/31 (32%)
Sigmoid	21/31 (68%)
Type of surgery*	
Resection	13/31 (42%)
Shaving	16/31 (52%)
Other confirmed endometriosis lesions*	
Endometrioma	13/37 (35%)
Uterosacral ligaments	23/37 (62%)
Torus	20/37 (54%)
Vagina	7/37 (19%)
Ureter	2/37 (5%)
Bladder	5/37 (14%)

^o : mean (IC95) ; * : number of cases / number of patients (percentage).

3.2 Surgery

Endometriosis diagnosis was confirmed by surgery and histology in every patient. Intestinal endometriosis lesions were confirmed by surgery in 31 out of 37 patients (84%). Nodules were located in the sigmoid in 68% of cases and in the rectum in 32% of cases. A surgical resection was performed in 42% of patients and a shaving in 52%. For two patients (6%), no digestive surgery was performed in accordance with the preoperative decision of the patient. Other endometriosis locations were often associated to the intestinal disease. The most frequent locations were the uterosacral ligament (62%) followed by the retrocervical space (54%), the ovaries (35%), the vagina (19%), the bladder (14%) and finally the ureters (5%).

3.3 Diagnostic performances of imaging examinations

The diagnostic performances of each examination are summarized in Table 2. 3D-RSG detected 29 intestinal nodules out of 31 confirmed during surgery. The two lesions not seen were located on the upper rectum (between 10 and 15 cm from the anal margin). 3D-RSG sensitivity, specificity, accuracy, PPV, NPV, LR+ and LR- were 94%, 100%, 95%, 100%, 75%, +∞ and 0.06 respectively. There was no procedure failure for the 3D-RSG.

The MRI detected 28 intestinal nodules out of 31 with three false negatives. One was located on the upper rectum and had also

Table 2
Diagnostic performances of 3D-RSG, RES and MRI for rectosigmoid endometriosis lesions.

	3D-RSG (95%CI)	RES (95%CI)	MRI (95%CI)
Sensitivity	0.94 (0.78–0.99)	0.81 (0.63–0.93)	0.90 (0.74–0.98)
Specificity	1 (0.54–1)	1 (0.54–1)	1 (0.54–1)
Accuracy	0.95 (0.87–1)	0.84 (0.79–0.99)	0.92 (0.72–0.96)
PPV	1	1	1
NPV	0.75 (0.44–0.92)	0.50 (0.33–0.67)	0.67 (0.40–0.85)
LR+	+∞	+∞	+∞
LR-	0.06 (0.02–0.25)	0.19 (0.09–0.40)	0.10 (0.03–0.28)

RSG: rectosonography, RES: Rectal Endoscopic Sonography, CI95%: 95% confidence interval, PPV: positive predictive value, NPV: negative predictive value, LR+ and LR-: positive and negative likelihood ratios.

not been seen in RSG. The other two lesions were located on sigmoid (>15 cm from the anal margin). MRI sensitivity specificity accuracy PPV, NPV, LR+ and LR- were 90%, 100%, 92%, 100%, 67%, +∞ and 0.10 respectively. There was no procedure failure for the MRI.

The RES detected 25 nodules out of 31 with six false negatives. Procedures that did not detect the nodule reported an incomplete examination in 3 cases, an unbearable pain in 2 cases and an unsatisfactory intestinal preparation in one case.

Four lesions were located on the sigmoid a (>15 cm from the anal verge), one was on the upper rectum and one on the middle rectum (between 5 and 10 cm from the anal verge). These six lesions were diagnosed through MRI and 3D-RSG. RES sensitivity specificity accuracy PPV, NPV, LR+ and LR- were 81%, 100%, 84%, 100%, 50%, +∞ and 0.19 respectively.

There was no significant difference between any of the performances of the 3 examination procedures. The accuracy was similar between 3D-RSG and MRI (p = 0.60), 3D-RSG and RES (p = 0.30) and between MRI and RES (p = 0.62). In univariate analysis after location adjustment (rectum or sigmoid), there was still no significant difference between the examinations in terms of accuracy. For rectal lesions, accuracy was 80% for 3D-RSG, 90% for MRI and 70% for RES (MRI vs RES p = 0.30, 3D-RSG vs MRI: p = 0.58 and 3D-RSG vs RES: p = 0.65). For sigmoid lesions, accuracy was 100% for 3D-RSG, 90.5% for MRI and 85.7% for RES (3D-RSG vs MRI: p = 0.16, 3D-RSG vs RES: p = 0.08, MRI vs RES: p = 0.65).

3.4 Characteristics of the intestinal nodules and prediction of surgical procedure

Endometriosis rectosigmoid nodules characteristics are summarized in Table 3. A rate of each surgical procedure was calculated according to the location, depth and size of the lesion (Table 4). Patients whose examination did not specify these characteristics were excluded from this analysis. According to 3D-RSG, the risk of resection was 0% when lesions infiltrated the serosal layer and 50% when the muscularis layer was infiltrated. Therefore, the depth observed in 3D-RSG was significantly associated with a higher risk of resection (p = 0.048). Observed size and volume of the lesions were not associated with a different risk of surgical resection (p = 0.073 and p = 0.13 respectively).

4 Discussion

This study compares 3D-RSG, a recent endovaginal ultrasound procedure combining intra rectal contrast and 3D acquisition, to both MRI and RES. Our main objective was to compare the diagnostic performances of these three imaging procedures for rectosigmoid endometriosis lesions.

In our population, 3D-RSG, RES and MRI enabled the diagnosis of rectosigmoid endometriosis lesions with an accuracy of 95%, 84% and 92% respectively (p > 0.05). These results are in accordance with other studies published on RES, MRI and endovaginal ultrasound with or without contrast. The performances of RES

Table 3
Characteristics of endometriosis lesions in 3D-RSG.

	3D-RSG
Location	
Rectal lesions	31%
Sigmoid lesions	69%
Depth	
Serosa	19%
Muscularis	81%
Maximum diameter (mean in mm)	20.9
Volume (mean in cm ³)	2.11

Table 4

Prediction of the surgical procedure (resection or shaving) according to the location, the depth, the size, the volume of the digestive lesions at 3D-RSG.

	Shaving	Resection
Location		
Rectal (n = 9)	6 (67%)	3 (33%)
Sigmoid (n = 19)	8 (42%)	11 (58%)
Depth		
Serosal (n = 5)	5 (100%)	0 (0%)
Muscularis (n = 22)	11 (50%)	11 (50%)
Maximum diameter		
<24 mm (n = 15)	9 (60%)	6 (40%)
>24 mm (n = 9)	4 (44%)	5 (66%)
Volume		
<2.11 cm ³ (n = 11)	7 (64%)	4 (36%)
>2.11 cm ³ (n = 10)	4 (40%)	6 (60%)

Table 5

Performances of the RES for diagnosing endometriotic colorectal lesions.

Author (year)	Ref	N	Se (%)	Sp (%)	PPV (%)	NPV (%)
Roseau (2000)	(11)	46	100	100	–	–
Abrao (2004)	(12)	32	100	67	–	–
Chapron (2004)	(13)	81	97.1	89.4	86.8	97.7
Griffiths (2008)	(14)	32	78	93	–	–
Bazot (2007)	(15)	56	88.9	92.6	96	80.6
Bazot (2009)	(5)	92	88.9	93.1	96.6	79.4
Bergamini (2010)	(16)	61	88.2	80	95.7	57.1
Cazalis (2012)	(17)	25	94.7	66.7	90	80
Kanté (2016)	(18)	407	92	87	91	88

Ref = reference; n = number of patients; Se = sensitivity; Sp = specificity; PPV = positive predictive value; NPV = negative predictive value.

in the literature for diagnosing colorectal lesions are presented in Table 5 with a sensitivity ranging from 78% to 100% and a specificity ranging from 67% to 100% [3,13–20]. For the MRI, the meta-analysis of Mederios et al. based on 6 studies with a total of 675 patients, found a sensitivity and specificity of 83% and 88%, which is consistent with our results [21]. Hudelist et al. in their meta-analysis took interest in the diagnostic value of endovaginal ultrasound for the diagnosis of rectosigmoid deeply invasive endometriosis lesions [22]. Using ten studies and including 1106 patients, they reported a sensitivity and specificity of 91% and 98% respectively. More recently, in a meta-analysis of 2639 patients, Guerriero et al. found similar values with a sensitivity and a specificity of 91% and 97% respectively [23]. Because of high performance, low price, accessibility and good tolerance, some authors recommend the use of endovaginal ultrasound in first-line in the diagnosis of rectosigmoid endometriosis [3,24]. For the 3D-RSG our results are consistent with those from previous studies, which found a sensitivity of 95% and a specificity of 97% for diagnosing colorectal lesions [11].

Addition of intra rectal contrast during endovaginal ultrasound enhances the contrast between the different intestinal layers. Valenzano et al. compared in a blinded study on 69 patients, ultrasound with and without intra rectal contrast for the diagnosis of rectosigmoid endometriosis lesions. TVS with intrarectal contrast shows a trend in favor of a higher sensitivity (97% versus 90%) and a higher specificity (100% versus 90%) than standard TVS, even if it was not significant ($p = 0.74$) [10]. Leone Roberti Maggiore et al. who recently reported a series of 28 patients, also found that the 2D ultrasound with intra rectal contrast showed similar performances than MRI for the diagnosis of rectosigmoid endometriosis lesions with a sensitivity, specificity and accuracy of 93%, 97% and 95% respectively for the ultrasound versus 95%, 98% and 97% respectively for the MRI ($p = 0.063$) [12].

Few teams use the 3D acquisition in daily practice. Guerriero et al. report in their series of 129 patients a superiority of 3D

ultrasound over 2D ultrasound for extra-intestinal deep invasive endometriosis with a sensitivity and a specificity of 94% and 87% respectively against 88% and 71% respectively ($p = 0.0193$) [25]. For rectosigmoid lesions, there was a trend in favor of 3D ultrasound but the difference was not significant. Our study does not allow the comparison of 3D-RSG and standard TVUS as no analysis was carried-out between the two techniques to avoid the multiplication of procedure carried out on patients. However, according to our experience, the 3D acquisition allows a better visualization and characterization of the nodules, with a more precise analysis of their location, depth and volume. This technique also allows the acquisition of a volume centered on the Region of Interest (ROI), which can be reinterpreted by an expert either remotely or at a later time.

The diagnostic performances of the three examinations were similar. Also, there were no false-positives in our study, therefore suggesting that only one procedure out of the three is enough to consider that a patient has a colorectal lesion. Among the 11 false-negatives procedures, ten were visualized by two of the three imaging techniques. Therefore, the use of the two imaging examinations out of the three allowed to improve the sensitivity in the detection of rectosigmoid lesions to reach almost 100% (97.3%). In the case of symptoms suggestive of intestinal location of endometriosis, it seems logical to suggest a second examination when the first one is negative. A second exam can also be suggested to improve the preoperative assessment of the nodules in order to provide important knowledge to the surgeon and the patient. In our practice 3D-RSG and MRI are the first line procedure, but RES remains useful in the second line in case of discordance between the others.

Among the false-negatives in RES: 4 out of 6 were found in the sigmoid area which is difficult to reach with this procedure. This may explain that in univariate analysis we found a trend in favor of the 3D-RSG compared to the RES in the diagnosis of sigmoid lesions ($p = 0.08$). We also note that three nodules that were not detected by RES were associated with an incomplete secondary examination due to pain or a non-satisfactory intestinal preparation. This leads us to think that RES is less effective in the diagnosis of higher rectosigmoid lesions.

The detection of the depth of the lesion allowed us to estimate the risk of surgical resection. Therefore, there was significantly more intestinal resections when the lesions reached the muscularis in 3D-RSG ($p = 0.048$). However, we cannot exclude that the decision to perform or not a bowel resection may have been influenced by the results of the imaging methods. Some studies also show that the choice is certainly related to surgeons' philosophy [26]. We did not report significant influence of the size nor the volume of the lesion on the risk of resection. However, the lack of power due to our limited population limits the interpretation of this result. At the time of the study, our team only considered shaving versus segmental resection for the treatment of rectosigmoid locations, which explain why disc excision or trans-anal resections were not discussed in this article.

The choice to include patients with intestinal endometriosis limited to the serosal layer is controversial. Indeed, in the literature, most studies only include patients whose lesion affects the muscularis, based on the strict definition of deep endometriosis that is supposed to infiltrate more than 5 mm under the peritoneum. However, a lesion which is superior to 5 mm and visible on ultrasound and/or MRI does not correspond to general criteria of superficial lesions, which are generally flat and therefore invisible in radiology. The screening of the patient who underwent three imaging examinations before surgery limited the number of patients included in the study and probably selected patients. The retrospective analysis of the files suggests that in our center, the use of RES was often proposed only in complex situations and/or in

cases of discordance between imaging and clinical observations. The majority of patients treated in our center usually only undergo 3D-RSG and MRI.

5 Conclusion

The 3D-RSG, RES and MRI are three efficient techniques for diagnosing rectosigmoid endometriosis when performed by a referent operator. The 3D-RSG, which is easy to use, cheap and non-invasive, also allows a complete exploration of the pelvis and therefore a complete preoperative mapping of endometriosis lesions. All of these 3 procedures are strongly specific but not perfectly sensitive, which highlights the interest of combining them especially in cases of clinico-radiological discordance. Finally, the choice and hierarchy between these three imaging techniques of equivalent performance should probably be considered depending on the local availability of the imaging experts.

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Declaration of Competing Interest

All authors report no potential conflicts of interest.

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