

# Diagnostic value of endoscopic ultrasonography in pelvic masses with bowel involvement

Yu Mo She  and Nan Ge

*Ther Adv Gastroenterol*

2023, Vol. 16: 1–9

DOI: 10.1177/  
17562848231163414

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**Abstract:** Benign and malignant pelvic masses with or without intestinal invasion are common in women of childbearing age. Patients may have nonspecific symptoms and signs or experience no symptoms. Laparoscopic resection of pelvic masses is currently the mainstream treatment; therefore, accurate preoperative evaluation is not only essential for patients suspected of having intestinal invasion, but also extremely important for the selection of follow-up treatment. Procedures, including endoscopic ultrasonography (EUS), pelvic magnetic resonance imaging, abdominal computed tomography, vaginal ultrasonography, barium enema, and colonoscopy, aid in determining the presence, depth, and histology of the disease. In particular, the wide application and continuous developments in EUS techniques have improved the diagnostic accuracy for intestinal subepithelial and peripheral organ lesions. This article reviewed the clinical value of EUS in the diagnosis of benign and malignant pelvic masses with bowel involvement.

**Keywords:** benign and malignant pelvic masses, endometriosis, endoscopic ultrasonography

Received: 14 October 2022; revised manuscript accepted: 26 February 2023.

## Introduction

The intestinal tract is the most common extra-genital invasive site of pelvic masses, such as endometriosis, affecting 3.8–37% of patients with endometriosis,<sup>1</sup> and up to 95% of intestinal endometriosis is found in the rectum and sigmoid. The digestive system-related symptoms of pelvic masses infiltrating the rectosigmoid may include diarrhea, constipation, abdominal distension, and periodic rectal bleeding, which are similar to or overlap with the symptoms of irritable bowel syndrome, making the diagnosis of pelvic masses infiltrating the rectosigmoid challenging.<sup>2</sup> Intestinal invasion of pelvic masses is difficult to diagnose in up to 30–40% of patients. This often leads to substantial treatment difficulties, including the delayed discovery of digestive system involvement, usually before or during surgery, which ultimately results in incomplete treatment. Since the late 1990s, endoscopic ultrasonography (EUS) has been used to preoperatively evaluate patients with endometriosis suspected of having rectosigmoid invasion.<sup>3,4</sup> The

development of EUS has improved the potential for the preoperative diagnosis of benign and malignant pelvic masses. Numerous studies have proven its clinical value. Compared with other imaging techniques, EUS has better sensitivity for the diagnosis of benign pelvic diseases, close to 100%, and the positive and negative predictive values are as high as 86.8% and 97.7%, respectively.<sup>5–7</sup> Moreover, EUS is superior to pelvic magnetic resonance imaging (MRI) for the diagnosis of benign rectal and sigmoid pelvic masses. This review aimed to summarize the diagnostic value of EUS and compare it with other imaging methods for benign and malignant pelvic masses infiltrating the intestine.

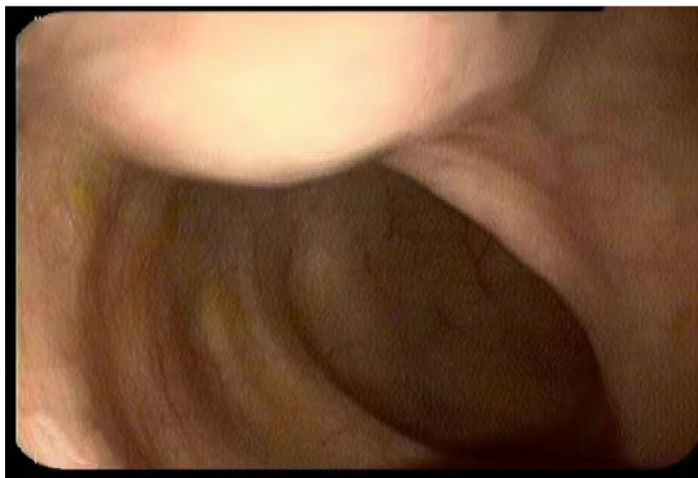
## Diagnostic value of EUS in benign pelvic masses with colorectal involvement

### *EUS of colorectal endometriosis*

EUS can provide detailed information regarding the structure of the gastrointestinal wall and

Correspondence to:  
**Nan Ge**  
Department of  
Gastroenterology,  
Shengjing Hospital of  
China Medical University,  
No.36 Sanhao Street,  
Heping District, Shenyang,  
Liaoning Province, 110004,  
China  
[nge@cmu.edu.cn](mailto:nge@cmu.edu.cn)

**Yu Mo She**  
Department of  
Gastroenterology,  
Shengjing Hospital of  
China Medical University,  
Shenyang, Liaoning  
Province, China



**Figure 1.** A bulge at the junction of rectum and sigmoid with smooth surface.



**Figure 2.** A huge cystic mass in the pelvic cavity. The boundary between the mass and the adjacent intestinal wall was unclear and fused.

adjacent organs with high image accuracy and can display submucosal lesions within the gastrointestinal wall and the ultrasonic hierarchy of their origin. In the colon and rectum, endometriosis may manifest as an extramural lesion or a hypoechoic mass infiltrating the fourth hypoechoic layer. Currently, the international community has summarized a unified definition of the characteristics of colorectal endometriosis under EUS<sup>8</sup>; all forms of endometriosis with intestinal invasion are defined as gastrointestinal endometriosis. These rectosigmoid nodules infiltrating the intrinsic muscle layer are usually irregular hypoechoic masses with fuzzy edges, located in or penetrating the intestinal wall, accompanied by diffuse myometrial thickening. Submucosal involvement is characterized by discontinuity of hyperechoic lines (Figures 1 and 2).

#### *Diagnostic value of EUS in colorectal endometriosis*

The preoperative diagnosis of rectosigmoid endometriosis helps determine the surgical plan. It can be diagnosed and treated by gynecologists and gastroenterologists to improve the cure rate of the disease. EUS has achieved satisfactory results in the diagnosis of endometriosis infiltrating the intestinal tract (Table 1). In a retrospective study including large samples, Theodore *et al.*<sup>9</sup> revealed that the positive predictive value of EUS in the diagnosis of rectosigmoid endometriosis was 93.8% and the negative predictive value was 96.4%. In addition, the sensitivity and specificity were 88.2% and 98.2%, respectively, and the overall diagnostic accuracy was 95.8%. This indicates that EUS has a high application value in the preoperative evaluation of women undergoing

**Table 1.** Diagnostic performance of EUS for endometriosis with bowel involvement (all patients had a history of endometriosis).

Study type	Sensitivity	Specificity	Accuracy	Positive predictive value	Negative predictive value
Prospective study	92–96	66–100	80	64–100	90–92
Retrospective study	81–100	75–100	79.3–95.8	93.8	96.4–98.2

EUS, endoscopic ultrasonography.

surgery for suspected or known endometriosis. Chen *et al.*<sup>10</sup> reached similar conclusions to confirm that EUS has a high diagnostic value in patients with endometriosis and intestinal invasion. It can not only accurately diagnose patients with myometrial invasion, but also plays a particularly prominent role in the detection of mucosal and submucosal involvement. Roseau *et al.*<sup>5</sup> performed EUS in patients with deep pelvic endometriosis and suspected rectal wall invasion. After the EUS examination, 9 patients showed normal anatomy, 12 had no rectal wall invasion in endometriosis, and 25 had a typical rectal invasion. These lesions were confirmed by the surgical results of therapeutic laparoscopy ( $n=22$ ), laparotomy ( $n=25$ ), and clinical follow-up, which helped decide between laparoscopic surgery and laparotomy and avoid unnecessary surgical procedures.

Delpy *et al.*<sup>11</sup> conducted a prospective study involving 30 patients to evaluate the utility of EUS in the diagnosis of rectal wall involvement in pelvic endometriosis. The sensitivity, specificity, and positive and negative predictive values of EUS for endometriosis infiltrating the rectal wall were 92%, 66%, 64%, and 92%, respectively, with a diagnostic accuracy of 80%. Thus, in terms of sensitivity and negative predictive value, EUS is a highly effective method for detecting rectal wall invasion in endometriosis. However, according to previous studies,<sup>12,13</sup> EUS has limited diagnostic value in identifying lesions far away from the probe. Compared with other imaging methods, EUS can more accurately distinguish the origin layer of lesions, and EUS remains the first-line method for detecting rectal invasion in endometriosis. A prospective study with a larger sample size is further needed to verify the clinical applications of EUS for endometriosis infiltrating the intestinal wall.

EUS is a noninvasive technique with high sensitivity and specificity (97%–100% and 97%–100%, respectively)<sup>5,14,15</sup> for the diagnosis of rectal involvement in patients with known pelvic endometriosis. However, the role of EUS in the de novo diagnosis of rectosigmoid endometriosis in patients without a history of endometriosis needs to be confirmed by further research. Aline *et al.*<sup>16</sup> performed EUS and EUS-guided fine-needle aspiration (EUS-FNA) in five patients. Although the accuracy of EUS and EUS-FNA for intestinal endometriosis is low (40%), it provides a scope for future research.

For endometriosis patients with colorectal invasion confirmed by EUS, there are two surgical methods, rectosigmoidectomy and lesion dissection. Victor *et al.*<sup>17</sup> conducted a multicenter retrospective study of 73 patients who underwent EUS and intestinal surgery and concluded that lesion thickness is a potential predictor of intestinal resection. The thickness of the rectosigmoid endometriosis nodule on the EUS image was greater than 5.20 mm, indicating that intestinal resection may be required and that EUS is important in the selection of follow-up treatment options.

#### *Diagnostic value of EUS-derived technologies for colorectal endometriosis*

*Endoscopic ultrasound-guided fine-needle aspiration.* EUS-FNA is a minimally invasive, feasible, and safe examination method for the pelvic and abdominal recurrence of gynecological tumors. José *et al.*<sup>18</sup> reported that the accuracy rate of EUS-FNA was as high as 95.4% when utilized to evaluate lesions that could not be reached by other imaging techniques, which is very similar to the conclusions drawn by other studies.<sup>19</sup>

EUS-FNA is an effective method for the preoperative diagnosis of intestinal endometriosis. As an alternative to laparotomy, EUS-FNA can accurately describe tissue morphology, which may aid in avoiding unnecessary or excessive surgery. Kenichi *et al.*<sup>20</sup> reported a case of a 42-year-old woman who was admitted to the hospital for examination because of nonspecific gastrointestinal symptoms, including pain and abdominal distension. Abdominal computed tomography (CT) and pelvic MRI results revealed thickening of the sigmoid wall. Owing to severe stenosis, the sigmoid colon could not be examined, and the examination could not be completed. Mucosal biopsy samples obtained during colonoscopy could not confirm the diagnosis. Subsequently, EUS-FNA was performed. EUS revealed hypoechoic lesions in the thickened intestinal wall through exploration of the intestinal wall and surrounding tissues, and puncture specimens from the lesions. The histological results obtained by EUS-FNA showed a large amount of fibrosis in the endometrial glands, and the diagnosis of sigmoid endometriosis was confirmed by immunostaining. This result is consistent with the pathological results obtained after the final laparoscopic surgery. Sciumè *et al.*<sup>21</sup> performed an accurate and positive diagnosis of a patient using EUS-FNA and administered a corresponding treatment, further proving the high accuracy and low complication rate of EUS-FNA.

Aline *et al.*<sup>22</sup> verified the diagnostic value of EUS-FNA for colorectal endometriosis; however, their final result was different from their hypothesis, which may be attributed to several factors, including insufficient puncture times, insufficient lesion targeting, and lack of experience in the field cell pathology. According to the literature, lesions in some parts require more fine-needle puncture times than those in other parts to ensure a good diagnostic rate. Owing to the nature of the diseased tissue, the diagnosis of endometriotic implants may require more than two or three fine needle punctures.

*Endoscopic ultrasound elastography.* EUS elastography (EUS-E) can distinguish fibrous and benign tissues from malignant lesions. This technology is based on the premise that some diseases (such as cancer) cause changes in tissue hardness.<sup>23</sup> EUS-E is performed using conventional EUS probes, without additional instruments or

real-time calculation of tissue distribution. The examination results are expressed in color superimposed on the traditional B-mode image, generally in blue for the hard tissue structure and in red for the soft tissue structure.<sup>24</sup> EUS-E is a real-time imaging technique. Gianni's preliminary research data<sup>25</sup> showed that the intraluminal ultrasound image is closely related to the pathological specimen obtained by surgery, and it confirmed that rectal EUS-E is a useful, non-invasive, and sensitive technique that can diagnose pelvic endometriosis with rectal invasion more accurately and provides a good basis for selecting the best surgical or medical strategy.

#### *Differential diagnosis value of EUS and other imaging methods*

Currently, the imaging methods used to diagnose rectosigmoid endometriosis include EUS, transvaginal ultrasound, barium enema, colonoscopy, contrast-enhanced CT, and pelvic MRI. MRI is very useful for the complete evaluation of the pelvis (pelvic floor, bladder, ureter, and muscle) and is the first-line choice for the evaluation of ovarian endometriosis and the accurate diagnosis of the rectovaginal septal implants. Because of its low cost and ease of operation, transvaginal ultrasound should be the first choice for diagnosing various gynecological diseases, including endometriosis infiltrating the intestine. The detection rate of barium enema for deep intestinal lesions is 88%; however, its specificity is very low (54%). Colonoscopy showed clear and typical specific signs of endometriosis in only 50% of deep intestinal lesions.

Chen *et al.*<sup>10</sup> evaluated the presence of rectal endometriosis using physical examination, transvaginal ultrasound, pelvic MRI, and EUS in 29 women with endometriosis suspected of rectal invasion. The sensitivity, specificity, positive predictive value, and negative predictive value obtained using these methods were compared with the surgical and histopathological results. The sensitivity, specificity, and accuracy of physical examination were 95.2%, 62.5%, and 86.2%, respectively; transvaginal ultrasound was 42.9%, 87.5%, and 55.2%, respectively; MRI was 90.5%, 87.5%, and 89.7%, respectively; and EUS was 81.0%, 75.0%, and 79.3%, respectively (Table 2). It was concluded that MRI combined with physical examination seems to be the main

**Table 2.** Diagnostic performance of EUS and other imaging methods for endometriosis with bowel involvement.<sup>10</sup>

Imaging methods	Accuracy	Sensitivity	Specificity
Physical examination	86.2	95.2	62.5
Transvaginal sonography	55.2	42.9	87.5
MRI	89.7	90.5	87.5
Rectal EUS	79.3	81	75

EUS, endoscopic ultrasonography; MRI, magnetic resonance imaging.

method for preoperative evaluation of rectovaginal endometriosis, and EUS is a valuable method for the diagnosis of rectal invasion.

Many studies have revealed that EUS is better than MRI for diagnosing rectosigmoid endometriosis. In the current large American cohort study, it was observed that EUS has high accuracy, with a negative predictive value of 98.2%, while the positive predictive value of MRI was 84–91.2%, and the negative predictive value was 64.1–84%.<sup>26–29</sup> In addition, compared with MRI, the cost of EUS is lower. The doctor's cost table of the United States Medical Assistance and Medical Insurance Service Center lists that the special cost for pelvic MRI (enhanced and non-enhanced) in February 2018 was \$434.52, which is in sharp contrast to the \$179.64 spent by EUS in the database in the same period. Dumontier *et al.*<sup>30</sup> reached a similar conclusion. Through a comparative analysis of 16 patients with endometriosis suspected of digestive tract invasion who had completed EUS and pelvic MRI examination and taking the final surgical and pathological results as the gold standard, they concluded that the sensitivity of EUS and MRI were 100% and 75%, respectively, and the specificity of both examinations was 100%. In this study, EUS was the best technique for diagnosing endometriosis with digestive tract invasion. However, MRI is more accurate in detecting other pelvic endometriosis lesions, such as those of the ovary, rectovaginal septum, and uterosacral ligament, and can perform more complete staging. A comparison of MRI and EUS showed that MRI results improved over time. The two studies by Thomasin *et al.*<sup>31</sup> and Bazot *et al.*<sup>32</sup> were prospective; in the former study, EUS showed better sensitivity and positive predictive value, whereas in the latter study, the superiority of EUS over MRI only

involved sensitivity and negative predictive value. Although MRI had slight advantages in terms of specificity and positive predictive value, it was not statistically significant. However, Amélie<sup>33</sup> has a different view. Amélie *et al.* revealed that the sensitivity, specificity, and accuracy of 3D transrectal ultrasound, EUS, and MRI were 94%, 100%, and 95%; 81%, 100%, and 84; and 90%, 100%, and 92%, respectively, for 37 patients who underwent surgical treatment at the same time. There was no significant difference between the three methods ( $p > 0.05$ ), indicating that they were all effective and performed well.

In a study comparing EUS and transvaginal ultrasound, there were two diametrically opposite results: Bazot *et al.*<sup>32</sup> tended to prefer transvaginal ultrasound to be more accurate, while Piketti<sup>34</sup> and Huang<sup>35</sup> believe that EUS has a higher diagnostic value. Further prospective studies with larger sample sizes are required to draw more accurate conclusions. Helizabet *et al.*<sup>36</sup> prospectively analyzed 37 patients with clinical suspicion of deep invasive endometriosis to evaluate the sensitivity, specificity, negative predictive value, and positive predictive value of double-contrast barium enema and EUS in diagnosing rectosigmoid endometriosis, which were 88%, 54%, 70%, and 78% and 96%, 100%, 90%, and 100%, respectively. Barium enema has good sensitivity and low specificity in the diagnosis of rectosigmoid endometriosis. However, compared to barium enema, EUS has a higher diagnostic value, and barium enema cannot be used for histological diagnosis. The sensitivity of colonoscopy in determining the depth of invasion of the intestinal wall is low, and only 5% of cases are allowed for histological diagnosis.<sup>37</sup> However, up to 60% of patients with deep endometriosis present with nonspecific chronic intestinal signs and



symptoms; therefore, in these cases, colonoscopy is necessary to exclude colitis and malignant epithelial diseases. Once the symptoms found by colonoscopy are clear, colonoscopy and EUS in the same procedure have a higher success rate and lower cost-effectiveness than those of the two methods alone.

#### **Diagnostic value of EUS in pelvic malignant tumors with colorectal involvement**

Pelvic malignant tumors refer to malignant tumors that occur in the uterus, ovary, fallopian tube, and other parts. Common pelvic malignant tumors such as cervical cancer, endometrial cancer, ovarian cancer, and fallopian tube cancer have progressed to the late stage and the best operation opportunity is lost due to atypical symptoms and lack of accurate diagnostic methods. At present, the commonly used diagnostic methods for pelvic malignant tumors include abdominal ultrasound, colonoscopy, abdominal CT, and pelvic MRI. When involving intestinal invasion of pelvic malignant tumors, the diagnostic value of various imaging methods is different; therefore, it is important to determine whether there is intestinal invasion, which determines the follow-up treatment plan.

Some studies have revealed that the sensitivities of colonoscopy and abdominal CT in the diagnosis of rectal invasion of recurrent cervical cancer are the same (33.3%).<sup>38</sup> However, Wang *et al.*<sup>39</sup> reported a case of primary cervical signet-ring cell carcinoma. The patient underwent colonoscopy and abdominal CT examination and underwent surgical treatment. The surgical records and abdominal CT showed suspicious malignant lesions and multiple metastases at the junction of the cervix and rectum; however, colonoscopy only showed the external pressure of the rectum without suggesting adhesion between the lesion and intestinal wall, which is inconsistent with previous conclusions. Future experiments are needed to verify the diagnostic accuracy of colonoscopy for malignant pelvic tumors infiltrating the intestine. The diagnostic value of abdominal CT is high, and intestinal invasion of endometrial cancer is relatively rare. Pinto *et al.*<sup>40</sup> reported a case of intermittent gastrointestinal bleeding in an elderly woman 2 years after treatment for endometrial cancer. CT not only showed the primary pelvic tumor, but also accurately showed

intestinal invasion and lymph node metastasis. Prasad *et al.*<sup>41</sup> found that CT had a 100% negative predictive value in excluding rectal invasion in cervical cancer patients; however, compared with colonoscopy, CT overestimated the invasion of the intestine. The diagnostic accuracy of pelvic MRI for intestinal invasion of pelvic malignant tumors is also high (up to 85%).<sup>42</sup> However, for patients, 6–12 months after radiotherapy, pelvic MRI cannot accurately distinguish between radiation changes and tumor invasion. Some studies have revealed that the diagnostic accuracy of enhanced MRI for rectal invasion is higher than that of ordinary MRI, which requires further research.<sup>43</sup>

At present, there are relatively few studies on the diagnostic value of EUS for malignant pelvic tumors; however, the existing literature proves that EUS has a higher diagnostic value than CT and MRI. Shirahana *et al.*<sup>44</sup> conducted various imaging assessments on 16 patients with pelvic malignant tumors to determine whether they had rectal wall invasion. EUS accurately determined that four patients had intestinal wall invasion; however, this was exaggerated in one patient; CT accurately identified two patients with intestinal wall invasion; however, the condition was exaggerated in three patients and underestimated in two patients; MRI was only performed in 14 patients, accurately evaluated the condition of two patients, exaggerated the condition of three patients, and underestimated the condition of one patient. This preliminary study indicates that EUS is more accurate than CT or MRI in assessing rectal wall involvement in pelvic tumors.

#### **Diagnostic value of EUS in pelvic rare causes with colorectal involvement**

Kizaki *et al.*<sup>45</sup> reported a case of mature cystic teratoma of the ovary with rectum fistula caused by local inflammation. Because the patient had diarrhea symptoms, they carried out relevant endoscopy. They found that there were ulcerative lesions adjacent to the ovarian cyst in the rectal wall and suspected that ovarian teratoma formed a fistula to the rectum. Finally, laparoscopy confirmed this inference. Although the description of endoscopy in this study is relatively few, it shows the accuracy of EUS in the etiological diagnosis of ovarian mature teratoma with intestinal fistula.

EUS is a promising and reliable minimally invasive imaging method for diagnosing benign and malignant pelvic tumors with digestive tract involvement. It has high diagnostic accuracy and cost-effectiveness. Most cases of pelvic masses of digestive tract infiltration are located at the distal end of the sigmoid, which is especially suitable for the application of EUS. It combines endoscopy and an ultrasound probe to evaluate the distal part of the rectum and sigmoid colon. Compared with other imaging examinations suitable for diagnosing pelvic masses and staging, EUS is easier to diagnose the intestinal and rectovaginal septal invasion of pelvic masses, while MRI and transvaginal ultrasound are more suitable for diagnosing ovarian lesions and bladder invasion. The diagnostic value of these imaging methods should be studied in prospective studies with a larger sample size to accurately determine which patients should benefit from EUS. For patients with pelvic masses who are worried about the rectosigmoid invasion, EUS, EUS-FNA, and EUS-E should be considered in addition to the diagnostic process of pelvic masses with intestinal invasion, and preoperative evaluation should be conducted through EUS and related technologies to help formulate the surgical plan, which can ensure that appropriate equipment and personnel are present to solve the most likely situation. In conclusion, MRI is the main examination method for comprehensive preoperative evaluation of benign and malignant pelvic masses. MRI combined with physical examination may be the main objective method for selecting the surgical approach and plan. The main function of EUS is to accurately evaluate the intestinal invasion of pelvic masses. The comprehensive application of various diagnostic methods for accurate preoperative evaluation can ensure complete resection of lesions, minimize the incidence of adverse events, and avoid the unreasonable use of medical resources.

## Declarations

### *Ethics approval and consent to participate*

Not applicable.

### *Consent for publication*

The patients/participants/guardians have obtained appropriate consent for publication.

### *Author contribution(s)*

**Yu Mo She:** Conceptualization; Methodology; Project administration; Resources; Software; Writing – original draft; Writing – review & editing.

**Nan Ge:** Conceptualization; Methodology; Project administration; Resources; Software; Supervision; Visualization; Writing – review & editing.

### *Acknowledgements*

The authors thank all the participants in this study. We are also grateful to the hospital staff who provided perspective and advice during the preparation of this manuscript.

### *Funding*

The authors received no financial support for the research, authorship, and/or publication of this article.

### *Competing interests*

The authors declare that there is no conflict of interest.

### *Availability of data and materials*

Not applicable.

## ORCID iD

Yu Mo She  <https://orcid.org/0000-0002-2925-6152>

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