






REVIEW ARTICLE

Are sonographers the future ‘gold standard’ in the diagnosis of endometriosis?

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Funding information

University of Adelaide; Australian Government

Abstract

Diagnosis of endometriosis has traditionally relied on laparoscopic surgery, which was considered the ‘gold standard’ diagnostic tool. This is not ideal as surgery carries risk, is expensive, is difficult to access, and disrupts patients work or education due to the recovery time needed. As such, imaging has been investigated as a potential method for non-invasive diagnosis, with transvaginal ultrasound showing high diagnostic accuracy for ovarian endometriomas and deep endometriosis. The advances in imaging capability led to recent international guidelines suggesting laparoscopy is no longer the ‘gold-standard’ for diagnosis and encouraging clinicians to utilise medical imaging as part of their diagnostic work-up for endometriosis. Imaging is emerging as not only a tool for planning endometriosis surgery but increasingly as the first approach for initial diagnosis. Given that transvaginal ultrasound is the primary imaging modality for assessment of gynaecological conditions, it is inevitable that sonographers will have a significant future role in endometriosis diagnosis. This moves away from endometriosis diagnosis being the exclusive realm of laparoscopic surgeons and increasingly involves medical imaging specialists. This review article will describe the origins of endometriosis ultrasound and the current capabilities of transvaginal ultrasound in this field. The expectations of sonographers in this evolving space will be explored, as well as recent novel research findings to gain insight into what the future of endometriosis diagnosis with ultrasound may look like.

KEYWORDS

diagnosis, endometriosis, sonographer, surgery, transvaginal ultrasound

1 | INTRODUCTION

Endometriosis is a complex, chronic condition, which typically arises within the pelvis. Defined as the presence of lesions similar to endometrial glands and stroma outside of the uterus,¹ it typically presents with chronic pelvic pain, dysmenorrhoea, dyspareunia, dyschezia and

abnormal bleeding.² The spectrum of symptoms however is broad, with less common symptoms such as fatigue, bloating and nausea reported.² In some cases, the condition will be completely asymptomatic. Latest Australian data suggests endometriosis affects as many as 1 in 7 women and people assigned female at birth,³ and the average Australian with endometriosis experiences a diagnostic delay of

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6.4 years.⁴ Endometriosis manifests in three ways; superficial endometriosis (SE), ovarian endometriosis (endometriomas) or deep endometriosis (DE), with the latter being the most severe and clinically challenging to manage.¹

Although not malignant and as such, often dismissed as a less serious disease, endometriosis can lead to severe complications such as infertility,² recurrent miscarriage,⁵ bowel obstruction,⁶ ureteric constriction leading to renal failure⁶ and mental health conditions such as depression.⁷ Furthermore, people with endometriosis experience higher rates of cancer,⁸ autoimmune conditions,⁹ and cardiovascular disease¹⁰ than those without endometriosis. As such, it is not surprising that people with endometriosis advocate against using the term 'benign' to describe the condition.¹¹

As there is currently no cure for endometriosis, all available therapies aim to provide symptomatic relief to improve quality of life. Laparoscopy surgery to excise lesions is a commonly employed therapy. However, given the risks associated with surgery, particularly repeated operations, and the high rates of recurrence reported after surgical procedures,¹² modern opinion suggests a more holistic approach to treatment involving excisional surgery along with medical (hormonal) treatments, pain management strategies as well as allied and complementary health techniques.¹³

The current consensus produced by the World Endometriosis Society (WES) suggests people with severe disease should be managed in centralised specialist endometriosis centres.¹³ In 2022, the Australian Federal Government initiated funding for 20 primary care facilities specialising in endometriosis management.¹⁴ Such centres will be extremely valuable to people with endometriosis and further heighten the need for reliable diagnostic tests to ensure timely triage to such services.

The aim of this review is to explore the origins, evolution, and current capabilities of transvaginal ultrasound (TVUS) for endometriosis. The expectations of sonographers in this changing space will be explored, as well as some exploration into emerging techniques within the literature to gain insight into what the future of endometriosis diagnosis with ultrasound may look like.

2 | THE ORIGINS AND EVOLUTION OF ENDOMETRIOSIS ULTRASOUND

Historically, diagnosis of endometriosis was only available through direct visualisation of the lesions (+/– histological confirmation) via laparoscopic surgery (Figure 1). Whilst this carries a high detection rate, surgery as a diagnostic test is not ideal due to cost and associated risks. Furthermore, surgery is invasive, and is disruptive to people's lives due to the need for time away from work or education to recover. In cases of DE, extensive adhesion of the pelvic organs, not discovered until the time of surgery, can make full visualisation and removal of the disease very challenging (Figure 2). This is particularly significant if the bowel or urinary tract are involved, as this requires an advanced laparoscopic surgeon along with a multidisciplinary surgical team to fully treat.¹⁵ Because of this, the typical standard of care

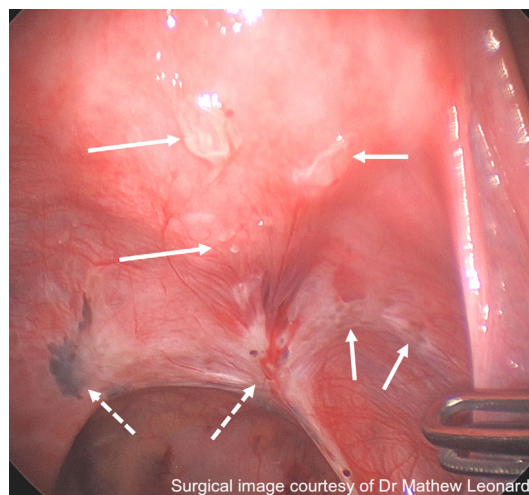


FIGURE 1 A laparoscopic image in which superficial and deep endometriosis exhibited. Superficial endometriosis (white arrows) can be seen lining the posterior uterine serosa and right pelvic sidewall. Deep endometriosis (dashed arrows) exhibited infiltrating both uterosacral ligaments.

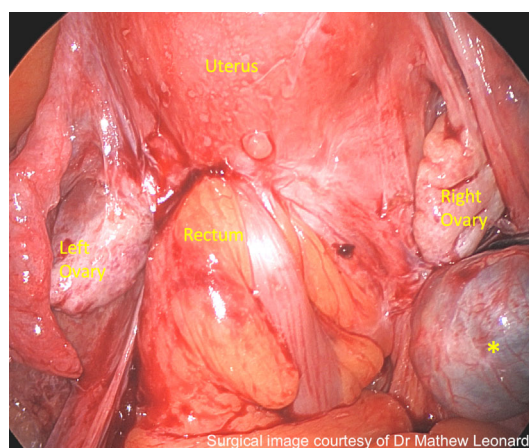


FIGURE 2 Laparoscopic image of severe endometriosis with obliteration of the pouch of Douglas. The bowel is specifically tethered to left uterosacral ligament and torus uterinus. The ovaries are normal appearing but affected by adhesions. A right paratubal cyst is also noted (*).

historically, when severe DE was discovered at diagnostic laparoscopy, was to abandon the procedure and perform a second surgery, once a suitable team could be established.¹⁵

Early in the twenty-first century, reports began appearing within published literature as to the utility of TVUS for the detection of pelvic endometriosis.¹⁶ The objective of TVUS in this early work was detecting DE prior to surgery, avoiding the need to perform multiple surgeries and reduce the number of laparoscopies being performed. After many years of research and refinement of the technique, multiple diagnostic test accuracy studies (DTAs), which have been synthesised into systematic reviews and meta-analyses have been published in the literature.^{17–21} In 2016, the International Deep Endometriosis Analysis (IDEA) group published their consensus paper

TABLE 1 The systematic, four-step approach as proposed by the International Deep Endometriosis Analysis (IDEA) consensus to perform transvaginal ultrasound for the detection of endometriosis including the anatomy assessed in each step. For further clarity, we have separated the fourth step into two parts.

Step	Assessment performed	Pathology detected
1	Uterus and ovaries	<ul style="list-style-type: none"> • Adenomyosis • Ovarian endometriomas
2	Ovarian mobility and site-specific tenderness	<ul style="list-style-type: none"> • Ovarian adhesions • Sites of tenderness which may indicate endometriosis
3	Uterine sliding sign	<ul style="list-style-type: none"> • Obliteration of the pouch of Douglas
4a	Anterior compartment <ul style="list-style-type: none"> • Bladder • Ureters • Vesicouterine space 	<ul style="list-style-type: none"> • Nodules of deep endometriosis within the anterior compartment
4b	Posterior compartment <ul style="list-style-type: none"> • Posterior vaginal wall • Uterosacral Ligaments • Rectosigmoid colon • Pouch of Douglas • Rectovaginal septum 	<ul style="list-style-type: none"> • Nodules of deep endometriosis within the posterior compartment

outlining the systematic approach which sonographers can utilise to perform a scan to detect DE (Table 1).²² The method proposed by the IDEA consensus is based on extensive literature from the decade up to 2016 and has since been validated.²³ Examples of endometriosis as it appears on TVUS can be seen in Figures 3 and 4.

From its initial origins as a tool to help reduce the incidence of repeated surgeries, endometriosis transvaginal ultrasound (eTVUS) has now evolved into a means of providing a non-surgical diagnosis of endometriosis, delivering validation of suffering to patients.²⁴ This change has likely been motivated by the high prevalence of the disease and its significant diagnostic delay, along with opening a pathway to non-surgical therapy as is becoming more frequent. Additionally, laparoscopy is by no means a perfect diagnostic tool. Multiple studies have highlighted that the 'gold standard' of laparoscopy is not faultless.²⁵⁻²⁷ In addition to the potential risks outlined previously, there is also the risk of false negative results due to subperitoneal lesions that may be occult at laparoscopy, and a false negative histopathologic result if disease has undergone surgical diathermy during the laparoscopy.²⁴ In addition, from a health economics perspective, there are significant costs with diagnostic laparoscopy, which can be reduced if non-invasive diagnostic options are available.²⁸

Due to the factors outlined above, a substantial change in diagnostic algorithms for endometriosis occurred in 2022 when the European Society for Human Reproduction and Endocrinology (ESHRE) endometriosis guideline²⁹ was updated to state that laparoscopy is no longer considered the 'gold standard' in the diagnosis of endometriosis. Instead, it is now suggested that imaging (whether eTVUS or magnetic resonance imaging [MRI]), be part of the diagnostic work up and that if that imaging reveals endometriosis, surgery is not required to confirm the diagnosis. It is explicitly stated within these guidelines however, that a negative imaging examination does not exclude endometriosis.²⁹

3 | LATEST LITERATURE AND TRANSLATION INTO THE CURRENT EXPECTATION OF AUSTRALASIAN SONOGRAPHERS IN THEIR CLINICAL PRACTICE

Early studies into eTVUS typically used inconsistent terminology and descriptors which made comparing studies and pooling results difficult.¹⁷ Since the publication of the IDEA consensus, most modern-day DTAs now utilise IDEA methodology in their ultrasound assessments.^{23,30-32} This shift both benefits our understanding of the research, as direct comparisons of studies are now simpler but has also allowed for refinement of the technique, which will translate into clearer understanding of the expectations of sonographers implementing these techniques. A comprehensive eTVUS, as proposed by the IDEA consensus, involves assessing the uterus and ovaries, as per a routine TVUS, as well as an assessment of the ovarian mobility, site specific tenderness, the uterine 'sliding sign', the anterior pelvic compartment (bladder, ureters and vesicouterine space) and posterior pelvic compartment (rectosigmoid colon, uterosacral ligaments (USLs), rectovaginal septum, pouch of Douglas (POD) and posterior vaginal wall) (Table 1).²² An example of how this is performed can be seen in Video S1. Many systematic reviews and meta-analyses have been performed on this subject confirming high levels of diagnostic accuracy for the assessment of the structures of the anterior and posterior compartment.^{17-21,33} When performed confidently, and in a systematic manner, eTVUS has been shown to exhibit sensitivities and specificities 88% and 96% for rectosigmoid endometriosis,³⁴ 94% and 96% for POD obliteration,³⁵ and 83%-100% and 100% for the uterosacral ligaments.³⁶ In the years following publication of the IDEA consensus, literature has emerged proposing the assessment of additional anatomical structures such as the parametrium³⁷ and the sacral nerve roots,³⁸ signifying that a comprehensive eTVUS may, in the future, become an even more detailed examination than that required today.

In addition to diagnostic accuracy, prevalence of disease per location has been reported within the literature, consistently showing DE to be detected on eTVUS most commonly within the USLs, ovaries (endometriomas) and rectosigmoid colon,^{23,32,36,39} which is in keeping with established beliefs from older literature.⁴⁰ This is helpful for sonographers who are upskilling to perform eTVUS for several reasons. Firstly, focus can be placed on first learning to assess these structures, which means that even if confidence has not been gained in all aspects of a comprehensive eTVUS, sonographers can be confident they are likely to detect disease, if present, by focusing on the most affected structures. If more disease is suspected, further referral to an expert sonographer or sonologists could then occur to both provide the patient with a complete examination and potentially, provide valuable feedback to sonographers during the upskilling phase.

It is not clear what exactly the expectation of Australian sonographers is regarding performing eTVUS currently. Despite international guidelines advocating for eTVUS for the diagnosis of endometriosis,²⁹ the Australasian guidelines for the performance of gynaecological ultrasound do not currently suggest routine inclusion of an

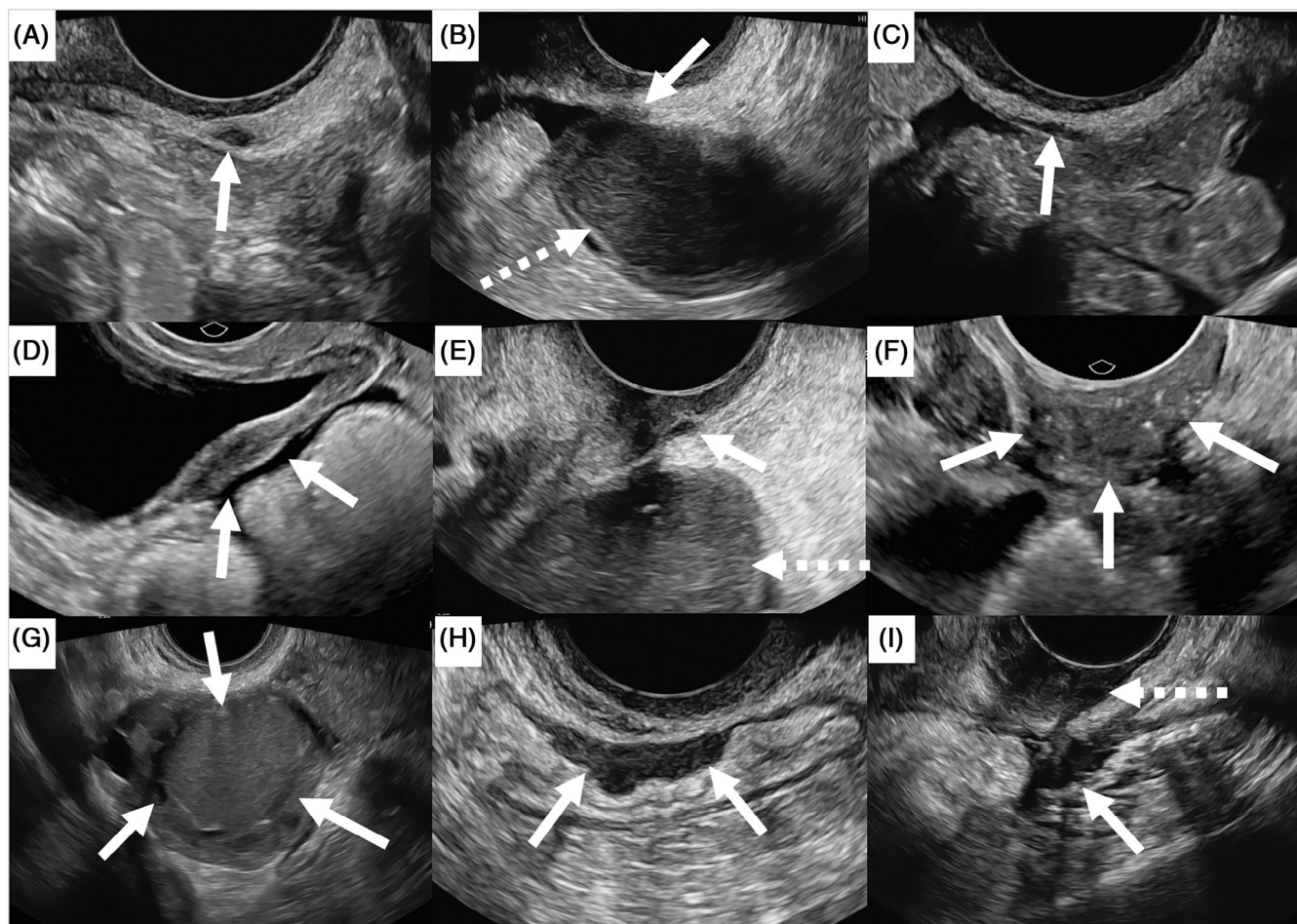


FIGURE 3 Various example of deep endometriosis as it can appear on transvaginal ultrasound at various anatomical locations as demonstrated by the white arrows. (A) Left uterosacral ligament nodule. (B) Left uterosacral ligament nodule. Note how this nodule is abutting an endometrioma within the left ovary (dashed arrow). (C) Right uterosacral ligament disease. (D) Bladder nodule presenting as fusiform thickening within the posterior bladder wall. (E) A small nodule within the pouch of Douglas abutting the posterior vaginal wall. (F) A large nodule within the posterior vaginal fornix. (G) An ovarian endometrioma showing the classic appearance of a unilocular cystic lesion containing 'ground-glass' internal echoes. (H) A nodule of endometriosis within the rectosigmoid colon. (I) A nodule of endometriosis which is adherent to a nodule of endometriosis within the posterior vaginal fornix (dashed arrow) sonographically presenting as a diablo lesion.

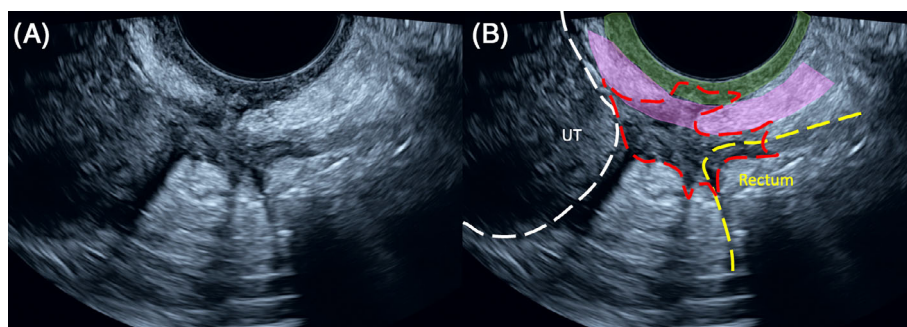


FIGURE 4 A transvaginal ultrasound image of a nodule of deep endometriosis originating within the right uterosacral ligament (A). Deep endometriosis will often infiltrate into surrounding anatomical structures. In this case, this lesion can be seen infiltrating into the vaginal wall, rectum and adhering to the uterus. Image (B) is the same image marked up to highlight the relevant anatomy. The nodule is demarcated with the red dashed line. Green = posterior vaginal wall, pink = uterosacral ligament, yellow dashed line = anterior rectal wall and white dashed line = uterine serosa.

assessment of the anterior and posterior compartment for endometriosis, although it is stated that this can be done if needed.⁴¹ Currently in Australia, eTVUS is not available in all imaging centres and typically, patients must present to specialised practices to access eTVUS.^{42,43} As most published DTAs to date come from specialised endometriosis centres, with high prevalence of disease, it is unclear what the level of diagnostic accuracy is when eTVUS is performed within the general imaging setting, where prevalence of disease is lower and imaging is performed by sonographers who may not be specialists in endometriosis.^{17,32} As such, questions still remain as to whether scanning for endometriosis will be a technique which should be performed within general ultrasound departments, or whether it is best placed in specialised practices.¹⁷ Indeed, the current Australasian Competency Framework for sonographers lists scanning for endometriosis as an advanced skill in gynaecological ultrasound, rather than a core skill for all sonographers performing gynaecological ultrasound.⁴⁴ It has been demonstrated that obstetrics and gynaecology focused sonographers were able to perform eTVUS with comparable levels of diagnostic accuracy to those produced in specialised endometriosis centres.³² Although no published DTAs exists to show the accuracy achieved by general sonographers in the general radiology setting, it is the opinion of the authors that, given the high-level of education and skill Australian sonographers possess, eTVUS is a technique which all sonographers can achieve with adequate training. For instance, most general sonographers can perform fetal morphology scans, which are extremely technically complex, in a community setting to a high standard. Furthermore, some promoters of eTVUS have advocated for the inclusion of an endometriosis assessment into all TVUS examinations.⁴⁵ Given that Leonardi et al.⁴⁶ reported 28% of people presenting for gynaecological ultrasound, in a low-risk community, had symptoms suggestive of endometriosis and Chaggar et al.⁴⁷ reported 19% of people presenting to a gynaecology clinic had endometriosis visible on TVUS, the argument for eTVUS, or at least key elements of it, to become the routine gynaecological ultrasound examination is strong.

Implementing eTVUS into routine sonographic practice is not without its challenges. Firstly, performing eTVUS requires sonographers and radiologists to increase their skills and build upon their clinical knowledge, which may be lacking in endometriosis, given it has not been a large part of imaging historically. Thankfully, many freely accessible educational resources exist to aid in the upskilling on imaging professionals, such as 'How To' articles by Fang et al.⁴⁸ and Leonardi et al.⁴⁹ Furthermore, several studies have shown the learning curve associated with eTVUS to be achievable within a reasonable number of scans,^{50–52} although this does differ between individual learners.⁵³ A limitation of these studies however is that they have all been conducted within specialised settings. As yet, no learning curve studies have been conducted within general imaging environments. It is reasonable to assume that the learning curve for those exposed to less disease would be longer than those who encounter endometriosis frequently. Given the highly dynamic nature of an eTVUS examination, it does not fit well into our established method of performing ultrasound in Australia in which sonographers capture still images for radiologists or sonologists to review offline. A solution to this has

been proposed by Young et al.⁵⁴ in the form of a protocol specifically for sonographer-acquired eTVUS which can be reported offline by radiologist. Additionally, when learning any new skill, receiving feedback is an essential part of the learning process which can be challenging if individual practices do not have staff members with enough experience to act as mentors for others.

Implementing eTVUS adds additional time to the examination. It has been shown that eTVUS takes, on average, 70% longer to perform than routine TVUS.⁴² As there is currently no additional remuneration from Medicare for performing eTVUS,⁵⁵ this additional time allocation may be cost prohibitive in some centres, especially those not charging gap payments. It has been suggested however, that changes could be made to gynaecological ultrasound protocols to reallocate time to an endometriosis assessment, by removing mandatory protocol inclusions with lower clinical value, such as routine kidney imaging in the general population⁵⁶ or extensive transabdominal scanning.⁴² It ought to be noted however, that while scanning the kidneys in every patient has been shown within the literature to be superfluous,⁵⁶ if DE is detected on TVUS, extending the scan to assess the kidneys for hydronephrosis is recommended as per the IDEA consensus to screen for ureteric compromise.²² In addition to the skill and knowledge progression of professionals, referring clinicians must also learn about the value of eTVUS and how it can be utilised in their care plan for patients, and evidence suggests there is still low awareness amongst gynaecologists about the value of eTVUS for endometriosis diagnosis,⁵⁷ although this is improving. These challenges, highlighted above, need to be addressed to expand access to this technique and allow more people with endometriosis to access a sonographic diagnosis.

4 | THE ROLE OF ULTRASOUND ALONGSIDE OTHER IMAGING TECHNIQUES SUCH AS MRI

TVUS is the first-line tool in the investigation of gynaecological pathologies. When it comes to endometriosis, MRI is the other imaging modality which has been shown within literature to have high diagnostic value for endometriosis.^{31,33,58–60} A 2016 Cochrane review into imaging methods for endometriosis from Niesenblat et al.³³ reported the diagnostic accuracy of MRI to be comparable to that of eTVUS. To obtain this level of diagnostic accuracy however, the correct sequences to maximise endometriosis detection must be performed and the radiologist reading the MRI must be experienced and skilled in pelvic imaging and endometriosis. If they are not, the diagnostic accuracy will likely be reduced because, unsurprisingly, just as ultrasound is an operator dependant modality, MRI is dependent on the skill of the reader to attain high diagnostic accuracy.⁶¹

In 2022, Medicare rebates for gynaecological MRI became available for Australians.⁵⁵ This funding however is limited to specific clinical indications, such as suspected DE, known uterine masses and failed in-vitro fertilisation cycles. Furthermore, this rebate can only be claimed once in a two-year period and, to be eligible for a rebate, the

MRI must be referred by a gynaecologist rather than a general practitioner.⁵⁵ By contrast, the rebates for ultrasound have no such restrictions (although there is no rebate specifically for eTVUS).⁵⁵ Given the second-line nature of MRI as an imaging modality for endometriosis, it is important to think of MRI as a means of complementing, not replacing eTVUS. Berger et al.⁶² reported that routinely adding MRI after eTVUS to the diagnostic work-up of endometriosis did not add value and as such, if a sonographer can perform a high-quality eTVUS, an MRI is generally unnecessary. The addition of an MRI to the diagnostic work-up of suspected endometriosis may be beneficial for cases in which eTVUS could not be completed or was suboptimally diagnostic due to limitations (such as large fibroids limiting views). One clear advantage of MRI over eTVUS is in cases of suspected extra pelvic endometriosis due to its extended field of view.⁶²

5 | LIKELY FUTURE DEVELOPMENTS OF ULTRASOUND IN THE DIAGNOSIS OF ENDOMETRIOSIS

5.1 | Superficial endometriosis (SE)

Ultrasound for the diagnosis of endometriosis has, until recently, been confined to the diagnosis of DE and endometriomas, with the detection of SE reliant on non-specific soft markers²² with poor diagnostic accuracy.^{32,63} In 2020 however, Leonardi et al.⁶⁴ were able to accurately detect SE lesions directly within the POD sonographically. They did this through artificially infusing saline into the POD through the uterus and fallopian tubes (a technique they named 'sonoPODography'), enabling the lesions to be seen protruding into the fluid.

Although this technique is not feasible in routine sonographic practice, in 2023 Pedrassani et al.⁶⁵ built upon this work to demonstrate sonographic detection of SE with the presence of physiological fluid in the POD by scanning during menses or the luteal phase of the menstrual cycle. In the clinical experience of the authors of this paper, detection of SE sonographically by utilising physiological fluid in the pelvis is very achievable (Figure 5). Although the few DTAs regarding sonographic detection of SE are single-centre studies, and all are yet to be validated, it is our opinion that sonographic detection of SE is achievable in clinical practice, if scanning is performed during the luteal phase of the menstrual cycle when physiological free fluid is likely to be present. Future studies further expanding on the works published to date regarding SE are needed which can then guide clinical practice for diagnosis of this subtype of endometriosis. If further studies confirm the findings of these early works, in the future, this will probably become an expectation during eTVUS examinations although, it is unlikely that any imaging test in isolation will ever be able to rule out SE.

5.2 | Elastography

As elastography measures tissue stiffness, there exists potential that this could be beneficial in the assessment of endometriosis, which overtime, causes fibrotic change to tissue.² Currently, only a few studies have investigated elastography in relation to endometriosis, however a systematic review by Brunelli et al.⁶⁶ revealed elastography has a high sensitivity and specificity for DE. Although there is currently insufficient evidence to know the exact clinical benefit, elastography could be a future advance in the diagnosis of endometriosis and

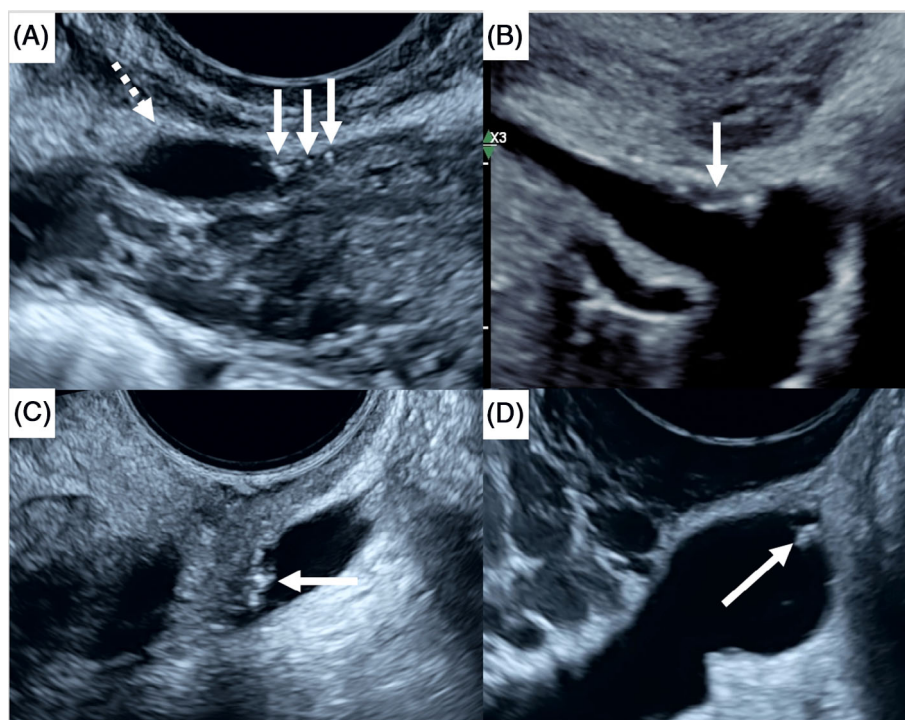


FIGURE 5 Examples for superficial endometriosis as they appear sonographically. (A) A cystic lesion on the anterior/right surface of the uterus (dashed arrow) with a subtle adjacent area of isoechoic tissue contain echogenic foci (solid arrows). Echogenic foci are a typical feature of superficial endometriosis on ultrasound. (B) A hypoechoic lesion arising from the surface of the peritoneum in the pouch of Douglas, again with associated echogenic foci. (C and D) Echogenic projections seen from the peritoneum in the pouch of Douglas protruding into the physiological free fluid (D).

future research is needed to guide how elastography may assist in the diagnosis of endometriosis.

5.3 | Artificial intelligence (AI)

No discussion of the future of sonographic practice would be complete without a mention of the role of artificial intelligence (AI). Reports of AI in the detection of endometriosis with ultrasound are at this stage, limited. Maicas & Leonardi et al.⁶⁷ reported high diagnostic accuracy when using a deep learning technique (Resnet(2 + 1)D) to detect POD obliteration from videos of the sonographic 'sliding sign'. Further work by Balica et al.⁶⁸ found an accuracy of 80% when augmenting endometriosis analysis from ultrasound with deep learning, although it is unclear exactly how this was achieved. This study was further limited by the very small data set ($n = 100$) used in this study.

Guerriero et al.⁶⁹ assessed the diagnostic accuracy of multiple machine learning algorithms in detecting rectosigmoid endometriosis, by analysing several indirect signs which may be detected on routine gynaecological ultrasound studies. This work is very preliminary in nature and, most importantly, was not able to replicate the accuracy of an experienced ultrasound expert. It is worth noting that these studies are all based on a relatively small sample sizes from single centres only. As a result, there may be limitations regarding the generalisability of these AI models, with external validation involving larger data sets needed. Furthermore, there is currently no discussion on how these AI models could fit into the workflow of a sonographer. It is likely however that in the future, AI analysis of 'big data' will be playing a much larger role diagnostic prediction. Future research further investigating AI will guide what exactly this role is.

6 | CONCLUSION

The utility of eTVUS has evolved over the last two decades from a surgical planning instrument to a wide-spread diagnostic tool, with contemporary guidelines suggesting a move away from laparoscopic diagnosis towards imaging for the purpose providing a diagnosis of endometriosis. Given the role of TVUS as the first-line imaging modality for gynaecological conditions, it is inevitable that sonographers will play key role in endometriosis diagnosis into the future. However, there are challenges which exist in learning the skills required to perform eTVUS and implementing eTVUS into general sonography practice as outlined within this review.

As imaging professionals, if we can rise to these challenges and expand ultrasound diagnosis, this will reduce health costs, complex pain and infertility complications and the morbidity of surgery, whilst optimising care and facilitating treatment options for people suffering with endometriosis.

ACKNOWLEDGMENT

Open access publishing facilitated by The University of Adelaide, as part of the Wiley - The University of Adelaide agreement via the Council of Australian University Librarians.

FUNDING INFORMATION

Alison Deslandes is a recipient of a Research Training Program Stipend from the University of Adelaide and a research training program fee offset scholarship from the Australian Commonwealth Government. This manuscript is the work of the IMAGENDO group, which received funding from the Australian Government through the Medical Research Futures Fund: Primary Health Care Research Data Infrastructure Grant 2020 and from Endometriosis Australia.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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REFERENCES

- Tomassetti C, Johnson NP, Petrozza J, Abrao MS, Einarsson JI, Horne AW, et al. An international terminology for endometriosis, 2021. *Facts Views Vis Obgyn*. 2021;13(4):295–304.
- Horne AW, Missmer SA. Pathophysiology, diagnosis, and management of endometriosis. *BMJ*. 2022;14(379):e070750.
- Australian Institute of Health and Welfare. Endometriosis, Economic burden. 2023 [cited 2023 Sep 25]. Available from: <https://www.aihw.gov.au/reports/chronic-disease/endometriosis-in-australia/contents/impact/economic-burden>
- O'Hara R, Rowe H, Fisher J. Managing endometriosis: a cross-sectional survey of women in Australia. *J Psychosom Obstet Gynaecol*. 2022;43(3):265–72.
- Sachs MK, Makieva S, Dedes I, Kalaitzopoulos DR, El-Hadad S, Xie M, et al. Higher miscarriage rate in subfertile women with endometriosis receiving unbiopsied frozen-warmed single blastocyst transfers. *Front Cell Dev Biol*. 2023;11:1092994.
- Charatsi D, Koukoura O, Ntavela IG, Chintziou F, Gkorila G, Tsagkoulis M, et al. Gastrointestinal and urinary tract endometriosis: a review on the commonest locations of extrapelvic endometriosis. *Adv Med*. 2018;26(2018):e3461209.
- Facchin F, Barbara G, Dridi D, Alberico D, Buggio L, Somigliana E, et al. Mental health in women with endometriosis: searching for predictors of psychological distress. *Hum Reprod*. 2017;32(9):1855–61.
- Kvaskoff M, Mahamat-Saleh Y, Farland LV, Shiges N, Terry KL, Harris HR, et al. Endometriosis and cancer: a systematic review and meta-analysis. *Hum Reprod Update*. 2021;27(2):393–420.
- Shiges N, Kvaskoff M, Kirtley S, Feng Q, Fang H, Knight JC, et al. The association between endometriosis and autoimmune diseases: a systematic review and meta-analysis. *Hum Reprod Update*. 2019;25(4):486–503.
- Blom JN, Velez MP, McClintock C, Shellenberger J, Pudwell J, Brogly SB, et al. Endometriosis and cardiovascular disease: a population-based cohort study. *Can Med Assoc Open Access J*. 2023;11(2):E227–36.
- #DropTheBenign: Endometriosis UK wants to end long-term undermining of debilitating condition. Endometriosis UK. [cited 2023 Nov 14]. Available from: <https://www.endometriosis-uk.org/dropthebenign-endometriosis-uk-wants-end-long-term-undermining-debilitating-condition>

12. Nirgianakis K, Ma L, McKinnon B, Mueller MD. Recurrence patterns after surgery in patients with different endometriosis subtypes: a long-term hospital-based cohort study. *J Clin Med*. 2020;9(2):496.
13. Johnson NP, Hummelshoj L, World Endometriosis Society Montpellier Consortium. Consensus on current management of endometriosis. *Hum Reprod Oxf Engl*. 2013;28(6):1552–68.
14. Australian Government Department of Health and Aged Care. Endometriosis and pelvic pain clinics. 2023 [cited 2023 Oct 24]. Available from: <https://www.health.gov.au/our-work/endometriosis-and-pelvic-pain-clinics>
15. Reid S, Condous G. Transvaginal sonographic sliding sign: accurate prediction of pouch of Douglas obliteration. *Ultrasound Obstet Gynecol*. 2013;41(6):605–7.
16. Bazot M, Thomassin I, Hourani R, Cortez A, Darai E. Diagnostic accuracy of transvaginal sonography for deep pelvic endometriosis. *Ultrasound Obstet Gynecol*. 2004;24(2):180–5.
17. Deslandes A, Parange N, Childs JT, Osborne B, Bezak E. Current status of transvaginal ultrasound accuracy in the diagnosis of deep infiltrating endometriosis before surgery. *J Ultrasound Med*. 2020;39(8):1477–90.
18. Zhou Y, Su Y, Liu H, Wu H, Xu J, Dong F. Accuracy of transvaginal ultrasound for diagnosis of deep infiltrating endometriosis in the uterosacral ligaments: systematic review and meta-analysis. *J Gynecol Obstet Hum Reprod*. 2021;50(3):101953.
19. Gerges B, Li W, Leonardi M, Mol BW, Condous G. Meta-analysis and systematic review to determine the optimal imaging modality for the detection of bladder deep endometriosis. *Eur J Obstet Gynecol Reprod Biol*. 2021;261:124–33.
20. Gerges B, Li W, Leonardi M, Mol BW, Condous G. Optimal imaging modality for detection of rectosigmoid deep endometriosis: systematic review and meta-analysis. *Ultrasound Obstet Gynecol*. 2021;58(2):190–200.
21. Tian Z, Zhang YC, Sun XH, Wang Y, Zhao Y, Chang XH, et al. Accuracy of transvaginal ultrasound and magnetic resonance imaging for diagnosis of deep endometriosis in bladder and ureter: a meta-analysis. *J Obstet Gynaecol*. 2022;42(6):2272–81.
22. Guerriero S, Condous G, van den Bosch T, Valentin L, Leone FPG, Van Schoubroeck D, et al. Systematic approach to sonographic evaluation of the pelvis in women with suspected endometriosis, including terms, definitions and measurements: a consensus opinion from the International Deep Endometriosis Analysis (IDEA) group. *Ultrasound Obstet Gynecol*. 2016;48(3):318–32.
23. Leonardi M, Uzuner C, Mestdag W, Lu C, Guerriero S, Zajicek M, et al. Diagnostic accuracy of transvaginal ultrasound for detection of endometriosis using International Deep Endometriosis Analysis (IDEA) approach: prospective international pilot study. *Ultrasound Obstet Gynecol*. 2022;60(3):404–13.
24. Avery JC, Deslandes A, Freger SM, Leonardi M, Lo G, Carneiro G, et al. Non-invasive diagnostic imaging for endometriosis part 1: a systematic review of recent developments in ultrasound, combination imaging and artificial intelligence. *Fertil Steril*. 2023; [cited 2024 Jan 10]. Available from: [https://www.fertstert.org/article/S0015-0282\(23\)02075-7/fulltext](https://www.fertstert.org/article/S0015-0282(23)02075-7/fulltext)
25. Harth S, Roller FC, Zeppernick F, Meinhold-Heerlein I, Krombach GA. Deep infiltrating endometriosis: diagnostic accuracy of preoperative magnetic resonance imaging with respect to morphological criteria. *Diagn Basel Switz*. 2023;13(10):1794.
26. Fadadu PP, Cope A, Weng CS, Mara K, Khan Z, VanBuren W, et al. Gastrointestinal symptoms as a predictor of deep endometriosis of the pelvic posterior compartment on magnetic resonance imaging. *J Endometr Pelvic Pain Disord*. 2022;14(2):92–7.
27. Hausmann D, Perignon V, Grabherr R, Weiland E, Nickel MD, Murer M, et al. Can dynamic contrast-enhanced MRI contribute to improved assessment of rectosigmoid involvement in deep infiltrating endometriosis? *In Vivo*. 2021;35(4):2217–26.
28. Leonardi M, Martin E, Reid S, Blanchette G, Condous G. Cost analysis of the use of deep endometriosis transvaginal ultrasound in the workup of patients with symptoms of endometriosis. *Ultrasound Med Biol*. 2019;1(45):S105.
29. Becker CM, Bokor A, Heikinheimo O, Horne A, Jansen F, Kiesel L, et al. ESHRE guideline: endometriosis. *Hum Reprod Open*. 2022;2022(2):hoac009.
30. Szabó G, Hudelist G, Madár I, Rigó JJ, Dobó N, Fintha A, et al. Diagnostic accuracy of the IDEA protocol for non invasive diagnosis of rectosigmoid DE – a prospective cohort study. *Ultraschall Med Stuttgart, Germany*. 1980. 2023; [cited 2023 Mar 07]. <https://doi.org/10.1055/a-2034-2022>
31. Indrielle-Kelly T, Frühauf F, Fanta M, Burgetova A, Lavu D, Dundr P, et al. Diagnostic accuracy of ultrasound and MRI in the mapping of deep pelvic endometriosis using the international deep endometriosis analysis (IDEA) consensus. *Biomed Res Int*. 2020;30(2020):e3583989.
32. Deslandes A, Parange N, Childs JT, Osborne B, Hull ML, Panuccio C, et al. What is the accuracy of transvaginal ultrasound for endometriosis mapping prior to surgery when performed by a sonographer within an outpatient women's imaging centre? *J Med Imaging Radiat Oncol*. 2023;67(3):267–76.
33. Nisenblat V, Prentice L, Bossuyt PMM, Farquhar C, Hull ML, Johnson N. Combination of the non-invasive tests for the diagnosis of endometriosis. *Cochrane Database Syst Rev*. 2016;7(7):CD012281.
34. Ferrero S, Scala C, Stabilini C, Vellone VG, Barra F, Leone Roberti Maggiore U. Transvaginal sonography with vs without bowel preparation in diagnosis of rectosigmoid endometriosis: prospective study. *Ultrasound Obstet Gynecol*. 2019;53(3):402–9.
35. Venkatesh S, Anjali M, Vasudeva A, Kumar P. Sliding sign and gel sonovaginography: a sneak peek prior to laparoscopy in patients with endometriosis. *J Hum Reprod Sci*. 2020;13(1):26–30.
36. Freger SM, Turnbull V, McGowan K, Leonardi M. Prospective diagnostic test accuracy of uterosacral ligament and torus uterinus endometriosis using transvaginal ultrasound posterior approach. *Ultrasound Obstet Gynecol*. 2024; [cited 2023 Sep 22]. <https://doi.org/10.1002/uog.27492>
37. Barra F, Zorzi C, Albanese M, Stepniewska A, Deromemaj X, De Mitri P, et al. Ultrasonographic findings indirectly predicting parametrial involvement in patients with deep endometriosis: the ULTRA-PARAMETRENDO I study. *J Minim Invasive Gynecol*. 2023;30(1):61–72.
38. Szabó G, Madár I, Hudelist G, Arányi Z, Turtóczki K, Rigó J Jr, et al. Visualization of sacral nerve roots and sacral plexus on gynecological transvaginal ultrasound: feasibility study. *Ultrasound Obstet Gynecol*. 2023;62(2):290–9.
39. Manieri Rocha R, Leonardi M, Eathorne A, Armour M, Condous G. Anatomical distribution of endometriosis: a cross-sectional analysis of transvaginal ultrasound in symptomatic patients. *Australas J Ultrasound Med*. 2023;26(3):131–41.
40. Chapron C, Fauconnier A, Vieira M, Barakat H, Dousset B, Pansini V, et al. Anatomical distribution of deeply infiltrating endometriosis: surgical implications and proposition for a classification. *Hum Reprod*. 2003;18(1):157–61.
41. Guidelines on the Performance of a Gynaecological Ultrasound Examination. *Australasian Society for Ultrasound in Medicine*. 2020 [cited 2023 Sep 20]. Available from: <https://www.asum.com.au/files/public/SoP/curver/Obs-Gynae/Gynaecological-GL-2020.pdf>
42. Deslandes A, Parange N, Childs JT, Osborne B, Panuccio C, Croft A, et al. How long does a transvaginal ultrasound examination for endometriosis take in comparison to a routine transvaginal ultrasound examination? *Australas J Ultrasound Med*. 2022;25(1):20–7.
43. Pattanasri M, Ades A, Nanayakkara P. Correlation between ultrasound findings and laparoscopy in prediction of deep infiltrating

- endometriosis (DIE). *Aust N Z J Obstet Gynaecol.* 2020;60(6):946–51.
44. Childs J, Thoires K, Osborne B, Halligan T, Stoodley P, Quinton A, et al. Professional competency framework for sonographers. Australia: Australian Sonographer Accreditation Registry. 2021 [cited 2022 Dec 11]. Available from: https://figshare.com/articles/online_resource/Professional_Competency_Framework_for_Sonographers/17148035
 45. Piessens S. Is it time to include assessment of the most common gynaecological condition in the routine ultrasound evaluation of the pelvis? *Australas J Ultrasound Med.* 2019;22(2):83–5.
 46. Leonardi M, Martins WP, Espada M, Georgousopoulou E, Condous G. Prevalence of negative sliding sign representing pouch of Douglas obliteration during pelvic transvaginal ultrasound for any indication. *Ultrasound Obstet Gynecol.* 2020;56(6):928–33.
 47. Chaggar P, Tellum T, Thanatsis N, De Braud LV, Setty T, Jurkovic D. Prevalence of deep and ovarian endometriosis in women attending a general gynecology clinic: prospective cohort study. *Ultrasound Obstet Gynecol.* 2023;61(5):632–41.
 48. Fang J, Piessens S. A step-by-step guide to sonographic evaluation of deep infiltrating endometriosis. *Sonography.* 2018;5(2):67–75.
 49. Leonardi M, Condous G. How to perform an ultrasound to diagnose endometriosis. *Australas J Ultrasound Med.* 2018;21(2):61–9.
 50. Tammaa A, Fritzer N, Strunk G, Krell A, Salzer H, Hudelist G. Learning curve for the detection of pouch of Douglas obliteration and deep infiltrating endometriosis of the rectum. *Hum Reprod.* 2014;29(6):1199–204.
 51. Aas-Eng M, Salama M, Sevelde U, Ruesch C, Nemeth Z, Hudelist G. Learning curve for detection of pelvic parts of ureters by transvaginal sonography: feasibility study. *Ultrasound Obstet Gynecol.* 2020;55(2):264–8.
 52. Menakaya U, Infante F, Lu C, Phua C, Model A, Messyne F, et al. Interpreting the real-time dynamic ‘sliding sign’ and predicting pouch of Douglas obliteration: an interobserver, intraobserver, diagnostic-accuracy and learning-curve study. *Ultrasound Obstet Gynecol.* 2016;48(1):113–20.
 53. Leonardi M, Ong J, Espada M, Stamatopoulos N, Georgousopoulou E, Hudelist G, et al. One-size-fits-all approach does not work for gynecology trainees learning endometriosis ultrasound skills. *J Ultrasound Med.* 2020;39(12):2295–303.
 54. Young SW, Groszmann Y, Dahiya N, Caserta M, Yi J, Wasson M, et al. Sonographer-acquired ultrasound protocol for deep endometriosis. *Abdom Radiol.* 2020;45(6):1659–69.
 55. Medicare Benefits Schedule Online. [cited 2023 Oct 23]. Available from: <http://www.mbsonline.gov.au>
 56. Brennan O, Oh S, Necas M. The value of surveying the kidneys during pelvic ultrasound examinations. *Australas J Ultrasound Med.* 2019;22(2):118–28.
 57. Leonardi M, Robledo KP, Goldstein SR, Benacerraf BR, Condous G. International survey finds majority of gynecologists are not aware of and do not utilize ultrasound techniques to diagnose and map endometriosis. *Ultrasound Obstet Gynecol off J Int Soc Ultrasound Obstet Gynecol.* 2020;56(3):324–8.
 58. Puri S, Gupta A, Sandhu GS, Mohi JK. Comparison between ultrasonography and magnetic resonance imaging in endometriosis: a prospective study in a tertiary hospital. *J South Asian Fed Obstet Gynaecol.* 2022;14(2):85–90.
 59. Roditis A, Florin M, Rousset P, Touboul C, Bendifallah S, Bazot M, et al. Accuracy of combined physical examination, transvaginal ultrasonography, and magnetic resonance imaging to diagnose deep endometriosis. *Fertil Steril.* 2023;119(4):634–43.
 60. Alborzi S, Poordast T, Askary E, Javedanmehr M, Shahraki MH, Alborzi S, et al. Evaluation and comparison of the accuracy of transvaginal ultrasound and MRI for the diagnosis of deep rectal endometriosis: a cross-sectional study. *Int J Gynecol Obstet.* 2023;161(2):586–93.
 61. Bruyere C, Maniou I, Habre C, Kalovidouri A, Pluchino N, Montet X, et al. Pelvic MRI for endometriosis: a diagnostic challenge for the inexperienced radiologist. How much experience is enough? *Acad Radiol.* 2021;28(3):345–53.
 62. Berger JP, Rhemrev J, Smeets M, Henneman O, English J, Jansen FW. Limited added value of magnetic resonance imaging after dynamic transvaginal ultrasound for preoperative staging of endometriosis in daily practice: a prospective cohort study. *J Ultrasound Med.* 2019;38(4):989–96.
 63. Reid S, Leonardi M, Lu C, Condous G. The association between ultrasound-based “soft markers” and endometriosis type/location: a prospective observational study. *Eur J Obstet Gynecol Reprod Biol.* 2019;234:171–8.
 64. Leonardi M, Robledo KP, Espada M, Vanza K, Condous G. SonoPO-Dography: a new diagnostic technique for visualizing superficial endometriosis. *Eur J Obstet Gynecol Reprod Biol.* 2020;254:124–31.
 65. Pedrassani M, Guerriero S, Pascual MÁ, Ajossa S, Graupera B, Pagliuca M, et al. Superficial endometriosis at ultrasound examination—a diagnostic criteria proposal. *Diagn Basel Switz.* 2023;13(11):1876.
 66. Brunelli AC, Brito LGO, Moro FAS, Jales RM, Yela DA, Benetti-Pinto CL. Ultrasound elastography for the diagnosis of endometriosis and adenomyosis: a systematic review with meta-analysis. *Ultrasound Med Biol.* 2023;49(3):699–709.
 67. Maicas G, Leonardi M, Avery J, Panuccio C, Carneiro G, Hull M, et al. Deep learning to diagnose pouch of Douglas obliteration with ultrasound sliding sign. *Reprod Fertil.* 2021;2(4):236–43.
 68. Balica A, Dai J, Piiwaa K, Qi X, Green AN, Phillips N, et al. Augmenting endometriosis analysis from ultrasound data with deep learning. 2023 [cited 2023 Sep 3]. Available from: <https://arxiv.org/abs/2302.09621v1>
 69. Guerriero S, Pascual M, Ajossa S, Neri M, Musa E, Graupera B, et al. Artificial intelligence (AI) in the detection of rectosigmoid deep endometriosis. *Eur J Obstet Gynecol Reprod Biol.* 2021;261:29–33.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Deslandes A, Panuccio C, Avery J, Condous G, Leonardi M, Knox S, et al. Are sonographers the future ‘gold standard’ in the diagnosis of endometriosis? *Sonography.* 2024;11(3):278–86. <https://doi.org/10.1002/sono.12402>