The role of 3-D ultrasound in the prediction of deep infiltrating endometriosis

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Introduction
Endometriosis is a common gynaecological disease, which affects up to 7 - 10% of asymptomatic women of reproductive age. Deep infiltrating endometriosis (DIE), is a severe form of endometriosis which is defined histologically as an endometriotic lesion which invades the peritoneum by > 5mm. The most common locations for posterior compartment DIE to occur include: uterosacral ligaments (USL), vaginal apex, rectovaginal septum, rectum and rectosigmoid. More rarely, anterior compartment DIE can be found in the bladder and uterovesical folds. Although 5 - 10% of women with endometriosis will have bowel involvement, it can be very difficult to predict this subgroup pre-operatively.

The complexity involved with the excision of DIE lesions requires the skill of an advanced laparoscopic surgeon, and in the case of bowel endometriosis, consultation with a colorectal surgeon is also recommended. When DIE nodules which infiltrate the bowel wall and/or other important pelvic structures (bladder, ureters, rectovaginal septum) are excised, this can result in an increased risk of surgical complications to the surrounding anatomical structures. Pre-operative mapping of DIE lesions is therefore essential in the planning of this often complex laparoscopic surgery.

Pre-operative imaging of women with chronic pelvic pain (CPP), or a history of endometriosis, aids in the planning of endometriosis surgery, both in terms of allocating the most appropriately skilled laparoscopic surgeon as well as giving the most appropriate counselling and consenting in terms of the likely surgical procedure. The role of transvaginal ultrasound (TVS), and more recently 3-Dimensional (3-D) TVS, has become more important in mapping the location and extent of posterior compartment DIE, which in turn has the potential to optimise surgical outcomes for women with severe underlying...
These 3-D images of a DIE lesion located in the posterior compartment, which is essential for mapping the extent of DIE. Off-line analysis to assess DIE lesion volume may include the calculation of the Mean Gray Scale Index (MGSI) and volume of the lesion itself (Figures 1 and 6). The value of identifying and measuring DIE lesions prior to laparoscopy using 3-D TVS are beginning to be demonstrated by recently published research.

In a small study by Pascual et al., 3-D TVS was used to predict DIE involving the rectovaginal septum prior to surgery in women with suspected disease (n = 39). 3-D TVS had a sensitivity and specificity of 94.7% and 89.5%, respectively. Grasso et al. compared the usefulness of 3-D TVS and magnetic resonance imaging in the pre-operative diagnosis of DIE, and found that 3-D TVS could accurately diagnose DIE lesions in specific locations. The sensitivity and specificity of 3-D TVS for the diagnosis of DIE in specific sites were USL 50% and 94.7%; vagina 84% and 80%; rectosigmoid septum 76.9% and 100%; rectosigmoid 33.3% and 100%; bladder 25% and 100%, respectively. Another advantage of 3-D HDVI TVS may be the use of the Power Doppler (PD) function for the assessment of vascular patterns of DIE lesions. A previous study found that there was a high propensity of blood vessels in women with endometriosis, especially with respect to rectal endometriosis, when compared with controls. PD allows for the assessment of vascular indices such as flow index (FI), vascular index (VI), and vascular-flow index (VFI), which may prove to be advantageous in the assessment of these lesions prior to surgery. HDVI improves the contrast and resolution of 3-D imaging of the posterior compartment, which is essential for mapping the extent of DIE. Off-line analysis to assess DIE volumetric acquisitions may include the calculation of the MGSI. The values of identifying and measuring DIE lesions prior to laparoscopy using 3-D TVS are beginning to be demonstrated by recently published research.

The advantages of 3-D HDVI TVS in the assessment of endometriotic lesions have been identified as: the ability to view DIE lesions off-line interactively in three dimensions, the ability to assess DIE lesions with regard to their relationship with adjacent organs, and the ability to store 3-D HDVI volumes for educational purposes. Another potential advantage of 3-D HDVI volumetric acquisitions of the posterior compartment is the ability to validate volumes for DIE lesions, including the use of the histogram function to calculate the Mean Gray Scale Index (MGSI) (Figure 1). We believe MGSI may be useful in distinguishing normal from diseased longitudinal muscle of the anterior rectal wall. In our centre, women with CPP also undergo a technique called real-time Sonovaginography (SVG), where 20 ml of ultrasound gel is placed into the posterior vaginal fornix prior to 2-D and 3-D TVS (Figure 2). The concept of placing extra gel into the posterior vaginal fornix during TVS allows for the creation of an acoustic window between the tip of the TVS probe and the surrounding structures; including the anterior and posterior vaginal founices. During SVG, the posterior vaginal wall, vaginal founices, pouch of Douglas, rectovaginal septum, anterior rectum, rectosigmoid colon, USLs and bladder are assessed for DIE with the use of 2-D and HDVI 3-D TVS. The use of the “Multi-Slice View” may aid in the assessment of location and extension of DIE nodules. We believe that the “Multi-Slice View” allows for off-line post-processing of 3-D volumetric acquisitions (Figure 3). Guerriero et al. used 3-D TVS to identify DIE nodules and to improve the assessment of the shapes and borders of these lesions. Figure 3 illustrates the ability to visualise DIE nodules in terms of their shape and 3-D volume, using off-line VOCAL analysis. Further options for 3-D imaging in the assessment of endometriotic nodules include the use of the “OVIX” and “Mirror View” functions (Figures 4 and 5). From our experience, using 3-D TVS in combination with real-time SVG is a promising new technique in the identification and assessment of DIE lesions in women with CPP or a history of endometriosis, and this 3-D TVS technique warrants further research for validation. Although 2-D TVS is the currently recommended first line imaging technique for the diagnosis of DIE, we believe the new technology of High Definition Volume Imaging (HDVI) has overcome the previous weakness of 3-D ultrasound imaging. HDVI improves the contrast and resolution of 3-D imaging of the posterior compartment, which is essential for DIE mapping and extent of the disease. Off-line analysis to assess DIE lesion volume may include the

Figure 1 This image represents the 3-D volume of a DIE nodule located in the longitudinal muscle layer of the rectum. The volume of the DIE lesion was calculated using VOCAL. The Mean Gray Scale Index (MGSI) was calculated using the histogram feature of VOCAL.

Figure 2 This 2-D sagittal image of the posterior compartment demonstrates the modified TVS technique known as Sonovaginography, where gel is placed into the posterior fornix prior to insertion of the TVS probe to allow for improved visualisation of the structures of the posterior compartment. (RVS = rectovaginal septum).

Figure 3 These sagittal images of the posterior compartment were obtained during 3-D SVG and analysed off-line using the “Multi-Slice View”. There is a DIE nodule (N) invading the longitudinal muscle of the rectum (R). (C = cervix, V = vagina).

Figure 4 These 3-D images of a DIE lesion located in the longitudinal muscle layer of the rectum was obtained using the "OVIX" function.

Figure 5 These 3-D images of a DIE lesion located in the longitudinal muscle layer of the rectum using the "Mirror View" function.

Figure 6 This 3-D image represents the shape, volume and MGSI (calculated using VOCAL) of a DIE nodule located in the longitudinal muscle of the rectum.
These 3-D images of a DIE lesion located in the posterior compartment (Figure 1). We believe MGSI may be useful in distinguishing normal from diseased longitudinal muscle of the anterior rectal wall. In our centre, women with CPP also undergo a technique called real-time Sonovaginography (SVG), where 20 ml of ultrasound gel is placed into the posterior vaginal fornix prior to 2-D and 3-D TVS (Figure 2). The concept of placing extra gel into the posterior vaginal fornix during TVS allows for the creation of an acoustic window between the tip of the TVS probe and the surrounding structures; including the anterior and posterior vaginal founcnes. During SVG, the posterior vaginal wall, vaginal founcnes, pouch of Douglas, rectovaginal septum, anterior rectum, rectosigmoid colon, USLs and bladder are assessed for DIE with the use of 2-D and HDVI 3-D TVS. The use of the “Multi-Slice View” may aid in the assessment of location and extension of DIE nodules. We believe that the “Multi-Slice View” allows for off-line post-processing of 3-D volumetric acquisitions (Figure 3). Guerriero et al. used 3-D TVS to identify DIE nodules and to improve the assessment of the shapes and borders of these lesions. Figure 3 illustrates the ability to visualise DIE nodules in terms of their shape and 3-D volume, using off-line VOCAL analysis. Further options for 3-D imaging in the assessment of endometriotic nodules include the use of the “OVIX” and “Mirror View” functions (Figures 4 and 5). From our experience, using 3-D TVS in combination with real-time SVG is a promising new technique in the identification and assessment of DIE lesions in women with CPP or a history of endometriosis, and this 3-D TVS technique warrants further research for validation. Although 2-D TVS is the currently recommended first line imaging technique for the diagnosis of DIE, we believe the new technology of High Definition Volume Imaging (HDVI) has overcome the previous weakness of 3-D ultrasound imaging. HDVI improves the contrast and resolution of 3-D imaging of the posterior compartment, which is essential for DIE mapping and extent of the disease. Off-line analysis to assess DIE lesion volume may include the calculation of the MGSI and volume of the lesion itself (Figures 1 and 6). The value of identifying and measuring DIE lesions prior to laparoscopy using 3-D TVS are beginning to be demonstrated by recently published research. In a small study by Pascual et al, 3-D TVS was used to predict DIE involving the rectovaginal septum prior to surgery in women with suspected disease (n = 39). 3-D TVS had a sensitivity and specificity 94.7% and 89.5%, respectively. Grasso et al. compared the usefulness of 3-D TVS and magnetic resonance imaging in the pre-operative diagnosis of DIE, and found that 3-D TVS could accurately diagnose DIE lesions in specific locations. The sensitivity and specificity of 3-D TVS for the diagnosis of DIE in specific sites were USL 50% and 94.7%; vagina 84% and 80%; rectosigmoidal septum 76.9% and 100%; rectosigmoid 33.3% and 100%; bladder 25% and 100%, respectively. Another advantage of 3-D HDVI TVS may be the use of the Power Doppler (PD) function for the assessment of vascular patterns of DIE lesions. A previous study found that there was a high propensity of blood vessels in women with endometriosis, especially with respect to rectal endometriosis, when compared with controls. PD allows for the assessment of vascular indices such as flow index (FI), vascular index (VI), and vascular-flow index (VFI), which may prove to be advantageous in the assessment of these lesions prior to surgery. HDVI improves the contrast and resolution of 3-D imaging of the posterior compartment, which is essential for mapping the extent of DIE. Off-line analysis to assess DIE volumetric acquisitions may include the calculation of the MGSI. The values of identifying and measuring DIE lesions prior to laparoscopy using 3-D TVS are beginning to be demonstrated by recently published research. The advantages of 3-D HDVI TVS in the assessment of endometriotic lesions have been identified as: the ability to view DIE lesions off-line interactively in three dimensions, the ability to assess DIE lesions with regard to their relationship with adjacent organs, and the ability to store 3-D HDVI volumes for educational purposes. Another potential advantage of 3-D HDVI volumetric acquisitions of the posterior compartment is the ability to validate
the intra- and inter-observer reproducibility of TVS detection of DIE.

Discussion

We believe that the use of pre-operative TVS imaging, incorporating 3-D HDVI functionality, will be the future in posterior compartment DIE location prediction. Traditional 2-D TVS, with the addition of 3-D HDVI TVS, improves operative planning of women with suspected severe endometriosis by identifying not only the location of the posterior compartment DIE lesions but also the depth of infiltration. Due to the complex nature of the laparoscopic surgical techniques required to expertly excise posterior compartment DIE lesions, the accurate pre-operative ultrasound assessment of women with suspected endometriosis prior to surgery is imperative. This in turn allows for appropriate referral to an advanced laparoscopic surgeon with the potential for pre-operative colorectal input.

References


