Austin Journal of Reproductive Medicine & Infertility

Open Access

Austin Publishing Group

Special Article - Endometriosis

Modified Virtual Colonoscopy in the Diagnosis and Quantification of Bowel Endometriosis

Kaplan M[1] and Van der Wat J[2]*

[1]Department of Rosebank Radiology, Netcare Rosebank Hospital, South Africa

[2]Endometriosis Institute, Park Lane Hospital, South Africa

***Corresponding author:** Johan van der Wat, Endometriosis Institute, The Park Lane Hospital, Johannesburg, South Africa

Received: February 10, 2017; **Accepted:** May 19, 2017; **Published:** June 08, 2017

Abstract

Bowel endometriosis affects 4%-37% of women with endometriosis. The workup and staging of the patient requires confirming or excluding bowel involvement, and extension of the disease to other pelvic organs such as the urinary tract and urogenital spaces.

Several conventional non-invasive and invasive diagnostic techniques have attempted to resolve these issues, but have often been inconclusive.

The conventional Virtual Colonoscopy (VC) or CT Colonography (CTC) scan is a non-invasive multi-detector Computed Tomographic (MDCT) scan of the abdomen and pelvis performed while the colon and rectum are insufflated with air or carbon dioxide, to primarily screen for colorectal polyps and early cancers.

The Modified Virtual Colonoscopy scan (MVC) for endometriosis, originally described in 2007 is based on the conventional VC/CTC scan, but with several modifications. It is a comprehensive, non-invasive scan technique, tailored specifically to the characteristics of the patient population particularly applicable to deep infiltrating rectogenital and bowel endometriosis.

This article describes the MVC technique and imaging features in colorectal endometriosis, to confidently decide on surgical candidacy and provide a pre-surgical roadmap, in these clinically problematic patients. This is achieved by accurately defining the stage and extent of disease, particularly multi-focal bowel, urogenital and other deep pelvic involvement, as well as extra-pelvic disease, in one comprehensive, non-invasive examination.

Keywords: Modified virtual colonoscopy; Endometriosis; Colorectal, imaging; Pelvic involvement

Introduction

Endometriosis is an enigmatic disease. It is defined as the presence of endometrial glands and stroma outside of the endometrial cavity. Symptoms usually arise from cyclical bleeding into the surrounding tissue causing inflammation and scarring.

Endometriosis is a chronic gynecological disorder that affects more than 70 million women and adolescents worldwide [1]. It is the leading cause of pelvic pain and infertility [2].

A staging system for the severity of the disease has been proposed by the American Society for Reproductive Medicine (ASRM) and is based on the size of the implant and the severity of adhesions [3]. Staging is from Stage I (minimal) to Stage IV (Severe), with the fourth stage representing spread to distant organs like the bowel.

Bowel endometriosis affects 4%-37% of women with endometriosis [4]. The anatomic distribution of endometriosis of the bowel has been reported by Weed and Ray [5].

Endometriosis of the bowel may present clinically with symptoms of partial or complete bowel obstruction, rectal bleeding, abdominal distention or dyschezia. These are usually due to stricture formation and penetration of endometriosis through the bowel wall and mucosa. These symptoms may be exacerbated during menstruation. The symptoms are often non-specific and may mimic irritable bowel syndrome [6], and in some cases Crohn's disease [7]. A recent study has shown that there is a loss of sympathetic nerve fibers close to endometriotic bowel lesions, which may be responsible for the myriad of gastrointestinal symptoms, leading to a difficult differential diagnosis [8].

It is now well established that deep infiltrating endometriosis of the posterior cul-de-sac, rectosigmoid and bowel is best treated surgically [9,10].

The surgical candidacy and surgical approach will depend on the ability to accurately diagnose the stage and quantify the extent of the disease process.

Current imaging techniques like ultrasound and MR focus primarily on the rectogenital area with visualization of proximal bowel, multi-focal bowel involvement and abdominal disease lagging.

To address these issues, Kaplan and Van der Wat introduced the Modified Virtual Colonoscopy scan (MVC) in 2007, specifically for the diagnosis and staging of rectogenital and disseminated disease [11]. This technique has now found favor with other workers in this field [12].

Citation: Kaplan M and Van der Wat J. Modified Virtual Colonoscopy in the Diagnosis and Quantification of Bowel Endometriosis. Austin J Reprod Med Infertil. 2017; 4(1): 1046.

The clinical indications for modified virtual colonoscopy (MVC) include those findings suggesting possible bowel or rectogenital involvement, including recto-vaginal septum (RVS) nodules, dyschezia, catamenial (menstrual) rectal bleeding, and catamenial change in bowel habits.

Some patients present with abdominal pain and obstructive symptoms, which may indicate multifocal and distant colonic disease or small bowel infiltration.

Modified virtual colonoscopy (MVC) for endometriosis

The conventional Virtual Colonoscopy (VC) scan, also known as CT Colonography (CTC), is a noninvasive Multi-detector Computed Tomographic (MDCT) Scan of the abdomen and pelvis performed while the colon is insufflated with air or carbon dioxide via a rectal catheter, usually after a bowel cleansing laxative preparation. The volumetric data set obtained from the scanner is then post-processed on a workstation to obtain various 2D and 3D reconstructions, including the virtual fly-through of the colon and rectum.

The main VC applications are for colorectal cancer screening, and failed or incomplete or contra-indicated optical colonoscopy.

This technique is now regarded as accurate as optical colonoscopy for polyps above 5 mm and early colorectal cancers.

Additional benefits over optical colonoscopy are extra-luminal intramural, serosal and functional (stricture) assessment. Furthermore, since a volumetric data set is obtained, the entire abdominal and pelvic contents are simultaneously visualized for extra-colonic pathology, as in an abdomino-pelvic CT scan.

The limitations are X-ray radiation exposure; and relatively poor assessment of the rectogenital space, particularly the RVS, due to lack of tissue plane separation, which is essential in the diagnosis and staging of rectogenital endometriosis.

The Modified Virtual Colonoscopy technique (MVC) for endometriosis was first described in 2007 [11]. This is based on the VC/CTC scan, with several modifications. It is in essence a comprehensive, non-invasive scan, which takes into account the characteristics of the patient population being scanned, and is particularly applicable to deep infiltrating bowel and recto-genital endometriosis. This article describes the MVC technique, which has subsequently been further enhanced by Kaplan and van der Wat.

The MVC provides the diagnostic information to solve surgical decision making and provide pre-surgical planning, by accurately defining extent of bowel and other organ involvement (including urogenital disease), in a single examination.

MVC technique

Preparation: As for conventional VC, the patient undergoes a 24 hour colon cleansing preparation. The preparation ensures that the colon and rectum are free of obscuring faecal material and excessive fluid, allowing an unobstructed mucosal surface assessment. During the preparation, faecal tagging or labeling, via small oral contrast aliquots, is also performed. This facilitates electronic subtraction of any residual faecal material that may have remained. It increases sensitivity of smaller lesions as well as increasing lesion specificity.

Pre-scan oral/enteral contrast is generally not necessary for the MVC. However, if challenging disease or potential small bowel involvement is suspected, dilute iodinated oral contrast is ingested, half an hour before the scan so as not to disturb colorectal assessment.

Vaginal tampon: A large volume, obstetrical tampon is inserted by the patient just prior to scanning. The patient is instructed to position the tampon high into the vagina to reach the cervix. High insertion is important to visualise the proximal RVS. The air filled tampon will create a RVS interface with the (gas insufflated) rectum during the scan. The tampon additionally distends the vagina, thereby placing the RVS under tension. This facilitates assessment of the septum and recto-cervical spaces. As a future development, we are of the opinion that simultaneous gaseous (via the same carbon dioxide rectal insufflation source) balloon distention of the vagina may yield better RVS imaging than the current tampon. We are in the process of investigating such a device.

Rectal tube: In conventional VC, the rectal tube or catheter bulb is fully distended prior to gaseous insufflation of the rectum. With MVC, a Foley catheter with small volume bulb is used and only partially inflated to avoid distortion and effacement of the distal rectum and RVS plane. We have found that in the younger patient demographic, there is usually sufficient anal tone to retain the catheter tip during bowel insufflation, so that the conventional large bulb, full inflation is not necessary. Additionally the small caliber, flexible Foley catheter is more comfortable than the semi-flexible larger rectal tubes on the market.

Intravenous anti-spasmodic: Intravenous hyoscine butylbromide (Buscopan, Boehringer Ingelheim) is routinely administered, unless contra-indicated, prior to the scan. It appears to reduce spasm and make the examination more comfortable for the patient.

Automated carbon dioxide (CO_2) insufflation

Room-air insufflation of the colonic loops, although convenient, is not used. Instead, an automated CO_2 insufflator with pressure limiter is used for patient comfort and better insufflation control and distention consistency. A pressure of 25 mm/Hg is set to standardize the intra luminal pressure. As the CO_2 is exhaled once insufflation is stopped, no residual gas remains resulting in greater post-scan patient comfort.

Scan

Once colonic distention is adequate, the patient is scanned on a 64 slice MDCT Scanner (Aquilion 64, Toshiba Medical Systems). As with conventional VC, both supine and prone position scans are performed (two sequential breath hold scans) to ensure all pelvic colorectal segments are sufficiently distended and mucosal surfaces visualized. The two scans also assess the degree of functional distensibility of strictures, and also allows for the exclusion of bowel spasm verses stricture.

Low-dose scan: To prioritize low-dose scanning, which is critical in this often young population, several low dose protocol modifications are strictly adhered to.

Scan range modification: The tight scan range often includes the pelvis only, and not the abdomen. This is a significant X-ray dose saving variation. Pelvic colorectal assessment is usually diagnostically sufficient in this patient population. Since these patients are usually

young and are not being screened for colorectal polyps or cancers (as in conventional VC), the likelihood of such lesions is particularly low and complete colonic assessment (abdomino-pelvic) is usually not required. In those patients where there is potential disseminated or multi-focal supra-pelvic disease or in older patients where colorectal cancer screening is applicable, the range of the supine scan only, can simply be extended to include the abdomen as well.

Breast shield: A bismuth radiation breast shield is applied despite the breasts not being included in the scan range, to avoid scatter. Manual breast displacement is also performed.

Tube current, patient position and other factors: The supine scan is performed at an adequate tube current (mA) to ensure fine extra-colonic tissue detail for pelvic disease assessment. The prone scan is however performed as a low-dose scan, as only high-contrast colorectal endo-luminal detail is required. There is thus a further dose saving.

A third decubitus scan is avoided if at all possible. Only rarely, when there is inadequate mucosal surface visualization, is this performed at an even lower mA. Other dose saving factors are chosen, including automated exposure modulation, a high pitch, and low kVp (100 kVp as oppose to 120) where patient body habitus permits (low BMI). Iterative Reconstruction techniques should be applied where available.

Thus the pelvic MVC effective dose (ED) can be reduced down to 5 mSv or less, below half the average conventional VC dose.

It must be noted that this is a diagnostic, once-off study for potential surgical candidacy, and not a repeated screening study as in conventional VC.

IV iodinated contrast: The scan may be performed in a non-enhanced fashion (no IV contrast), as contrast enhancement is on occasion unnecessary for diagnosis, particularly since the bowel is gas distended and the RVS interface outlined. This reduces iodinated contrast risks and dose.

IV contrast is administered in patients with suspected complex or recurrent disease, those who have undergone previous intervention, low BMI patients where fat plane definition is poor, or where renal tract involvement is suspected.

Imaging features

Extrinsic colorectal lesions: Colorectal bowel involvement may be due to a purely extrinsic and non-invasive endometrial space occupying lesion (SOL) with no direct serosal involvement.

This is visualized as a smooth extrinsic impression, or if large enough, an extrinsic stenosis. There is absence of bowel wall thickening and no mucosal distortion. A fat plane of separation may be visualized with the adjacent cystic / solid or complex peri-colic SOL.

A smooth extrinsic impression on the wall contour or "double wall" sign may be seen on the 3D reconstructed images (Figure 1A,B). The 2D MPR, 3D Transparent View (TV) and 3D Fly through (FT) reconstructions are most suitable for visualization.

Colorectal serosal involvement: Serosal surface involvement occurs as a result of direct invasion or scarring from a contiguous lesion. This may complicate as a bowel stricture.

This is demonstrated as bowel segment distortion, mucosal line

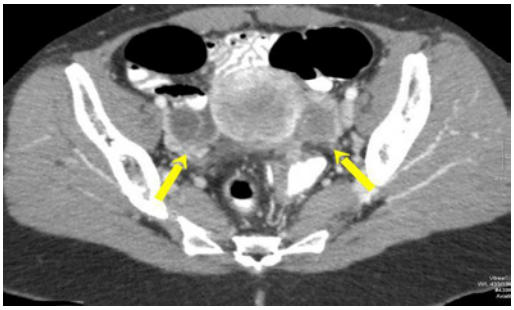

Figure 1A: Bilateral adnexal lesions n. The perirectal fat plane is preserved (2D axial MPR).

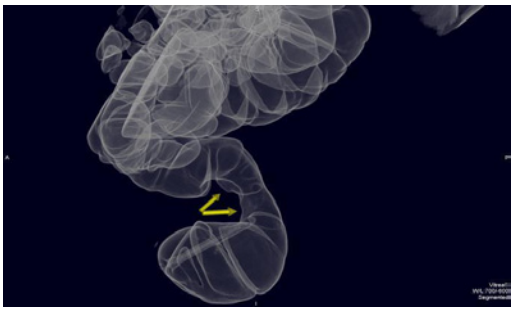

Figure 1B: Smooth rectal wall impression with "double wall" sign (arrows) from an extrinsic rectogenital lesion (3D TV recon).

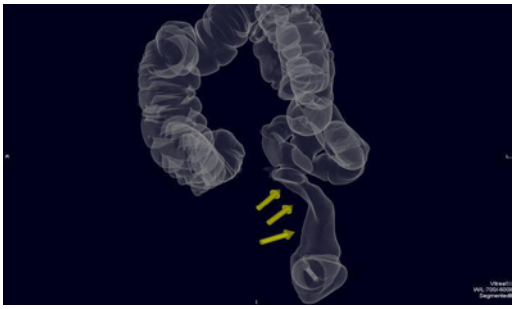

Figure 2: Lesion involving the serosa of the anterior rectal wall with resultant mucosal "puckering" (arrows) (3D TV recon).

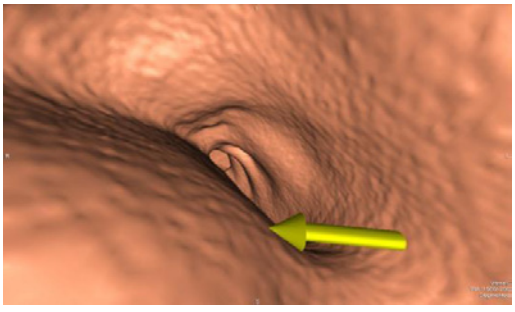

Figure 3: Endoluminal appearance of serosal irregularity (arrow) due to involvement by an extrinsic lesion (3D FT recon).

puckering, and fixity or loop palisading (Figure 2,3). The 2D MPR and 3D TV reconstructions demonstrate this best.

Colorectal wall invasion and strictures: Trans-mural invasion occurs with extension of a lesion into the colonic wall, without necessarily causing endo-luminal mucosal involvement. The features are bowel wall thickening, bowel wall mass and intrinsic strictures. These strictures are generally characterised by a relatively smooth mucosal surface with little irregularity or ulceration. The entry and exit angles are usually obtuse and the strictures are usually asymmetrical in configuration.

Imaging findings are wall or fold thickening and contiguity with the extra-colonic lesion(s) (Figure 4A,B). There may be a related rigid stricture with fixity and non-distensibility, (Figure 5, 6A,B). This is in contrast to a malignant lesion, which has an irregular, distorted mucosal surface, often with ulceration (Figure 7). The 2D oblique MPR and 3D TV reconstructions are best suited for assessment.

An important advantage of MVC stricture assessment is that functional information is obtained. Since adequate distensibility is obtained due to the pressure provided by gaseous insufflation, the true degree of maximal stenosis can be objectively measured, using a similar ratio to that in vascular stenosis i.e. minimum diameters at maximal stricturing versus normal adjacent bowel lumen. This measure, which may assist in future research, assists objective decision making regarding which degree (percentage) of stenosis would be most suitable for segmental resection or discoid excision.

The distance of the distal margin of the stricture from the anal verge, as well as the stricture length can also be obtained from the software, using the automated colonic center-line. This information is necessary for the accurate anatomical site and length of surgical resection and anastamosis, particularly important in low resection cases where sphincter function may be compromised and colostomy contemplated. This is also vital regarding pre-surgical patient counseling.

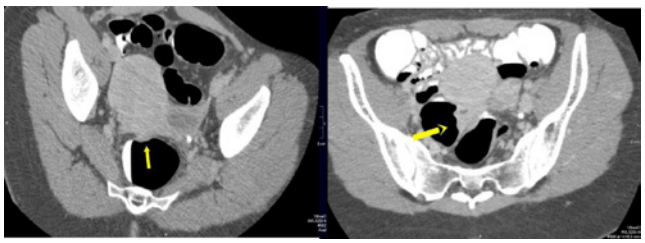

Figure 4: Involvement of the anterior rectal wall (arrow) (2D axial MPR). Rectosigmoid wall invasion with fold thickening (arrow) (2D axial MPR).

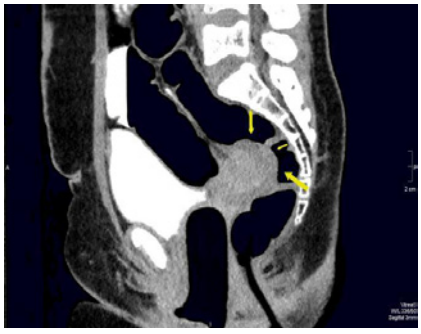

Figure 5: Rectal lesion with smooth short segment stricture (arrows) (2D Sagittal MPR).

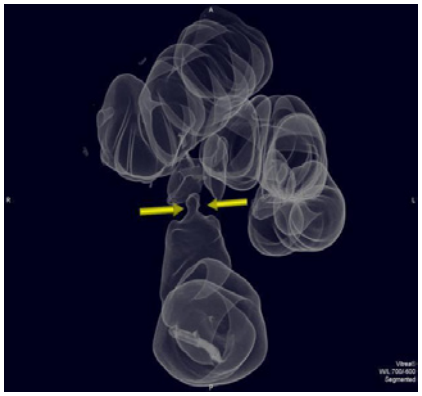

Figure 6A: Proximal rectal segment stricture (arrows) (3D TV recon).

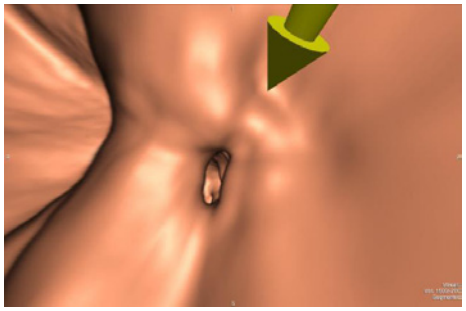

Figure 6B: Smooth tight stricture that could cause obstruction (arrow) (3D FT recon).

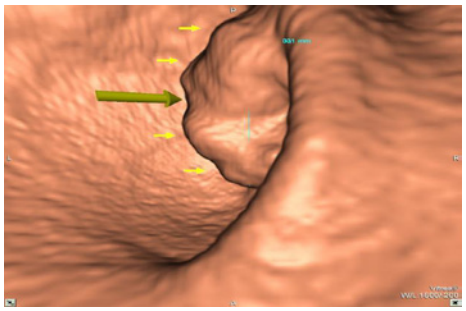

Figure 7: Malignant colorectal carcinoma with irregular mucosa and ulceration (arrows) (3D FT recon).

These objective stricture metrics have not been previously applied to potential surgical endometriosis cases.

Endo-luminal exophytic (polypoid) lesions: In these cases there is transmural extension of the process directly involving the mucosa, with exophytic mucosal polypoid lesions demonstrated. The lesions protrude into the lumen with acute mucosal angles demonstrated, as well as thickening of basal wall due to involvement. There may be associated fold distortion and stricturing (Figure 8A,B and 9).

The 3D FT reconstruction is particularly well suited for endo-luminal mucosal involvement and imaging of fistulisation.

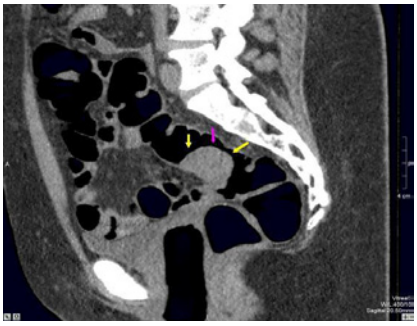

Figure 8A: Rectogenital lesion involving the anterior rectal wall (arrows) with polypoid endoluminal lesion and acute mucosal angles. There is related basal wall thickening (2D Sagittal MPR).

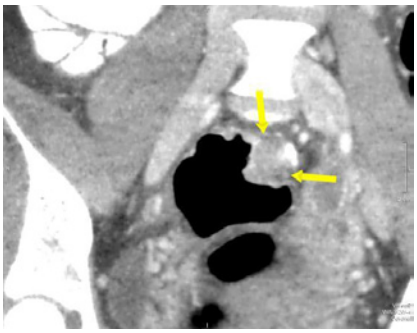

Figure 8B: Transmural lesion invasion with mucosal involvement (arrows) (2D coronal MPR).

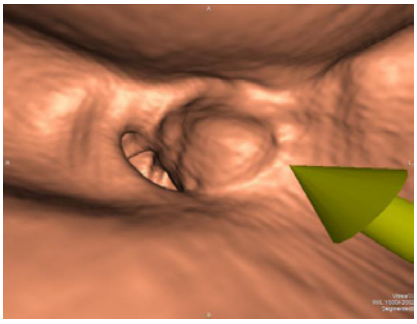

Figure 9: Endoluminal lesion with associated stricture (arrow) (3D FT recon).

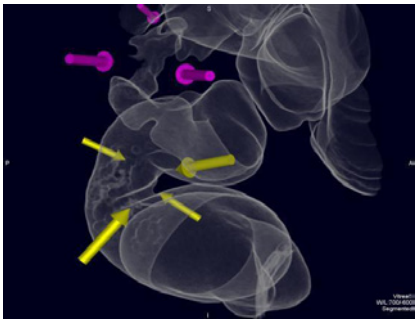

Figure 10: Rectovaginal fistula (arrow) with endoluminal exophytic rectal lesion anteriorly (2D axial oblique MPR).

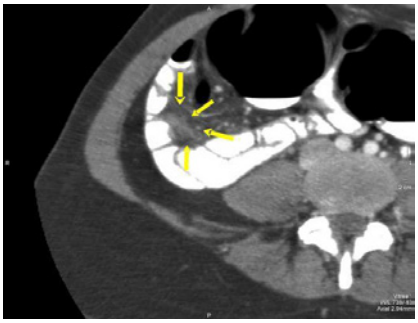

Figure 11: 3D imaging of rectovaginal fistulisation fistula (arrow) (3D TV recon).

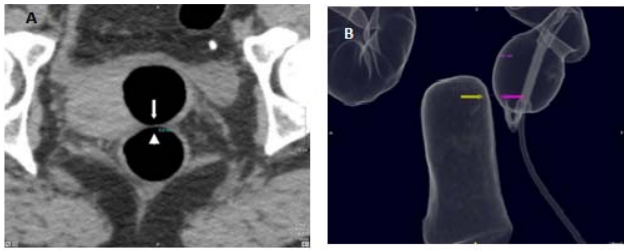

Figure 12: Multifocal disease with an anterior rectal wall lesion and more proximal rectosigmoid stricture (Arrows). Normal rectum between (3D TV recon).

Multifocal colorectal involvement: Defining multifocal colorectal disease is an important pre-surgical requirement that has traditionally been problematic to diagnose with current ultrasound and MRI techniques. With MVC, multifocal bowel lesions with uninvolved interleaving segments are well demonstrated. This provides a unique imaging advantage, as these focal involved regions can be assessed together. If multifocal disease is suspected, the full abdomino-pelvic range is scanned.

Multi-focal involvement with normal interleaving segments is then demonstrated (Figure 10).

The 3D TV reconstruction is best suited for assessment of multifocal disease with the 2D MPR reconstructions providing further assessment.

Small bowel involvement: Small bowel involvement, particularly the ileo-caecal and distal ileal segments, occurs with mesenteric/omental or peritoneal lesions (Figure 11). Urogenital (particularly ovarian or adnexal) lesions also may complicate with small bowel disease.

Oral water-soluble contrast is administered a half hour prior to the scan to further enhance visualisation, when this is suspected.

Recto-genital lesion definition: Bowel involvement as described above is usually associated with deep infiltrating involvement of the recto-genital spaces- RVS, recto-cervical, and recto-uterine. These recto-genital lesions are well defined on MVC.

RVS thickening or focal nodulation is visualised, since the RVS forms an interface between the air-filled tampon and the gaseous rectal distention. This distended vagina and rectum place the RVS under tension. The normal RVS measures 5 mm or less (Figure 12A,B).

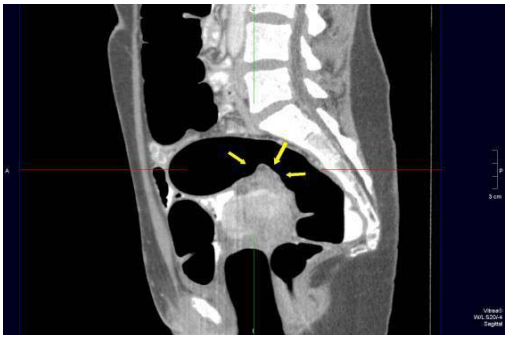

Figure 13: Ileal involvement by a mesenteric/omental lesion (Arrows) (2D axial MPR recon).

RVS involvement is best demonstrated on the 2D MPR (oblique axial plane perpendicular to the vaginal axis or in the oblique sagittal plane parallel to the axis) and on the 3D TV reconstruction. Recto-genital lesions involving the recto-cervical and recto-uterine spaces efface these planes, and appear as solid/ cystic or complex space occupying lesions, which frequently extend to involve the anterior rectal wall or recto-sigmoid loops; or the adnexae/ovaries and uterus. There is loss of fat planes between these structures and there may be pelvic side-wall extension (Figure 13).

The 2D MPR, particularly in the sagittal and oblique-sagittal planes, is most suited.

Discussion

In the clinical work up of the patient with suspected rectogenital and disseminated endometriosis, it is important to be able to confirm or exclude bowel involvement, and extension of the disease to other pelvic organs such as the urogenital organs and recto-genital spaces. This will provide the necessary information regarding surgical candidacy and planning of appropriate surgery, as well allow for better pre-operative patient counseling.

Conventional non-invasive and invasive imaging techniques have attempted to resolve these diagnostic issues, but are often unsatisfactory regarding both the extent of the disease, and particularly the presence of multifocal disease, and therefore have an impact on surgical decision making.

Endo-vaginal Ultrasound is painless, harmless and inexpensive. It is however operator dependent and limited in defining colonic lesions, multifocal lesions, small bowel lesions or ureteric involvement. An endo-vaginal examination in combination with vaginal examination [13] and water contrast instilled in the rectum [14] was found to have a good likelihood ratio and is an excellent test for confirming the presence of rectal involvement [15]. Recently introital 3D ultrasonography was used to diagnose RVS endometriosis with 95% confidence limits [16]. Transrectal ultrasound has been used [17-19] and is a reasonable test for confirming rectal disease, but does not perform better than the transvaginal approach [15].

MRI may be performed without IV Gadolinium contrast [20] or with contrast enhancement [21-23], as well as rectal or vaginal gel insertion [24,25]. This provides excellent contrast resolution of the pelvic viscera and solid/cystic lesions, and is radiation free.

The scans are however prolonged and require sedation in claustrophobic patients, which may be unacceptable. Multifocal bowel disease is not adequately assessed as full colonic distention is not obtained. Gel distention is also suboptimal as the intraluminal pressure obtained is too low for accurate assessment of colo-rectal strictures and segment distensibility, as well as endo-luminal mucosal invasive disease.

A recent review comparing ultrasound and MRI techniques concluded that transvaginal ultrasound is slightly more accurate than MRI in confirming or excluding the disease [15].

However, with both of these modalities, multifocal disease, proximal colonic and small bowel involvement (particularly extra-pelvic) and endo-luminal bowel extension are difficult to assess. Furthermore, functional colorectal lesions such as rigid, non-distensible segments or strictures, where distensibility assessment is required, are challenging.

The Double Contrast Barium Enema was historically performed to assess isolated colorectal involvement. It is unpleasant and often painful. The patient is exposed to a high radiation dose, and no extra-colonic information is obtained. There are technical failures and accuracy for small endo-luminal lesions is relatively poor.

Invasive optical sigmoidoscopy or colonoscopy is excellent for large bowel endo-luminal or mucosal involvement. They are however poor at functional stricture assessment and provide little information regarding serosal surface and intra-mural involvement. No information concerning extra-colonic pelvic disease is gleaned, thereby requiring further cross-sectional imaging techniques in the workup. The procedures are invasive with associated risks, and there is a sedation or anesthesia requirement.

Laparoscopy is a valuable diagnostic tool. The ASRM staging is based on laparoscopic findings [3] however, it is not of much help to diagnose the extent and severity of bowel and deep infiltrating endometriosis. It is a score primarily for peritoneal disease and adhesion formation which may predict fertility outcomes.

Furthermore, frequently more than one of the afore-mentioned investigations are required for adequate pre-surgical assessment resulting in multiple investigations being performed and a potentially high cumulative radiation exposure should a barium enema or IVP be requested.

This is also inconvenient or unpleasant for the patient, and becomes costly.

It is possible to overcome these limitations with the MVC scan. This technique provides accurate diagnostic information and provides information to structure a staging model that will make standardized prospective multi-center co-operation possible [26].

Conclusion

MVC is a single, comprehensive imaging study for accurately assessing a patient with suspected bowel endometriosis regarding their potential surgical candidacy and approach. It is a non-invasive, safe, and rapid out-patient scan, with a relatively low dose exposure.

The current diagnostic modalities of ultrasound and MRI are

unable to effectively diagnose multifocal and proximal bowel disease. Endoluminal lesions and stricturing are further limitations with these modalities. This diagnostic inability has made counseling and surgical planning problematic.

To overcome these limitations, MVC was developed to diagnose colorectal endometriosis, multifocal disease, strictures and retroperitoneal disease, involvement of the urogenital tracts and other abdominal organs such as the Liver. Furthermore, this technique will provide accurate information as to the appropriate access route either by laparoscopy or laparotomy and has the potential to allow multi-centre participation for prospective studies regarding the management of disseminated and recto-genital endometriotic disease.

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Austin J Reprod Med Infertil - Volume 4 Issue 1 - 2017
ISSN : 2471-0393 | www.austinpublishinggroup.com

Citation: Kaplan M and Van der Wat J. Modified Virtual Colonoscopy in the Diagnosis and Quantification of Bowel Endometriosis. Austin J Reprod Med Infertil. 2017; 4(1): 1046.