Dynamic magnetic resonance imaging and transperineal sonography in the assessment of patients presenting primarily with evacuatory difficulty: a short position paper

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INTRODUCTION

It has become clear in recent years that the symptom complex presenting as the clinical “final common pathway” of evacuatory dysfunction is associated with a multiplicity of pelvic floor and perineal soft tissue anomalies1,2. Moreover, the functional outcomes in patients where single entities such as rectocele and enterocele alone are operatively treated are often disappointing despite anatomical correction of these pathologic states3. The recent introduction of a range of minimally invasive treatments for the management of these pelvic floor conditions has provided many new operative options but has also confused the picture, as their indications and contraindications, long-term functional results and quality of life outcomes are presently unknown.4-7 Further, in the available literature, the diversity of pathology treated with individual procedures is often not comparable8 and there is no currently accepted standard of patient assessment for data comparison9.

The clinical assessment of patients presenting with this symptom complex is notoriously unreliable,10 where the gold standard for the dynamic interaction between pelvic structures on provocative manoeuvres has been an extended technique of defaecography11. This more extended technique with a selective need during proctography for opacification of the small bowel, bladder and vagina with in some cases coincident peritoneography for the determination of enterocele, is often poorly tolerated12 and involves a moderately high radiation exposure in a relatively young patient cohort13. As a result of these drawbacks, newer modalities which are less invasive and which provide a representation of the dynamic interchange during straining and simulated defaecation have been devised, including dynamic magnetic resonance imaging (either standard or open-configuration), dynamic transperineal sonography and 2- and 3-dimensional echodefaecography.

These new modalities have only been partially validated in this clinical setting and will be complementary for assistance in definitive diagnoses and management decision-making depending upon the local expertise and equipment availability. The recommendations for these modalities in patients presenting with obstructed defecation syndrome (ODS), the available comparative modality data and the limitations of these modalities is outlined in this short position paper.

DYNAMIC MAGNETIC RESONANCE IMAGING

The availability of experienced staff and equipment with a dedication to this technique is somewhat limited as most MR imaging units have a maximum allowable time for research gastroenterological use. The clear advantages include its relatively non-invasive qualities for defaecating proctography, its high-resolution soft tissue contrast, multiplanar imaging capability and lack of exposure to ionizing radiation. At present, imaging sequences do not permit adequate characterization of motion using 3D technology and in order to overcome this dynamic disadvantage multiple single-slice technology at the same slice position and stacked slices are used. The former technique permits a greater temporal resolution with analysis of inherent bo-
wel motility and straining motion providing more detail regardless of patient position. Slice stacking defines the region of interest given the limited field of view and individual slice thickness for a more rapid acquisition of images during limited straining manoeuvres. The technique was initially introduced independently by Yang and colleagues\textsuperscript{14} and Kruty et al\textsuperscript{15} after preliminary work in a single female normal volunteer had provided images of changes in the levator ani muscle during contraction and following the Valsalva manoeuvre\textsuperscript{16}. The accuracy of functional cine-MRI in patients with evacuatory dysfunction has been extensively validated\textsuperscript{17-20} using a range of dynamic sequences, where the basic methodology incorporates a high-field system, supine or sitting positions and the utilization of non-echo planar images as a reference point for construction of a mid-sagittal image during rest or straining.

Most data pertains to the use of a conventional high-field 1.5 T system with standard matrices and T1-, T2- or Turbo SE sequencing for representation of the anatomic region of interest\textsuperscript{21}. This sequencing allows tracing of the course of an organ over several slices with adequate assessment of the anal canal and paravaginal spaces\textsuperscript{22}. A range of fast non-echo sequences are needed to obtain correct image freezing where gradient-echo sequencing (GRE), T2-weighted single-shot fast spin echo (FSE), steady-state free precession (SSFP), fully refocused transverse magnetization (FISP, fast imaging with steady precession), fast-field-echo (FFE), gradient recalled acquisition in steady state (GRASS) and rapid acquisition with relaxation enhancement (RARE), are variably reported. More recently single-shot turbo spin echo sequencing (HASTE), has provided ultra-fast image acquisition with parallel imaging and lower signal-to-noise ratios. The former sequence uses a high speed of image acquisition (very short TR) with contrast use for distinct advantage\textsuperscript{23}. A simple basic protocol needs to be established for most units, although SSF sequences obtained at rest, squeeze, strain and after evacuation or T1-weighted GRE during defaecation are easiest to employ providing an imaging window which is of sufficient duration during difficult evacuation attempts. Standard mid-sagittal images may be supported by stacked coronal slices at the inferior border of the pubic symphysis and ischial tuberosities where the latter images show the levator ani muscle for the detection of rectoceles, levator herniation and atrophy and rectoanal intussusceptions. In unusual circumstances where insufficient detail is obtained, supplementary oblique images can be viewed for the detection of lateral rectoceles and in the post-operative patient.

Specific algorithms for contrast use may be utilized in the demonstration of lower signal intensity structures, (particularly on T1-weighted sequences), including the vagina and the anal canal. The bladder may be filled with gadopentate dimeglumine (Magnevist\textsuperscript{24} Schering Berlin), the vagina with acoustic contrast gel and the rectum with gel or potato-starch\textsuperscript{25}. The instillation of material into the rectum is somewhat sequence-dependent where for SSFE or SSF sequences, ultrasound gel is more suitable and where if T1-weighting is utilized, a more mixed enema (using gel, potato mash plus gadolinium chelate) is preferred\textsuperscript{26}. Although a variety of papers have defined specific measurable parameters such as the dimensions of the levator hiatus and muscle thicknesses and angles, the technology is associated with considerable variability because a linear plate is assessed for what is essentially a 3-dimensional structure, where most muscle cuts are not perpendicular to their plane, as there is considerable inter- and intraobserver variability and because patient position may vary between scans. The clinical significance of these demonstrable levator asymmetries is questionable\textsuperscript{27}. The dynamic evaluation of organ movement requires the agreement of a range of reference lines including the pubo-coccygeal line, PCL (co-opted from conventional cystography and proctography), as well as the point of coccygeal insertion of the levator ani, horizontal and mid-sagittal levels of the inferior pubic ramus and the mid-pubic line through the longitudinal axis of the pubic bone. These other lines are adopted from defaecography\textsuperscript{28}. The PCL, (extending from the lower border of the pubic symphysis to the last coccygeal joint), is drawn electronically and defines the pelvic floor level, being used to assess perineal pelvic organ descent and to define enteroceles\textsuperscript{29}. The distance between the PCL and the bladder, cervix and anorectal junction are able to be measured at rest, strain and evacuation\textsuperscript{30}. Image interpretation is provided by reference points to create diagnostic categories in an anterior compartment (bladder base), middle compartment (cervix and posterior vaginal fornix) and a posterior compartment (anal canal), where abnormal descent is defined for all compartments in accordance with the suitable reference line, although grading systems for individual prolapse and for enterocele are yet to be standardized. Rectocele depth is readily measured using this strategem although there is debate concerning what represents a pathologically significant rectocele\textsuperscript{31}.

The specific analysis of these compartments is made at rest initially in T2-weighted high-resolution sequences in the axial, sagittal and coronal planes the levator ani muscle sifting, the levator hiatus, the basic positions and relations of the pelvic organs under study, the vagina and the urethra can be identified. In the sagittal plane, dynamic cine-loops are used during the Valsalva manoeuvre and in the coronal plane for assessment of the mobility of the iliococcygeal component of the levator ani is. Simulated evacuation is then assessed by video mode in the supine position to determine the pre-sence of rectoanal intussusception.

Alternatives (depending upon availability) for dynamic MR assessment include the use of an open-magnet configuration in the sitting position, where the position of the patient is deemed more physiological for the demonstration of disorders which appear at the end of defaecation and straining; most notably, rectal prolapse and rectoanal intussusception. These open configuration MR units (0.5 T multiphase T1-weighted spoiled gradient-echo sequence, superconducting Signa S, GE Medical Systems, Milwau-kee WI) have restricted signal-to-noise ratios which are a result of unfavourable surface coil designs and which ha-
TABLE 1

ADVANTAGES AND DISADVANTAGES OF THE DIFFERENT IMAGING MODALITIES FOR PATIENTS PRESENTING WITH OBSTRUCTED DEFACTION SYNDROME (ODS)

<table>
<thead>
<tr>
<th>Modality</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defaecography</td>
<td>Dynamic</td>
<td>Invasive</td>
</tr>
<tr>
<td></td>
<td>Accurate interocele diagnosis</td>
<td>Hing-dose radiation</td>
</tr>
<tr>
<td></td>
<td>Defines rectal emptying</td>
<td>Patient embarrassment</td>
</tr>
<tr>
<td></td>
<td>Relatively physiological</td>
<td>Difficulty with children</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Overdiagnostic tendency</td>
</tr>
<tr>
<td>Dynamic magnetic resonance imaging</td>
<td>High soft-tissue detail</td>
<td>Limited availability</td>
</tr>
<tr>
<td></td>
<td>No radiation exposure</td>
<td>? non physiological</td>
</tr>
<tr>
<td></td>
<td>Accurate for enterocoele</td>
<td>cost</td>
</tr>
<tr>
<td></td>
<td>Can be used in young patients</td>
<td>requires diagnostic expertise</td>
</tr>
<tr>
<td>Dynamic transperineal sonography</td>
<td>dynamic</td>
<td>Learning curve</td>
</tr>
<tr>
<td></td>
<td>Inexpensive</td>
<td>Time consuming</td>
</tr>
<tr>
<td></td>
<td>Accurate in ODS</td>
<td>Somewhat messy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Patient reticence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>?less physiological</td>
</tr>
<tr>
<td></td>
<td></td>
<td>?Diagnostic validation</td>
</tr>
<tr>
<td>Dynamic endoanal sonography</td>
<td>Able to diagnose concident</td>
<td>Learning curve</td>
</tr>
<tr>
<td></td>
<td>Anorectal pathology</td>
<td>potentially less</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diagnostic of endorectal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pathology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>relatively unvalidated</td>
</tr>
</tbody>
</table>

ve limitations in spatial and temporal resolutions resulting in somewhat poorer overall image quality$^{32-36}$. Comparative studies between closed- and open-magnet configurations for specific diagnosis of individual pelvic floor disorders has not shown a specific advantage for the open-configuration MR unit$^{31}$.

ANTERIOR COMPARTMENT DISORDERS

The bladder appears as a hyperintense structure on T2-weighted images with the urethra not well visualized in the midsagittal plane. Many of the measurements pertaining to this compartment are dependent upon the extent of bladder filling and are therefore not strictly comparable. In these views, a cystocele is readily identifiable when the bladder neck (or any part of it and the posterior vesical wall) descend below the PCL. Very large cystoceles may mask small rectoceles. These images may accurately define recurrent postoperative cystoceles and the radiologic appearance of periurethral bulking agents deployed for urinary stress incontinence$^{37,38}$.

MIDDLE COMPARTMENT DISORDERS

Diagnosis in this region is somewhat dependent upon the degree of rectal filling but specific diagnosis of enteroceles and peritoneoceles can be made along with the delineation of fascial defects within the region of the recto-genital septum$^{39}$. The latter has been supplemented by the use of 3D dynamic translabial ultrasonography as described by Dietz$^{40}$. Loss of vaginal support results in lengthening and asymmetry of the normal vault along with prolapse in relation to the PCL. The delineation of the pouch of Douglas is critical for the diagnosis of enterocoele and it represents the deepest point of the discernable intraperitoneal cavity where herniation of fat (peritoneocele), small bowel (enterocele) or colon (sigmoidocele) can be ascertained. The hernia sac extending below the PCL will
tend to follow the course of the vaginal wall and if there is excessive descent, a small cystocele or rectocele as well as minimal vault prolapse can be effectively masked.  

Assessment of this area is useful for designation of mesh locale following sacrocolpopexy for enterocoele management.  

**POSTERIOR COMPARTMENT DISORDERS**

Within this compartment definitive rectoceles are evident where their size is measured as part of a natural progression of the line of the normal anal canal. Thickening of the rectal mucosa here is indicative of occult rectal prolapse. This series of images is used to view the position of the anorectal junction in relation to the PCL and for evaluation of the integrity of the levator plate. Perineal descent is measurable as is the anorectal angle, junctional descent and the efficiency of rectal elimination. Although there is no standardized diagnostic parameter for anismus (paradoxical puborectalis contraction) during defaecation, in this condition the puborectalis muscle fails to physiologically relax and remains hyperactive during evacuation, where T2-weighted MR images show an indented impression of the muscle on the rectum with excessive obtuse anorectal angulation accompanied by very prolonged rectal emptying. These findings, however, only loosely correlate with conventional defaecography, electromyography or balloon expulsion testing.

In summary, dynamic MR imaging has become somewhat of the gold standard particularly in demonstrating the presence of enteroceles in postoperative patients. Its multiplanar capacity, dynamic evaluation and good temporal resolution along with its high-resolution soft-tissue contrast makes it an ideal modality in the assessment of such patients. Imaging in the midsagittal plane allows evaluation of the anal canal, anorectal angle, levator muscle and hiatus and the vaginal disposition as well as their relationship to a consistent electronically designated PCL. Its relative lack of availability and lack of specific interpretative expertise make its use limited in some locales as a first-up methodology unless specific questions pertaining to the pelvic floor are to be asked.

**DYNAMIC TRANSPERINEAL ULTRASONOGRAPHY (DTP-US)**

Dynamic transperineal ultrasound (DTP-US) is a recently developed, simple means of dynamic assessment of the pelvic floor assessing in real-time the components of the anterior, middle and posterior compartments. Independently developed by Beer-Gabel in Israel, Kleinübing in Brazil, Roche in Switzerland and Piloni in Italy, it has a significant learning curve and dedication but because of its widespread availability and low cost, it is recommended as a first step analysis for patients presenting with ODS and as a marker for the more selected use of dynamic MR imaging. Its other advantages include the lack of radiation exposure, its repeatability and its ability to define the presence of intrinsic internal and external anal sphincter anomalies. More recently it has provided use in the assessment of patients presenting with ODS who have extra-rectal disorders such as recurrent pelvic tumour and pelvic endometriosis. DTP-US provides static and dynamic images of the anal canal, anal sphincters, puborectalis sling, bladder base, urethrovaginal junction and rectogenital septum for the diagnosis of rectoceles, enterocele and rectoanal intussusceptions where it has shown co-mparative diagnostic equivalency with conventional defaecography and where individual measurement of the anorectal angle and anorectal junction movement on straining between the methodologies is similar.

The technical conduct and performance of DTP-US has been well described, where individual calculations of anorectal junction movement on straining and rectocele depth vector calculation have been defined. No specific preparation is required for the examination and the latest soft-ware provides facility for video scrolling in the assessment of the pelvic floor. The rectogenital septum is well displayed with the instillation into the vagina of a small volume of acoustic gel contrast and rectal evacuation may also be qualitatively assessed with intrarectal instillation of gel. A standard 7.5-10 MHz curvilinear or linear array transducer is utilized covered with a condom or glove with initial registering of the anal canal and sphincters in an axial mode. Under vision, the transducer is rotated through 90 degrees for a sagittal assessment locating the hyperintense pubis, the hypoechoic bladder and urethrovaginal angle, the hypoechoic parallel lines of the internal anal sphincter and the contrast in the vaginal vault. The area of the rectogenital septum is easily identified between the vaginal and rectal contrast lines.

The axial images obtained using DTP-US are akin to those obtained with an endoanal probe with this static technique having been described for sphincter assessment independently by Peschers et al. and Rubens and colleagues. Rotation of the probe demonstrates the puborectalis bundle end-on and the prior ingestion of saline and Gastrografin (Schering UK) permits the delineation of an enterocele in the rectovaginal septum by the presence of definable peristalsis. The rectogenital septum is considered abnormal if its maximal dimensions exceed 2 cm. in width, where absent bowel but an enlarged septal region are diagnostic of a rectocele. The anterior compartment will demonstrate any significant cystoceles as well as abnormal widening of the urethrovaginal angle. In dynamic mode, in comparison with defaecography for patients presenting with ODS, the diagnostic characterization with DTP-US shows good agreement with proctography although there is a tendency towards more diagnoses with DTP-US. These diagnoses do not appear to be affected by the extent of rectal or vaginal distension suggesting that over-distension or a “crowded pelvis syndrome” is a not a significant disadvantage in DTP-US use for patients with ODS where even small rectoceles are identifiable. There is a high correlation between the two modalities for anorectal angle measurement although this value tends to be higher during DTP-US with a greater overall descent of the anorectal junction during defaecography. These differences are likely as a result from the different positions in which these patients are examined. Currently, the ability or advantage of expanding the use of DTP-US to 3-dime-
nsonal mode is somewhat limited and this technique has yet to be standardized.

There is much validation work that is still required for DTP-US particularly following gynaecological surgery, but as a first-up technique which is simple, inexpensive and reliable it is likely to direct the colorectologist in selected cases towards dynamic MR imaging or extended defaecography. This author believes that DTP-US is sufficient for rectocele and rectoanal intussusception diagnosis, however, where a coincident enterocele is suggested on this initial examination, this finding should be confirmed by dynamic MR imaging. The coincident place and advantage of related but distinct techniques including transvaginal and translabial sonography in such patients presenting primarily with ODS is yet to be determined. The limitations of DTP-US are its substantial learning curve, reticence in some patients of straining adequately for accurate diagnosis in the proximity of the hand of the examiner and the delineation of some disorders in the left-lateral position of examination.

As a first-up procedural investigation it is well tolerated and best clinicianed. It may be used in the intraoperative setting for sphincteroplasty and coloperoineuroraphy where immediate anal distension may be contrainicated, as well as for the ultrasonographic determination of sphincter bioaugmentation where endoanal probes may initially disperse the supplemented material. Its validation in patients with coincident urovaginal prolapse is awaited.

From clinical experience it is limited in its accuracy in large-buttocked males as well as in very obese females. Although there is considerable prospective blinded validation required for DTP-US (particularly in the postoperative and posthysterectomy case), it is intuitive that it is a valuable complementary technique which can guide definitive management in patients presenting with ODS and towards more sophisticated investigative procedures.

**DYNAMIC 2- AND 3-DIMENSIONAL ECHODEFECOG- RAPHY**

This novel technique developed by Regadas and colleagues in Brazil uses a conventional 2050 3-dimensional endoanal scanner for assessment of the anal canal in dynamic mode between rest and straining and is an extension of work using a two-dimensional endoanal probe by Barthet and colleagues in 2000. It may be supplemented by 3D software conventionally used for the diagnosis of anismus by demonstration of a narrow angle of the puborectalis during evacuation effort; an effect which can be highlighted in 3-dimensional mode following the muscle in its longitudinal extent and by definition of the angle between the external anal sphincter and the puborectalis sling. The technique has been used in longitudinal mode for the demonstration and classification of rectoceles and enteroceles, where it has been suggested that rectoceles commence from the anterior wall at or even above the anorectal junction with calculation of the rectocele depth from an extended line of the posterior vaginal wall. Rectoanal intussusception is identified with the technique by axial and longitudinal impressions of extra muscular layers on straining as is mucosal rectal prolapse and descending perineal syndrome by variation in longitudinal puborectalis position between rest and strain. The advantage of this dedicated technique is its coincident accuracy in determination of sphincter pathology but as a technique it remains to be validated against other modalities. The same may also be said for the technique of transvaginal sonography which has been recently used for the assessment of internal rectal prolapse.

**CONCLUSIONS**

The advantages and disadvantages of dynamic MR imaging, dynamic transperineal sonography and endoanal dynamic sonography for use in patients presenting with ODS is shown in Table 1. Newer clinicianed techniques such as dynamic transperineal and endoanal sonography will aid the management of these patients and direct their more sophisticated investigation. Preliminary demonstration by these simpler technologies in dynamic mode of an enterocele may significantly modify the operative management of patients presenting with coincident rectocele where a combined laparoscopic abdominoperineal approach may be indicated and where endorectal stapled technology is specifically contrainicated. These technologies require prospective validation with clinical and operative findings particularly in the postoperative patient presenting with evacuatory difficulty.

**SUMMARY**

DINAMI~KA MAGNETNA REZINANCA I TRANSPE- RINEALNA SONOGRAFIJA U EVALUACIJI PACI- JENATA KOJI SE PRIMARNO PREZENTUJU SA PROBLEMIMA U PRA@NJENJU

Pacijenti koji primarno imaju probleme u pra@njenu imaju i mnogostruke anomalije mekih tkiva pelvi@nog po- da i perineuma. Radiolo~ka evaluacija kod ovih pacijen- nata za@teva modalitete koji prate dinami~ke interakcije pelvi@nih organa u toku manevara koji izazivaju napinaja- nje i simuliraju defekaciju. Prednosti i nedostaci ovih me- djusobno dopunjuju@ih modaliteta (dinami~ke magnetne rezonance, dinami~ke transperminalne sonografije i dinami- ~ke dvo- i trodimenzionalne endoanalne sonografije) su opisani u ovom radu.

Klju~ne re~i: dinami~ka magnetna rezonanca, transperinealna sonografija, pra@njene

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