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Research article

Supine magnetic resonance defecography for evaluation of anterior compartment prolapse: Comparison with upright voiding cystourethrogram

Neil M. Kumar[a], Gaurav Khatri[a,*], Alana L. Christie[b], Robert Sims[a], Ivan Pedrosa[a,b,c], Philippe E. Zimmern[c]

[a] Department of Radiology, University of Texas Southwestern Medical Center, 2201 Inwood Road, Dallas, TX 75390-9085, United States
[b] Simmons Comprehensive Cancer Center, University of Texas Southwestern Medical Center, 5323 Harry Hines Blvd., Dallas, TX, 75390-8851, United States
[c] Department of Urology, University of Texas Southwestern Medical Center, 5323 Harry Hines Blvd., Dallas, TX, 75390-8851, United States

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ABSTRACT

Purpose: To compare utility of supine Magnetic Resonance Defecography (MRD) with upright Voiding Cystourethrogram (VCUG) for evaluation of cystocele and urethral hypermobility (UHM).

Methods: This was an IRB-approved, HIPAA-compliant, retrospective study of 51 consecutive patients with symptomatic pelvic organ prolapse (POP) and lower urinary tract symptoms who underwent both upright VCUG and supine MRD. Cystocele height was defined in centimeters with reference to the inferior edge of the pubic bone on VCUG and the pubococcygeal line on MRD. Urethral angle at rest (UAR) and during straining (UAS) was measured in degrees between the urethral axis and a vertical line at the external meatus. Paired*t*-test and simple linear regression were applied to compare VCUG and MRD data sets. $p < 0.05$ was considered significant.

Results: The mean cystocele extent was 1.58 cm lower (more inferior to the reference point) (95% CI for the mean difference: 1.21, 1.94;$p < 0.0001$) on MRD (-2.73 ± 1.99 cm) than on VCUG (-1.16 ± 1.75 cm). Mean UAS on MRD (72.29 ± 26.45) was 31.8 degrees higher compared to that on VCUG (40.45 ± 21.41), (95% CI for mean difference in UAS: 37.57, 26.11; $p < 0.0001$). Mean UAS-UAR on MRD (74.30 ± 28.50) was 58.6 degrees higher compared to that on VCUG (15.70 ± 11.27) (95% CI for mean difference in UAS-UAR 65.94, 51.26; $p < 0.0001$). Cystocele size was upgraded in 22 (43.3%) patients on MRD compared to VCUG. Five (9.8%) patients demonstrated UHM on VCUG; 48 (94.1%) patients demonstrated UHM on MRD. The differences between VCUG and MRD scores persisted across the range of VCUG measurements. Cystocele size was significantly larger in POP (+) patients than in POP (-) patients on MRD ($p = 0.005$) but not on VCUG ($p = 0.06$).

Conclusions: Supine MRD demonstrates significantly higher prevalence and degree of cystocele and UHM than upright VCUG, and alters the grade of bladder prolapse in a significant portion of the patient population. Cystocele size on MRD correlates with clinical presence of prolapse symptoms.

1. Introduction

Pelvic floor dysfunction including pelvic organ prolapse (POP), stress urinary incontinence (SUI), and fecal incontinence affects nearly 25% of women age 20 or older, and nearly 50% of women age 80 or older [1]. More than 500,000 surgical procedures are performed annually for POP and urinary incontinence [2], and up to 81% of repair procedures involve the anterior compartment [3]. Anterior compartment POP may be associated with urethral hypermobility, defined as a urethral angle greater than 30° at rest, strain, or a change of at least 30° between rest and strain [4]. Accurate detection of POP and urethral hypermobility is important in guiding appropriate surgical management, however clinical examination may underestimate the site or extent of prolapse in 45–90% of patients [5]. 13–29% of patients undergo reoperation after initial surgery for POP or SUI [3,6] with 40% of these involving occult defects in compartments of the pelvic floor not treated by the initial procedure [3]. Imaging with fluoroscopy, ultrasound, or magnetic resonance (MR) defecography may be indicated for evaluation of patients with pelvic floor dysfunction [7], and allows for multicompartment assessment prior to initial surgery regardless of the presenting symptoms.

Upright Voiding Cystourethrogram (VCUG) provides objective

* Corresponding author.
E-mail addresses: nmk2008@gmail.com (N.M. Kumar), Gaurav.Khatri@utsouthwestern.edu (G. Khatri), Alana.christie@utsouthwestern.edu (A.L. Christie), robert.sims@va.gov (R. Sims), Ivan.Pedrosa@utsouthwestern.edu (I. Pedrosa), Philippe.Zimmern@utsouthwestern.edu (P.E. Zimmern).

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evaluation of cystocele and urethral mobility in pre and post-operative patients [8]. Limitations of VCUG include a targeted evaluation limited only to the anterior compartment, lack of direct visualization of pelvic floor anatomy, and patient exposure to ionizing radiation. Pre and post-operative data from VCUG have been validated against age-matched controls for assessment of cystocele and urethral hypermobility [8].

MR defecography (MRD) allows multi-compartment functional evaluation of the entire pelvis in addition to direct visualization of pelvic floor anatomy. In a cohort of patients with fecal incontinence, MRD demonstrated pelvic floor descent involving all three compartments in 62% of cases, and influenced treatment for the fecal incontinence in 22 of 33 surgically managed patients [9]. In another more recent study, a multi-disciplinary group of pelvic floor surgeons found MRD to be essential for diagnosis in 44% of cases [10]. Recently published joint recommendations of the ESUR and ESGAR pelvic floor working group specify various indications for MR imaging of the pelvic floor, with moderate agreement for evaluation of the anterior compartment [11].

MRD can be performed in supine or sitting positions, however sitting MRI can only be performed in upright open-configuration magnets which are not readily available at most centers. Supine MRD, on the other hand, can be performed on most routine closed magnets, which are more ubiquitously available. Prior studies have compared the utility of supine MRI of the pelvic floor to upright fluoroscopic or upright MR examinations with variable results [12–18], however, many of these studies were performed during Valsalva or straining rather than defecation on the supine MRI examination. Defecation during dynamic MRI of the pelvic floor increases sensitivity for detection of prolapse [19–21]. MRI with defecation (MRD) is thus preferred over MRI with straining or Valsalva for assessment of pelvic organ prolapse [7]. However, there is a paucity of studies in the literature comparing findings on supine MRI with defecation (MRD) to upright fluoroscopy, in particular VCUG. Thus, the purpose of this study was to compare the ability of supine MRD to depict urethral hypermobility and cystocele relative to upright VCUG, the examination of choice for evaluation of anterior prolapse at our institution and others [22].

2. Materials and methods

2.1. Patient selection

This was an IRB-approved, HIPAA-compliant, retrospective study of 89 consecutive female patients with symptomatic POP and lower urinary tract symptoms who underwent both upright VCUG and supine MRD over a 15-month period at a single institution. A total of 37 patients were excluded based on the exclusion criteria (Fig. 1). The final study cohort consisted of 51 patients.

2.2. VCUG technique

VCUG was performed in the lateral standing position following a previously published protocol [8,23]. 125 cc of radio-opaque contrast (Cystografin®, Bracco Diagnostic Inc., Monroe Township, NJ) was instilled in the bladder via an indwelling Foley catheter. Sagittal fluoroscopic images were obtained at rest and strain. Following removal of the catheter, sagittal voiding images and post-void images were obtained. A radio-opaque ruler was placed within the field of view in order to accurately calibrate measurements since magnification during a fluoroscopic examination can result in overestimation of prolapse size (Fig. 2).

2.3. MRD technique

All MR examinations were performed in supine position on a single 1.5 T MRI scanner (Siemens Magnetom® Avanto, Erlangen, Germany) with a six-channel phased-array surface coil after instillation of ultrasound gel into the rectum. Multiplanar T2- and axial T1-weighted images of the pelvis were obtained at rest followed by cine MR true fast imaging with steady state precession (TrueFISP) images (single sagittal images acquired repeatedly through the midline pelvis at 1 image/sec) during Kegel (squeeze), Valsalva (strain) and defecation (Table 1). The patients were asked to empty their bladder upon arrival to the department and then ingest 16 ounces of water prior to scanning in an effort to obtain mild bladder distention.

2.4. Image analysis

VCUG and MRD images were reviewed in consensus by two radiologists with experience in pelvic floor imaging as well as a urologist specializing in treatment of female pelvic floor disorders. Cystocele height was measured in centimeters (cm) with reference to the inferior edge of the pubic bone for VCUG and with reference to the pubococcygeal line (PCL) on MRD (Fig. 2). PCL was defined as a line connecting the inferior edge of the pubic symphysis to the last coccygeal joint [11] or in cases where the last coccygeal joint was mobile, to the last non-mobile coccygeal or sacrococcygeal joint [24] (Fig. 2). Measurements above the inferior edge of the pubic symphysis on VCUG and PCL on MRD were considered positive whereas measurements below these landmarks were considered negative such that larger cystoceles would result in increasingly negative measurements. Cystocele grade was assigned as per previously published guidelines for both VCUG (mild or grade 1: < 2 cm below the pubic symphysis; moderate or grade 2: 2- < 5 cm; severe or grade 3: ≥ 5 cm) [8] and MRD (small: < 3 cm below the PCL, moderate: 3- < 6 cm; large: ≥ 6 cm) [25]. Urethral angles at rest (UAR) and at strain for VCUG or during defecation for MRD (UAS) were measured in degrees (°) as the angle between a line drawn along the urethral axis and a vertical line at the external urethral meatus along the longitudinal axis of the body [12]. On VCUG, the urethral axis was demarcated by the Foley catheter (Fig. 2). On MRD, it was defined as the line connecting the internal and external urethral meatus (Fig. 2). Urethral hypermobility was defined as a change in urethral angle greater than 30° between rest and strain (VCUG) or defecation (MRD) images (UAS minus UAR $>$ 30) [4].

2.5. Statistical analysis

SAS 9.4 (SAS Institute Inc., Cary, NC) software was used for all statistical analysis. Paired *t*-test was performed to compare cystocele heights and UAS, UAR, and strain minus rest angles (UAS-UAR) between VCUG and MRD. Simple linear regression was used to test if the difference between the MRD and VCUG values varied across the range of VCUG measurements. The Friedman and Binomial tests were used to compare the distribution of clinical grades assigned to cystocele heights and the proportion of patients with urethral hypermobility, respectively, between MRD and VCUG. Student's *t*-test was used to perform analysis of cystocele heights and urethral hypermobility in subgroups of patients with and without POP symptoms. Results with $p < 0.05$ were considered significant.

3. Results

The 51 patients included in the study had an average age of 56.8 years, an average BMI of 27.9, and average parity of 3.24 (Table 2). Overall, 44 of 51 (86%) patients had a history of prior POP repair(s) and/or a urethral sling procedure while 45 of 51 (88%) patients had prior hysterectomies. Nearly 90% of patients exhibited urinary symptoms and 30 of 51 (59%) patients experienced POP symptoms.

Cystocele heights and urethral angles for VCUG and MRD are shown in Table 3. The mean cystocele extent was 1.58 cm lower (more inferior to the reference point) for MRD (-2.73 ± 1.99 cm) than VCUG (-1.16 ± 1.75 cm), ($p < 0.0001$). The mean UAS on MRD (72.29° ± 26.45) was 31.8° higher compared to that on VCUG

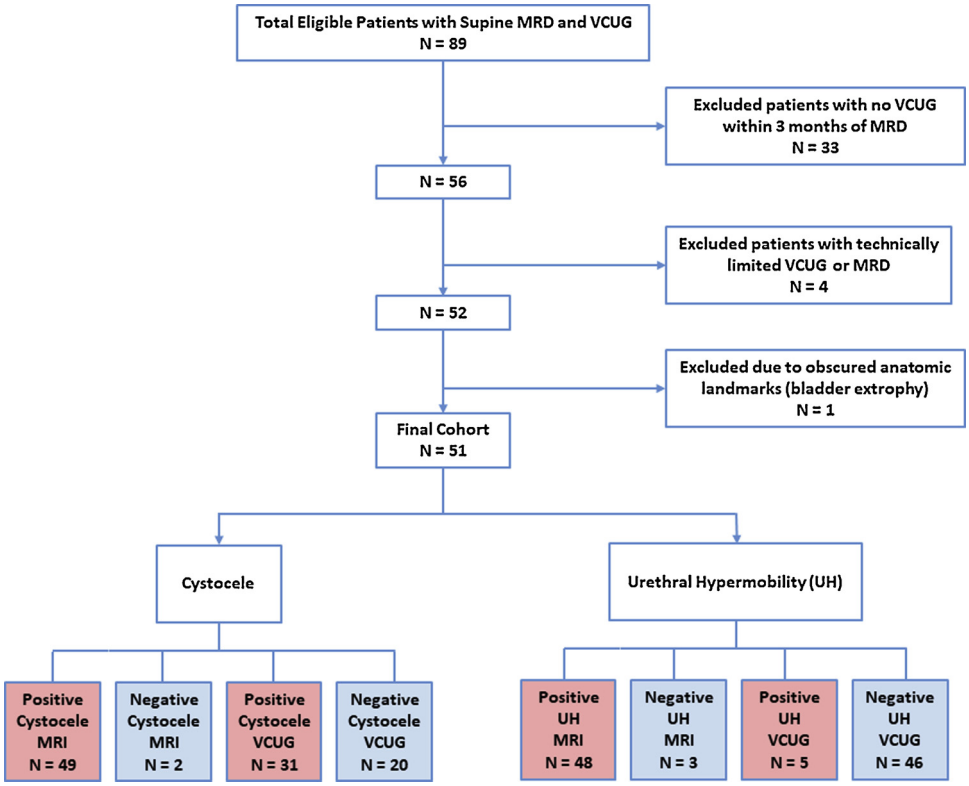

Fig. 1. Patient Enrollment Flowchart.

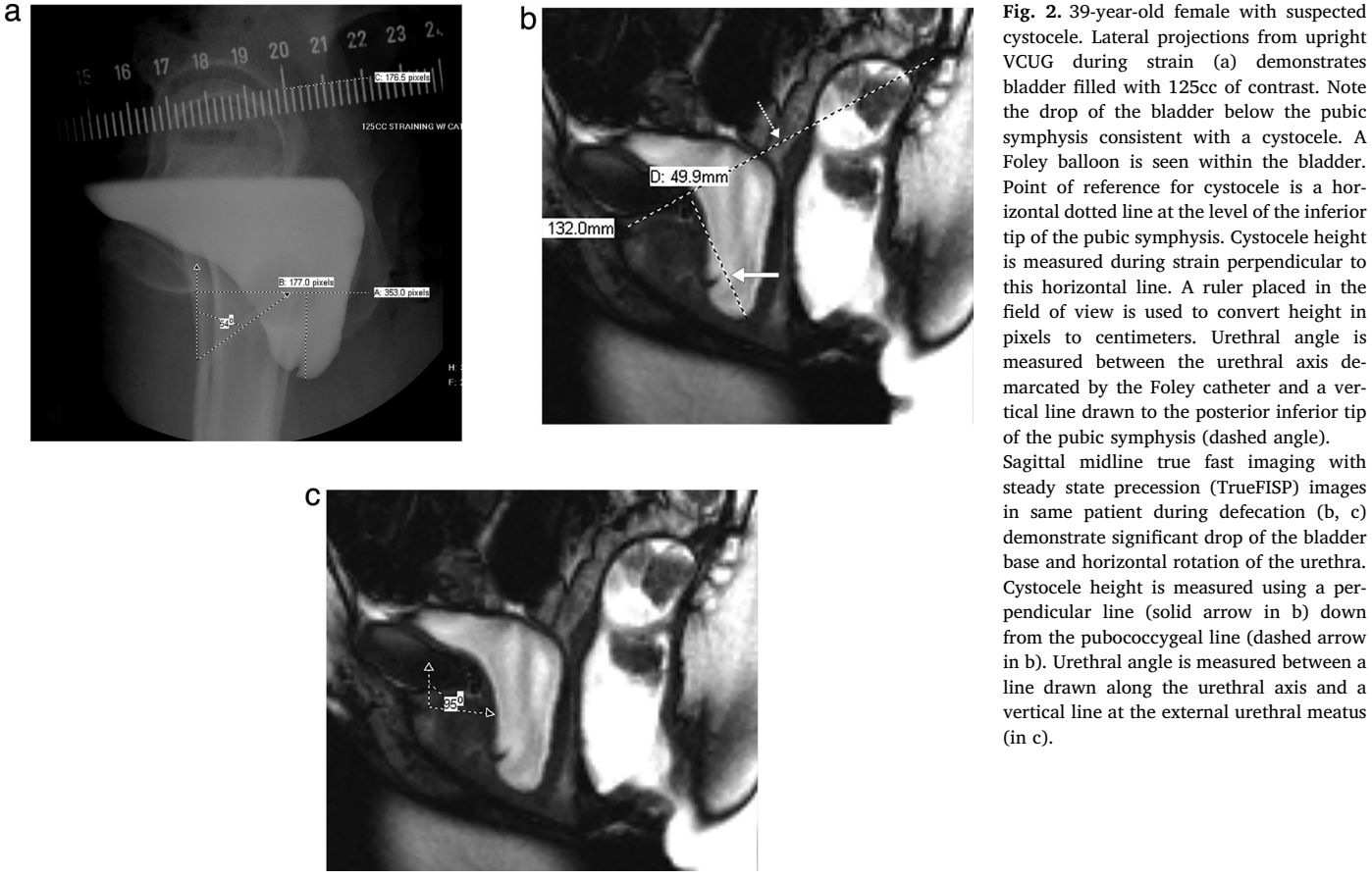

Fig. 2. 39-year-old female with suspected cystocele. Lateral projections from upright VCUG during strain (a) demonstrates bladder filled with 125cc of contrast. Note the drop of the bladder below the pubic symphysis consistent with a cystocele. A Foley balloon is seen within the bladder. Point of reference for cystocele is a horizontal dotted line at the level of the inferior tip of the pubic symphysis. Cystocele height is measured during strain perpendicular to this horizontal line. A ruler placed in the field of view is used to convert height in pixels to centimeters. Urethral angle is measured between the urethral axis demarcated by the Foley catheter and a vertical line drawn to the posterior inferior tip of the pubic symphysis (dashed angle).
Sagittal midline true fast imaging with steady state precession (TrueFISP) images in same patient during defecation (b, c) demonstrate significant drop of the bladder base and horizontal rotation of the urethra. Cystocele height is measured using a perpendicular line (solid arrow in b) down from the pubococcygeal line (dashed arrow in b). Urethral angle is measured between a line drawn along the urethral axis and a vertical line at the external urethral meatus (in c).

Table 1
Institutional MR Defecography protocol.

Sequence	Imaging Plane	Maneuver	TR (ms)	TE (ms)	FOV (cm)	Matrix	Slice thickness (mm)
T2 TSE	Axial	Rest	3920	91	26	320 × 256	5
T2 TSE	Sagittal	Rest	4070	91	26	320 × 256	5
T2 TSE	Coronal	Rest	4880	91	26	320 × 256	5
T1 SE	Axial	Rest	625	10	26	256 × 192	5
cine TrueFISP	Sagittal	Kegel	734.4	1.8	34	256 × 256	8
cine TrueFISP	Sagittal	Valsalva	734.4	1.8	34	256 × 256	8
cine TrueFISP	Sagittal	Defecation	734.4	1.8	34	256 × 256	8
cine TrueFISP	Sagittal	Post defecation Valsalva	748.8	1.8	34	256 × 256	8
T2 TSE	Axial	Rest	3920	91	26	320 × 256	5

Footnote: TR: repetition time; TE: time to echo; FOV: field of view; TSE: turbo spin echo; TrueFISP: true fast imaging with steady-state precession.

Table 2
Patient demographics (n = 51).

Patient Demographic	Results
Age, *mean*	56.8
BMI, *mean*	27.9
Parity, *mean*	3.24
Pop symptoms, *n (%)*	30 (59%)
POP/SUI Repair, *n (%)*	44(86%)
Hysterectomy, *n (%)*	45 (88%)

Table 3
Cystocele height and Urethral angle by imaging modality.

	Mean ± SD		Mean VCUG – MRD difference (95% CI)	*p*
	VCUG	MRD		
Height (cm)	−1.16 ± 1.75	−2.73 ± 1.99	1.58 (1.21, 1.94)	< 0.0001
UAS	40.45 ± 21.41	72.29 ± 26.45	−31.84 (-37.57, -26.11)	< 0.0001
UAR	25.08 ± 20.02	−1.74 ± 17.44	26.82 (21.71, 31.93)	< 0.0001
UAS-UAR	15.70 ± 11.27	74.30 ± 28.50	−58.60 (-65.94, -51.26)	< 0.0001

Footnote: UAS- urethral angle at strain; UAR- urethral angle at rest; VCUG- voiding cystourethrogram; MRD- magnetic resonance defecography.

(40.45° ± 21.41), ($p < 0.0001$). The mean UAS-UAR on MRD (74.30° ± 28.50) was 58.6° higher compared to that on VCUG (15.70° ± 11.27), ($p < 0.0001$) indicating higher degree of urethral hypermobility for MRD. VCUG showed significantly higher UAR than that on MRD (25.08° ± 20.02 on VCUG versus -1.74° ± 17.44 for MRD) ($p < 0.0001$).

Table 4 displays the clinical grade distributions for cystocele and urethral hypermobility on VCUG and MRD. The gradation of cystocele was altered in 22 patients (43%) based on MRD values, with all 22 patients demonstrating higher grade bladder prolapse on MRD. 16 patients with no cystocele on VCUG demonstrated grade 1 cystoceles on MRD; 2 patients with no cystocele and 2 patients with grade 1 cystoceles on VCUG demonstrated grade 2 cystoceles on MRD, and 2 patients with grade 2 cystoceles on VCUG demonstrated grade 3 cystoceles on MRD. Cystocele grading was significantly higher on MRD as compared to VCUG ($p < 0.0001$). Incidence of urethral hypermobility also differed significantly between MRD and VCUG ($p < 0.0001$). 5 (9.8%) patients demonstrated urethral hypermobility with VCUG while 48 (94.1%) of patients were found to have urethral hypermobility with MRD.

Table 4
Cystocele Grades and Urethral Hypermobility by imaging modality.

Cystocele Grades	VCUG = 0	VCUG = 1	VCUG = 2	VCUG = 3	*p*
MRD = 0	2	0	0	0	< 0.0001
MRD = 1	16	14	0	0	
MRD = 2	2	2	13	0	
MRD = 3	0	0	2	0	

Urethral Hypermobility	VCUG = Positive	VCUG = Negative	
MRD = Positive	5	43	< 0.0001
MRD = Negative	0	3	

Footnote: VCUG- voiding cystourethrogram; MRD- magnetic resonance defecography.

Table 5 shows subgroup analysis of the results separated by patients with POP symptoms (POP(+)) and without POP symptoms (POP(-)). Larger cystoceles were observed on MRD than VCUG for both POP(+) ($p < 0.0001$) and POP(-) patients ($p < 0.0001$). Overall, cystoceles were significantly larger in POP(+) patients than in POP(-) patients on MRD ($p = 0.005$). Although a similar trend was seen on VCUG, it did not reach statistical significance ($p = 0.06$). MRD demonstrated higher degree of urethral hypermobility (UAS-UAR) than on VCUG in both POP(+) and POP(-) subgroups. UAS and UAR were also significantly different between the two imaging studies in both POP(+) and POP(-) patients. Neither MRD nor VCUG showed significant difference in UAS or UAS-UAR between POP(+) and POP(-) patients. UAR was significantly higher in POP(+) patients than that in POP(-) patients on VCUG ($p = 0.04$), but not on MRD ($p = 0.2$).

Linear regression analysis revealed that differences in cystocele size between VCUG and MRD did not vary as a function of cystocele size on VCUG ($p = 0.2$). The difference in UAS-UAR between MRD and VCUG also did not change significantly in relation to UAS-UAR values on VCUG ($p = 0.8$).

Table 5
Cystocele height and urethral angle by presence or absence of POP symptoms (*t*-test).

	Mean ± SD		*p*
	POP -	POP +	
Height (cm)			
VCUG	−0.60 ± 1.28	−1.54 ± 1.95	0.0590
MRD	−1.89 ± 1.33	−3.33 ± 2.17	0.0051
P	< 0.0001	< 0.0001	
UAS			
VCUG	34.10 ± 19.84	44.90 ± 21.65	0.0758
MRD	66.48 ± 22.49	76.37 ± 28.56	0.1916
P	< 0.0001	< 0.0001	
UAR			
VCUG	17.95 ± 15.83	29.83 ± 21.33	0.0385
MRD	−5.40 ± 18.00	0.70 ± 16.91	0.2293
P	< 0.0001	< 0.0001	
UAS-UAR			
VCUG	16.65 ± 11.95	15.07 ± 10.94	0.6313
MRD	72.25 ± 27.73	75.67 ± 29.40	0.6824
P	< 0.0001	< 0.0001	

Footnote: UAS- urethral angle at strain; UAR- urethral angle at rest.

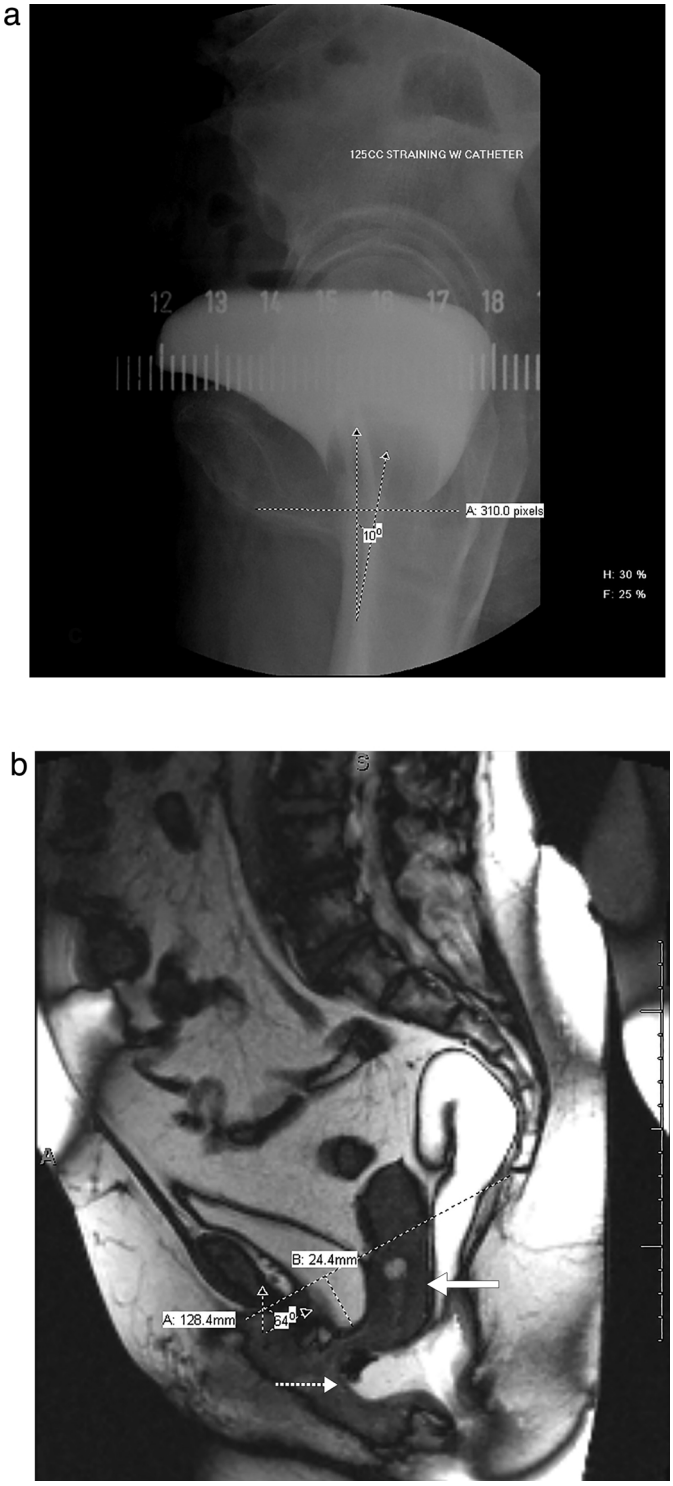

Fig. 3. 60-year-old female with previously treated stress urinary incontinence with dyspareunia, and no sensation of vaginal bulge or pressure. VCUG image during strain (a) demonstrates no cystocele. Urethral angle at strain (UAS) on VCUG is 10 degrees. MRD image during defecation (b) obtained 8 days later demonstrates grade 1 cystocele measuring 2.4 cm and urethral mobility (UAS 64 degrees). In addition to anterior compartment prolapse, the MRD also demonstrates uterine/cervix prolapse (solid arrow in b) below the PCL and a prominent rectocele in the posterior compartment (dashed arrow in b), information not provided by the fluoroscopic examination.

4. Discussion

We compared the size and prevalence of cystocele and urethral hypermobility on supine MRD to that on standing VCUG in 51 patients. Our study demonstrated significantly larger cystoceles on supine MRD compared to standing VCUG in patients both with and without prolapse symptoms (Figs. 3 and 4). In addition, MRD depicted significantly larger cystoceles in patients with prolapse than it did in patients without prolapse. Although cystocele size on VCUG followed a similar trend, it did not achieve statistical significance. Cystocele size on MRD thus correlates better with the clinical symptoms of prolapse than does cystocele size on VCUG. Supine MRD increased the grade of cystocele in nearly half of the patients relative to VCUG. Furthermore, 18 of the 20 patients that did not demonstrate cystoceles on VCUG showed at least grade 1 cystoceles on MRD. This is particularly important as the detection of low-grade cystoceles in patients with SUI may require additional surgical management to correct the anterior compartment prolapse and avoid a secondary urethrovesical angle obstruction [26]. Our results support the use of supine MRD, which can be performed on most routinely available closed magnets, for detection and grading of anterior compartment prolapse.

Supine MRD showed higher incidence (94% versus 10%) and higher degree of urethral hypermobility compared to VCUG (Figs. 3 and 4). Urethral hypermobility may be present in asymptomatic patients, and urethral mobility angles often overlap in continent and incontinent women [27], however when urethral hypermobility is found in patients with clinical SUI, it helps determine appropriate surgical management of SUI [26]. The presence of urethral hypermobility in SUI patients is associated with higher cure rates after urethral sling procedures [28,29]. Furthermore, large cystoceles can mask both urethral hypermobility and SUI, and up to 20–25% of continent women with cystoceles may develop SUI after cystocele repair. A concurrent urethral support procedure can be effective in preventing SUI in these patients [30]. The higher detection rate of MRD for urethral hypermobility may help identify patients that could benefit from urethral support procedures performed in conjunction with prolapse repair. In addition, MRD is able to demonstrate pelvic dysfunction not only in the anterior compartment, but evaluates the entire pelvic floor in unison, often depicting middle and posterior compartment dysfunction that would be occult on VCUG (Figs. 3 and 4). A larger scale systematic evaluation would be necessary to establish whether altering management based on the higher detection of urethral hypermobility and occult prolapse in other compartments by MRD affects clinical outcomes.

Prior studies comparing supine dynamic MRI to upright fluoroscopic examinations or upright MRI have shown lower prevalence or size of cystocele on the supine MRI [25,13,15], however the supine MRI technique in those comparisons did not include a defecation phase. Gufler et al. demonstrated no significant difference in bladder neck position and urethral angulation at strain between supine MRI and upright colpocystoproctography (CCP) [14]. Pannu et al. showed significantly higher prevalence and size of cystoceles on CCP compared to supine MRI with straining, but no significant difference was found when comparing CCP to defecation MRI [17]. In contrast, our study demonstrated larger degree of cystocele and urethral mobility on supine MRI with defecation when compared to an upright fluoroscopic examination. The larger degree of prolapse and urethral mobility on supine MRI in our study may be the result of actual defecation during the MRI compared to just straining on the prior studies. This is in keeping with prior MRI studies that have shown higher degree of prolapse in all compartments on the defecation phase compared to the strain phase [19,21]. It is conceivable that defecation in a supine position as it was performed in our study may require higher intra-abdominal pressure and may result in greater relaxation of pelvic floor muscles than voiding in upright position, thus resulting in larger degree of prolapse and urethral mobility. MRD may also allow more posterior rotation of the urethra and descent of the bladder into a dependent

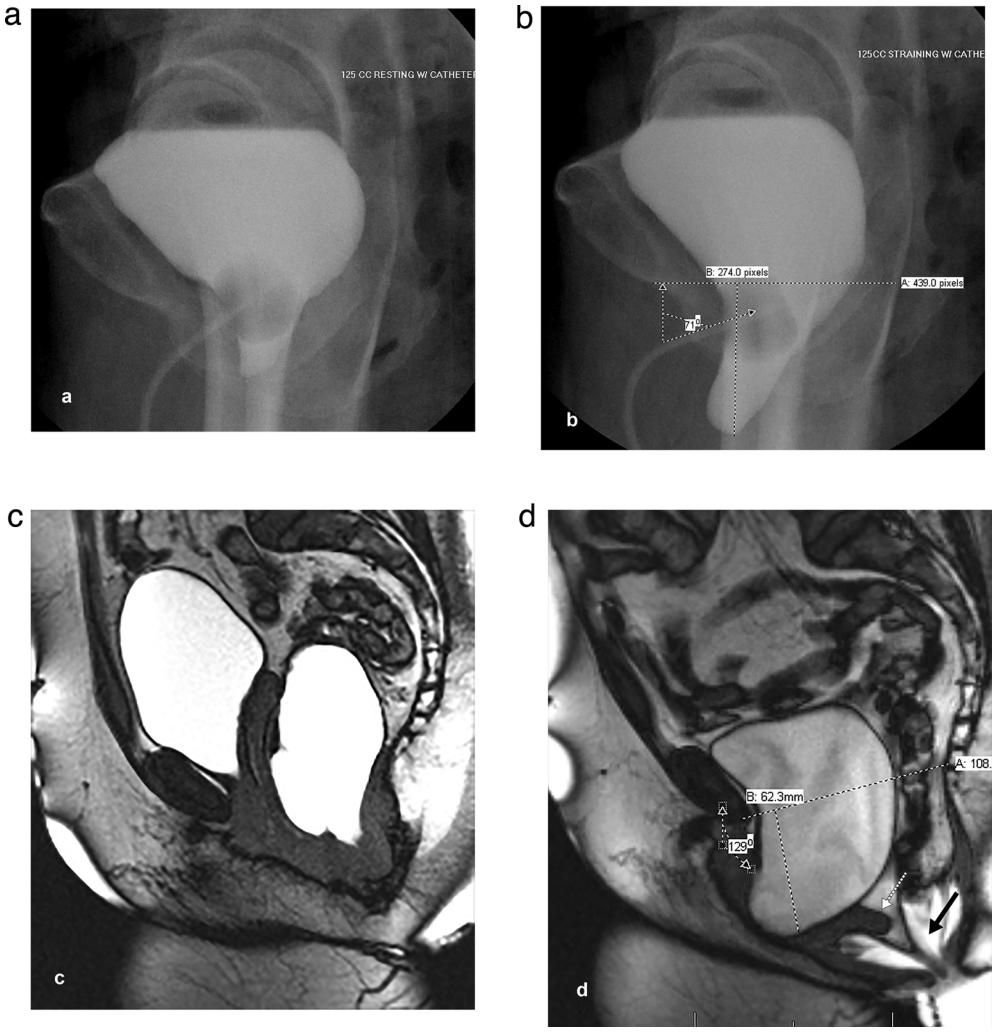

Fig. 4. 64-year-old female with chief complaint of prolapsed bladder manifested as vaginal heaviness and occasional bulge. VCUG images during rest (a) and strain (b) demonstrate urethral angle at strain (UAS) of 71 degrees and a grade 2 cystocele measuring 3.2 cm. MRD images during rest (c) and defecation (d) performed 2.5 h prior to the VCUG on the same day demonstrate larger UAS of 129 degrees, much larger change of urethral angle from rest, and a significantly larger grade 3 cystocele measuring 6.2 cm. Note the urethra at rest on VCUG (in a) demonstrated a more horizontal orientation compared to the orientation on MRD (in c). In addition to showing larger cystocele, the MRD also demonstrates severe prolapse of the vaginal apex (dashed arrow in d), unsuspected rectocele, moderate rectal descent, and rectal intussusception (solid arrow in d).

position due to gravitational effects in supine position rather than upright on VCUG.

The presence of a Foley catheter in the urethra during VCUG allows better visualization of the urethral axis on VCUG than can be seen on MRD, however it may result in increased tone of the pelvic floor, and may lend artificial support to the anterior compartment structures during strain. It may also weigh the urethra down during rest, explaining the significantly higher UAR seen on VCUG compared to MRI (Fig. 4), with prolapse patients demonstrating larger UAR than patients without prolapse. Our findings are concordant with those of Gufler et al. who also demonstrated larger resting urethral angles on upright fluoroscopic studies than on dynamic MRI. The urethra was marked with beaded chains in that study [14]. In order to most consistently measure the urethral angle on MRD, we defined the urethral axis as a line connecting the internal and external meatus (Fig. 2), bisecting the thickness of the urethra on sagittal images. With regard to other anatomic landmarks and grading of prolapse, we chose to use previously established reference points and grading schemes specific to each of the techniques (e.g., PCL for MRD and pubic symphysis for VCUG), in order to be able to generalize the results to techniques as used in current clinical practice. The PCL was chosen as a landmark for MRD as it is the most commonly clinically used point of reference for MRD and has shown high inter and intra-observer reliability [31].

The differences between VCUG and MRD scores for both cystocele and urethral hypermobility (UAS-UAR) in our study persisted across the range of VCUG values and did not correlate with change in the VCUG values. The persistence of these differences at all levels of disease highlights the utility of MRD in the assessment of mild as well as severe anterior compartment POP.

Limitations of our study include that it was a retrospective analysis and was performed in a symptomatic patient population. A larger multi-institutional study would be needed to assess its applicability to the more general patient population. Our study was also limited by the absence of an age-matched true negative control group. Nevertheless, we included patients with and without POP symptoms in order to serve as an internal control and limit selection bias. The control subgroup of patients without POP symptoms demonstrated statistically smaller cystoceles on MRD compared to the POP positive subgroup suggesting that the MRD findings may correlate with clinical presentation. Although a similar trend was seen on VCUG, the difference was not statistically significant. Neither test showed significant difference in degree of urethral hypermobility between POP + and POP- patients, although the resting urethral angle was significantly higher on VCUG in POP + patients. The clinical utility of this finding requires additional studies that compare imaging with physical examination and other tests such as the Q-tip test in both POP + and POP- patients.

VCUG or MRD findings were not compared to physical examination as a gold standard in our study. Previous comparisons between imaging and clinical examinations have shown poor correlation and the International Consensus Society's Pelvic Organ Prolapse Quantification system used to grade prolapse clinically correlates poorly with imaging findings [32]. Furthermore, estimation of prolapse can vary based on other factors such as degree of bladder distention, time of day, patient fatigue, degree of patient straining, and other factors such as biologic

variability within patients [33]. Another limitation of the study is that inter- and intra-observer variability was not assessed. While other single-institution studies have evaluated the interobserver variability of dynamic pelvic floor MRI [9,31,34], the imaging review in our study was performed in consensus to mimic our standard weekly multi-disciplinary review of clinical cases with radiology and urology. Future multi-institutional studies would be important to evaluate agreement between MRD interpretations across different sites.

5. Conclusion

In conclusion, supine MR defecography shows higher prevalence and degree of cystocele and urethral hypermobility than upright VCUG, and cystocele size on MR defecography correlates with presence of clinical symptoms of prolapse. These findings support the utility of supine MR defecography for assessment of anterior compartment prolapse. Multi-compartment analysis, widespread availability, and absence of exposure to ionizing radiation are additional advantages of supine MRD.

Declarations of interest

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