Restoration of continence by pessaries: magnetic resonance imaging assessment of mechanism of action

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OBJECTIVE: The objective of the study was to determine incontinence pessaries' mechanism of action by measuring changes on urodynamic studies (UDS) and dynamic magnetic resonance imaging (MRI) with and without pessaries in place.

STUDY DESIGN: Women with stress incontinence had UDS and MRI performed with and without incontinence dish pessaries.

RESULTS: Fifteen women were evaluated. Pessary insertion resulted in increased urethral resistance; detrusor pressures increased (33-45 cm H_2O) and maximal flow rates decreased (30 to 19 mL/second). With Valsalva on MRI, pessaries were associated with decreased posterior urethrovesical angles (175-130°), bladder neck elevation (0.3 below to 0 .8 cm above the pubococcygeal line) and increased urethral lengths (2.4 to 2.97 cm). Bladder neck funneling with cough occurred in 14 patients without pessaries and 3 with pessaries.

CONCLUSION: On UDS and MRI following pessary placement, continence restoration was associated with decreased posterior urethrovesical angles, bladder neck descent and funneling, and increased urethral lengths and resistance to urine flow.

Key words: magnetic resonance imaging, pessary, urinary incontinence, urodynamic studies

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Stress urinary incontinence (SUI), involuntary urine loss that occurs with increased intraabdominal pressure,[1] affects many women. A number of theories postulate why SUI occurs. Pessaries are among the few nonsurgical treatments of SUI. Pessary treatment is simple and can therefore serve as starting point in understanding the mechanisms underlying the restoration of continence.

Current theories of continence include Enhorning's pressure transmission theory, the hammock hypothesis, and the integral theory.[2-4] Enhorning's theory postulates that the proximal urethra must be subject to intraabdominal pressure to close during cough or Valsalva, maintaining continence.[2] The hammock hypothesis proposes that structures posterior to the urethra form a back-stop. When intraabdominal pressure increases, the urethra is compressed against this supportive tissue and continence is maintained.[3]

Supportive structures surrounding the urethra are also pivotal in preserving continence in the integral theory.[4] This theory proposes that musculoelastic properties of the vagina not only contribute to formation of a backstop posterior to the urethra but also result in lengthening of urethra, both components of continence. These theories are not mutually exclusive, and parts of 1 or more the theories may explain successful treatment of SUI.

Pessaries offer a unique approach to understanding continence mechanisms because they provide a readily reversible method of restoring continence. They allow the study of patients during periods of continence and incontinence that are separated in time by only minutes. Using both magnetic resonance imaging (MRI) and urodynamic studies (UDS), we quantified the acute anatomic and functional changes that followed placement of pessaries and restored continence. We performed this pilot study to both reveal pessaries' mechanism of action and improve our understanding of mechanisms of continence in general.

Materials and Methods

Women using pessaries to treat urinary continence were recruited for this study from October 2005 through August 2006. Women were excluded if they were pregnant, younger than 18 years old, had a urinary tract infection, or had greater than stage II prolapse on their Pelvic Organ Prolapse Quantitation examination.[5] We excluded women with greater than stage II prolapse because of concerns that more advanced stages of prolapse could be accompanied by distortion of the pelvic floor that could obscure findings specific for urinary incontinence. Women were eligible to participate in this study if they had a history of SUI, urethral hypermobility on examination, and were able to undergo MRI. We required evidence of stress incontinence on physical examination or urodynamic evaluation prior to performance of MRI. The University of New Mexico Institutional Review Board approved this study, and participants gave written informed consent prior to testing.

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A standardized history and physical examination form was used for all subjects. The Urogenital Distress Inventory-6 (UDI-6) [6] was administered and urinalysis obtained prior to urodynamic testing. The Q-tip test was performed before and after pessary insertion. Urethral hypermobility was defined as Q-tip excursion greater than 30 degrees with Valsalva.

Complex urodynamic testing was performed before and after pessary placement according to International Continence Society guidelines.[7] Nurses experienced in UDS performed the tests. A seven French double lumen fluid filled catheter was placed in the bladder and urethra. A single lumen catheter was placed in the vagina to measure intraabdominal pressure. Postvoid residuals and intravesical and urethral pressures were recorded. Duet Sensic (Mediwatch U.K. Ltd, Ruby, United Kingdom) urodynamic computer software was used on a Mediwatch Duet Sensic urodynamic machine (Mediwatch U.K. Ltd).

Bladders were filled with liquid at 50 mL/min with patients lying at a 45° incline. Sensory symptoms and presence of detrusor contractions were noted. Patients performed cough and Valsalva at 200 mL and again at maximal capacity. The maneuvers were repeated with patients standing if leakage did not occur with the previously mentioned provocative maneuvers. At maximal bladder capacity, static urethral pressure profilometry was performed, withdrawing the catheter through the urethra using an electronic puller at 1 mm/sec. Patients then voided with the catheters in place. The procedures were repeated following pessary placement.

Subjects used the same silicone incontinence dish pessaries for both UDS and MRI. Incontinence dish pessaries were used because they are MRI compatible. If patients used other pessaries prior to the study, they were fit with incontinence dish pessaries similar in size to their usual pessaries, which also restored continence.

MRI was performed on a 1.5 Tesla Siemens Symphony MRI (Siemens AG Medical Solutions, Erlangen, Germany) with a phased array pelvic coil to maximize spatial resolution. All sequences were performed with the subjects reclining. Subjects did not void for at least 30 minutes prior to MRI. Initial MRI scanning was performed without a pessary in place. Imaging was performed using T2W fast spin echo sequence in axial and sagittal planes to identify a midline sagittal imaging plane and establish anatomic landmarks using optimal spatial resolution. Subsequently T2 single-shot, fast-spin echo sequences were performed in the midline sagittal plane with the patient at rest and during Valsalva maneuver. Each image acquisition lasted approximately 20 seconds.

These sequences were followed by cinematic MRI in the sagittal plane using a true fast imaging with steady-state precession (FISP) (steady state gradient echo) with T2/T1 (ratio of spin relaxation time to spin lattice relaxation time) weighting. This technique allowed for exquisite temporal resolution with limited spatial resolution. Using this MRI sequence, we acquired the 20-30 subsecond images needed to accurately observe the change in morphology and location of the bladder neck over time. These cinematic sequences were performed during Valsalva and cough. These imaging sequences were completed in 10-15 minutes.

After the true FISP images were obtained, an incontinence dish pessary was placed while the patient remained on the MRI table. The true FISP cinematic imaging sequence and the aforementioned T2W single-shot sequence were then repeated in the same manner as performed without the pessary in place. Patients voided at the end of the session and urine volume was measured.

Measurements performed on single-shot, spin-echo MRI images included the following: the distance between the bladder neck and the pubococcygeal line,[8] the distance between the bladder neck and posterior pubis,[8] the midurethra and posterior pubis, and measurement of the posterior urethrovesical angle.[9] The posterior urethrovesical angle was the angle that intersected the axis of the proximal urethra and a posterior line representing at least one third of the bladder base.[9] Measurements made on cinematic images included distance of the bladder neck to the pubococcygeal line and posterior pubis during Valsalva and cough, presence or absence of bladder neck funneling during cough, and the posterior urethrovesical angle. Location of the pessary relative to the bladder neck was also noted.

MRI measurements were performed by 2 board-certified radiologists experienced in cross-sectional body imaging. Values for the measurements above were reached by consensus. Radiologists were unaware of UDS results and nurses performing UDS were unaware of MRI results.

Statistics

Our power analysis was based on prior work comparing changes of the bladder neck location before and after pessary placement.[9] Assuming 80% power, alpha = 0.05, and 50% change in bladder neck position, 14-16 patients were needed for this study. Continuous variables comparing within subject change were evaluated using 2-tailed paired *t* tests and the Wilcoxon test. Comparisons between subjects were evaluated using unpaired *t* tests. Categorical variables were analyzed by Fisher's exact test and McNemar's test of symmetry. Statistical analysis was performed using STATA software (version 10, Statacorp, PLC, College Station, TX).

Results

Eighteen women were recruited for this study. Of these, 1 declined further participation prior to her MRI, and 2 were ineligible for MRI: 1 subject lacked urethral hypermobility, and the other lacked objective urine leakage. The 15 women who had both UDS and MRI data for analysis form the basis of this study.

The median age of subjects was 52 years (range, 31-65), median parity was 2 (range, 0-6), and median body mass index was 26 kg/m^2 (range, 20-49). Two women had stage I prolapse, and the remainder had stage II. Although 4 women (27%) had previously undergone hysterectomy, only 1 (7%) had a prior incon-