UROGYNECOLOGY

Posterior compartment anatomy as seen in magnetic resonance imaging and 3-dimensional reconstruction from asymptomatic nulliparas

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OBJECTIVE: The objective of the study was to identify characteristic anatomical features of the posterior compartment using magnetic resonance (MR) cross-sectional anatomy and 3-dimensional (3-D) modeling.

STUDY DESIGN: Supine, static proton-density MR images of 20 nulliparas were analyzed. MR images were used to create models in a selected exemplar.

RESULTS: The compartment's upper, mid, and lower segments are best seen in the axial plane. It is bounded inferiorly by the perineal body, ventrally by the posterior vaginal wall, and dorsally by the levator ani muscles and coccyx. In the upper portion, the compartment is bordered laterally by the uterosacral ligaments, whereas in the middle portion, there is more direct contact with the lateral levator ani muscles. In the lower portion, the contact becomes obliterated because the vagina and levator ani muscles become fused to each another and to the perineal body.

CONCLUSION: The posterior compartment has characteristic anatomic features in MR cross-sectional anatomy that can be further elucidated and integrated with 3-D anatomy.

Key words: cross-sectional anatomy, levator ani, posterior compartment, 3-dimensional anatomy, uterosacral ligaments

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Posterior vaginal wall prolapse, including the clinical problems of rectocele and enterocele, is a distressing and rarely discussed problem. More than 225,000 operations are performed annually for prolapse,[1] and 87% of those include surgery involving the posterior compartment.[2] Posterior compartment dysfunction is the least understood form of pelvic organ prolapse, and many of the surgical treatments for it are empirically derived rather than based on objective, anatomic demonstration of structural abnormalities.

In 1999 we reported our early observations on posterior wall anatomy derived from the dissection of fresh and fixed cadavers, supplemented also by examination of histologic and macroscopic serial sections.[3] Cadaveric dissections have demonstrated that the posterior compartment has well defined boundaries. These boundaries can be understood as a box with 4 sides in which the top is open superiorly for the rectum and the rectouterine pouch of Douglas (Figure 1). The cranial end of the vaginal wall is suspended by the uterosacral ligaments, which extend below the peritoneum, and are seen in dissection and in cross-sectional imaging.[4] The distal end of the vagina fuses with the perineal body, whereas the lateral margins of the vagina form a visible line called the posterior arcus tendineus fascia pelvis.[5] Magnetic resonance imaging and (MRI)–based 3-dimensional (3-D) model reconstruction has allowed detailed anatomical study of living women that avoids many of the distortions that exist in cadaveric specimens. To date, however, magnetic resonance (MR) has not been undertaken in studying the posterior vaginal wall.

The purpose of this research was to evaluate posterior compartment anatomy in living, asymptomatic nulliparas using MR cross-sectional anatomy and 3-D model reconstruction. This type of information is needed so that MRI can be used as the basis for efforts to objectively identify specific structural defects in the posterior compartment to ultimately help guide research as well as clinical and surgical practices.

Materials and Methods

Twenty MR scans from the MR library at the University of Michigan were analyzed to identify and catalog the key structures that clearly define the posterior compartment. These scans were those of asymptomatic nulliparas under the age of 50 years who were recruited from the community by advertisements for study of pelvic floor anatomy and

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function not affected by vaginal birth. Inclusion criteria also included women older than age 18 years with no prior history of surgery for prolapse or incontinence. All subjects had uteri in situ. This sample size was chosen by the senior author based on prior experience with anatomic research as representing a sufficient number of scans to study features that are consistently present among normal women.

Static proton-density MR images were obtained in the supine position in axial, coronal, and sagittal planes with a body coil. Multiplanar 2-dimensional proton density pelvic MR images (echo time 15 milliseconds, repetition time 4000 milliseconds) were obtained by use of a 1.5 T superconducting magnet (General Electric Signa Horizon LX, Milwaukee, WI). The field of view in axial and coronal images were both 16 × 16 cm and in the sagittal images 20 × 20 cm. All 3 acquisitions had a slice thickness of 4 mm with a 1 mm gap between slices.

The project was conducted in 2 phases. In phase 1, detailed slice-by-slice examinations of axial, sagittal, and coronal images were conducted using the original source DICOM (Digital Imaging and Communications in Medicine) MR data in 5 subjects. Characteristic features of the posterior compartment components in each scan plane were cataloged. Next, in the additional 20 scans, the visibility of the characteristic features of the posterior compartment was tallied for all subjects, and a plane specific percentage visibility was obtained.

For the second phase of the study, 1 exemplar MR data set was selected. Using the 3-D slicer program (version 2.1b1, Brigham and Women's Hospital, Boston, MA), tracings and 3-D models were made of the structures bounding the posterior compartment in the plane in which each structure was best visualized. Tracing of the structures and 3-D models were reviewed by the senior author. Each 3-D model was validated by overlaying the model with the original source image.

RESULTS

All women were continent of stool and urine and had no symptoms of pelvic organ prolapse; the leading edge of pelvic organ descent was at least 1 cm above the hymenal ring. The mean age of these subjects was 37.6 years (± 10.6 years) and 18 of the 20 subjects (90%) were Caucasian. The mean body mass index (BMI) of subjects was 26.7 kg/m^2 (± 5.4).

In phase 1 it was found that the posterior compartment could be divided into an upper, mid, and lower portion that mirrors the levels of support described for the vagina.[3] Each portion of the posterior compartment has characteristic MR features in the various scan planes in asymptomatic nulliparas (Table).

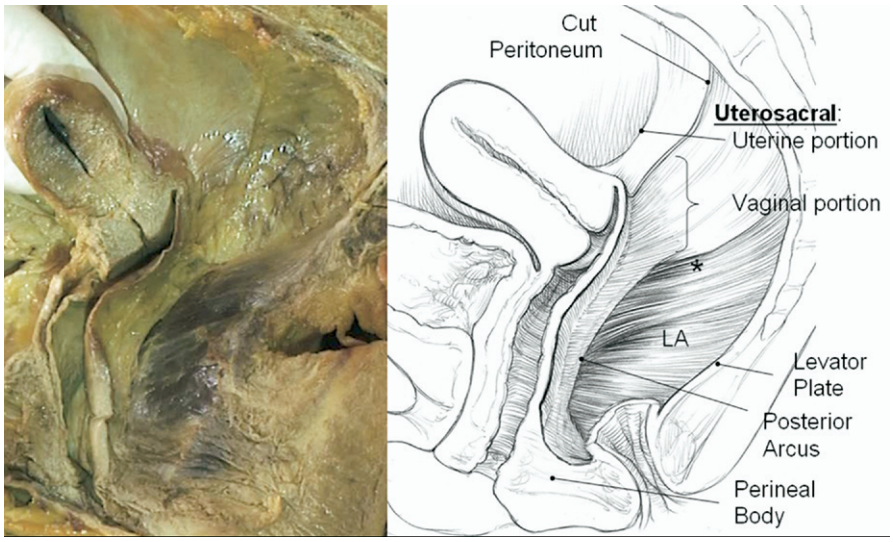
Axial plane

The axial scan plane shows the most MR details involving the posterior compartment (Figure 2). MR images are labeled in centimeters relative to the arcuate pubic ligament. Positive numbers are caudal to the ligament and negative numbers are cranial.

The axial MR images can be divided into 3 portions: the upper, middle, and lower, each with distinct characteristics. The 3-D model (Figure 3) provides orientation of the relative locations of the upper, middle, and lower images, which are shown in Figure 4. In the upper portion, the uterosacral ligaments form the lateral margins. The course of the uterosacral ligaments can be seen in 88% of the MR images analyzed and its visceral insertions on the cervix and vagina in 84%. The posterior compartment in the upper portion is bounded by the uterosacral ligaments on either side. The compartment is widest at this point, and the contact between the genital tract and the pelvic walls is least direct in this region.

In the midportion, the shape of the posterior compartment becomes smaller with the posterior vaginal wall forming

FIGURE 1
Posterior compartment showing structural relationships after the rectum has been removed



Cadaver dissection (*left*) and illustration (*right*) of posterior compartment of a 56 year old multiparous female showing structural relationships after the rectum has been removed. Note the apical connections of the upper posterior vagina to the inside of the pelvic wall in a retroperitoneal position. These lie below the peritoneum and are dorsal and caudal to what is traditionally referred to as the uterosacral ligament. These structures are continuous with the posterior arcus tendineus fascia pelvis. At the distal end of the vagina, the wall merges into the top of the perineal body. The lateral and dorsal margins of the compartment are formed by the levator ani muscles (LA) and the levator plate. The *asterisk* denotes the region of the sacrospinous ligament overlain by the coccygeus muscle.

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