MRI and US anatomy of female and male pelvic floor

Poster No.: C-1484
Congress: ECR 2013
Type: Educational Exhibit
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Keywords: Education and training, Education, Diagnostic procedure, Ultrasound, MR, Pelvis, Anatomy
DOI: 10.1594/ecr2013/C-1484

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Learning objectives

To illustrate the normal anatomy of the female and male pelvic floor through MR and US images and detailed anatomical schemes.

To illustrate different US techniques useful for evaluation of the pelvic floor.

Background

The pelvic floor is an anatomic compartment characterized by muscular structures and connective tissues difficult to analyze. With the increase in functional disorders of the pelvic floor, also due to the increase in life expectancy, familiarity with normal imaging findings and features of pathologic conditions is important for radiologists.

In the USA, a high number of women, ranging from 23.7% to 38%, with a peak of more than 60% in elderly, suffer from abnormal functions of the pelvic floor with different symptoms such as urinary incontinence, uterine or vesical prolapse, or fecal incontinency; in 2006 a National Health and Nutrition Examination Survey found that 39% of women aged 60-79 years and 50% of women aged 80 years or older suffered from, at least, one of pelvic floor disorders.

Clinical examination is the first step but an accurate pre-operative imaging evaluation, specially through US and MR, is crucial and indispensable.

Pelvic floor is an anatomic area composed of muscle fibers and connective tissue, that support female and male perineum and is located below the uro-genital diaphragm, between the pubic symphysis anteriorly, the inferior pubic rami laterally, the coccyx and sacrotuberous ligaments posteriorly. Muscular components have the purpose to maintain the pelvic muscular tonus, withstand gravity and the occasional increase of abdominal pressure. Also the endopelvic fascia, a fibrous connective layer connecting uterus and vagina to the pelvic walls, helps to increase pelvic floor stability; its anterior part, the pubocervical fascia, connects the anterior vaginal wall to the pubis, gives additional support to the vagina. The main muscular structures of pelvic floor are the levator ani and coccigei.

The levator ani muscle is divided in three parts: pubococcygeus muscle, puborectal muscle and iliococcygeus muscle.

The pubococcygeus muscle stretches from the body of the pubic bone to the coccyx and some fibers are inserted into the prostate, urethra and vagina.

The right and left puborectalis muscles joining behind the anorectal junction form a muscular sling, a fundamental component of the anal sphincter.
The ileococcygeus muscle, the most posterior part of levator ani muscles, is often poorly developed.

Images for this section:

![Anatomic scheme of female pelvic floor](image)

**Fig. 1:** Anatomic scheme of female pelvic floor
Imaging findings OR Procedure details

An accurate evaluation of the pelvic floor require imaging techniques including ultrasound with supra-pubic, trans-labial, trans-vaginal, endo-anal, or trans-perineal approach. The use of three-dimensional imaging significantly improves diagnostic performance of ultrasonography.

Magnetic resonance imaging is also useful to detect the presence of other pelvic abnormalities, because of its multi-planar evaluation, its intrinsic soft-tissue contrast and the absence of ionizing radiation.

**B-MODE ULTRASOUND**

The trans-labial technique is a particular US approach: the patient is in gynecologic position and the probe is applied directly on the perineum, between the labia majora, directly on the urethral meatus and the vulva (FIG:2); this approach allows to visualize the three compartments of the pelvic floor: the anterior (bladder and urethra), the median (vagina and uterus) and posterior (rectum and anus) and some connective support structures.

Ultrasound beam is directed upwards to visualize the hiatus of the pelvic floor and the pubo-rectal muscle, and posteriorly to visualize both internal and external sphincters (FIG.3). In functional studies, the exam must be performed with pre-void bladder both at rest and during Valsalva manoeuvre.

A video-loop registration can be useful to assess the urethro-vesical dynamics in relationship with others pelvic organs.

**THREE DIMENSIONAL ULTRASOUND**

While the two-dimensional ultrasound limits the evaluation of pelvic floor structures only to sagittal and coronal planes, but the axial evaluation of the anal canal is necessary for a careful assessment of the sphincters and the musculotendinous structures.

(FIG. 4-5)

Volumetric imaging of the pelvic floor can be obtained using two different techniques:

1. endo-vaginal mechanic probes with sectorialUSemission, used with a trans-labial approach. Dataset has a trapezoid shape;
2. endo-rectal/endo-vaginal with circumferential US emission. Dataset has a cylindric shape.

**URETHRA NORMAL ANATOMY**

At conventional B-mode ultrasound imaging, urethra has a thin hypoechoic bandlike appearance that can be detected both on sagittal and coronal planes. The hypoechoic appearance is due to the parallel course of the mucous, muscular layer and the ultrasound beam. The striated sphincter surrounds the hypoechoic structure and appears as a double-layer hyperechoic line when imaged on the long axis.

(FIG.6-7)

**VAGINA NORMAL ANATOMY**

At US imaging, the vagina is best detected in the midline sagittal plane with a translabial approach (FIG 8). An endovaginal 3D-US scan provides a high definition assessment of vaginal wall and related muscular structures with the possibility to obtain a multiplanar reconstruction of the findings. (FIG.9).

In reproductive age females, the normal vagina is seen as a collapsed, hypoechoic, tubular structure with a central high-amplitude linear echo representing the opposite surfaces of the vaginal mucosa. A 3D acquisition allows for reconstructing of the pelvic floor US images on a pure axial plane, thus depicting the vagina as a crescent-shaped hyperechoic linear structure (with anterior concavity) occupying the mid compartment of the pelvic floor.

**ANUS-RECTUM NORMAL ANATOMY**

Endo-anal ultrasound imaging allows for evaluating integrity of the inner and outer sphincters of anal canal, and significantly useful in patients with fecal incontinence. Generally the mucosal and submucosal layers appare hyperechoic. The inner sphincter has a uniform hypoechoic appearance and generally is less than 3 mm thick.

Conversely, the outer sphincter is slightly hyperechoic with variable thickness.(FIG.10)

**MRI TECHNIQUES**

Magnetic resonance (MR) imaging has an increasing role in assessing pelvic floor dysfunction because of its multiplanar imaging capability, its intrinsic soft-tissue contrast and the absence of ionizing radiation.
MRI allows morphological evaluations and dynamic-functional studies; the first one is performed through T2 fast spin echo sequences on the three planes of space.

Because abnormalities of the three pelvic compartments are often associated, a thorough assessment of the pelvis is required, in particular before surgery and MR imaging provide a full view of the pelvic floor.

The MR imaging protocol requires neither oral/intravenous contrast agents, nor bowel preparation.

We use a 1 Tesla open-magnet system with patient in a supine position.

With a rapid T1-weighted large-field-of-view localizer sequence, scout images are obtained to identify a midline sagittal section; this section should encompass the symphysis, bladder neck, vagina, rectum, and coccyx. The examination proceeds with sequences for imaging pelvic anatomy and any muscle defects, such as thinning and tears: T2-weighted thin-section sequences are performed in axial, sagittal and coronal planes (FIG.11-12-13-14-15).

It’s important to detect that three lines reveal the normal anatomy of the pelvic floor:

1) the pubococygeal line (PCL) runs from the inferior border of the pubic symphysis to the last coccygeal joint (FIG.16); the PCL represents the level of the pelvic floor and is the landmark for measuring organ prolapse;

2) the H line stretches from the inferior border of the pubic symphysis to the posterior wall of the rectum at the level of the anorectal junction and corresponds to the anteroposterior width of the levator hiatus (FIG.17);

3) the M line is a line which runs perpendicularly from the PCL to the posterior tip of the H line, and represents the vertical descent of the levator hiatus (FIG.18); normally, the H and M lines are less than 5 cm and 2 cm long, respectively.

Images for this section:
**Fig. 2:** Correct position of the probe in the sagittal plane during a trans-labial US exam, on a female patient.
**Fig. 3:** Trans-labial US evaluation of the posterior pelvic floor in axial scan. (IAS: inner anal sphincter. OAS: outer anal sphincter)

**Fig. 4:** Ultrasound image of the anal canal obtained with a volumetric probe. Three-dimensional images are reformatted on an axial plan. Four-dimension volume rendering of the anal canal allows detection of sphincters and support structures.
**Fig. 5:** a: cylindric volume with acoustic void in the centre (corresponding to the probe). The urethral sphincter muscle complex is located anteriorly (arrow). The anal sphincters are located posteriorly (asterisk). Arrowheads indicate the levator ani muscle complex and pubo-rectalis muscles. b: rotating probe inserted in the vagina.
**Fig. 6:** Axial reconstruction of the urethra from a volume at three different levels. (Arrows: striated sphincter. V=vagina )
**Fig. 7:** Urethra evaluated on a sagittal plane with (a) linear and (b) microconvex probe along the urethral long axis. The mucosa and the longitudinal sphincter are anechoic (arrows), while sphincters appear hyperechoic (asterisks).

**Fig. 8:** Sagittal US scan with translabial approach. Vagina appears as a tubular hypoechoic structure with collapsed wall (a:anterior wall; p:posterior wall; arrows:interface between anterior and posterior mucosa; U:urethra, is seen as a linear hypo-anechoic below the bladder (b); AC: anal canal.)
**Fig. 9:** Sagittal transvaginal scan at the level of the middle third of the vagina. anterior and posterior walls (a and b, respectively) are fully separated. Anterior fornix (*) ad rectum (R) are also visible.
**Fig. 10:** MR (T2 weighted axial scan) and US (trans-labial axial scan) image of the anal canal.
Fig. 11: T2-weighted scan, coronal plane. The ileococcygeus and the pubococcygeus muscles (small arrows) seen in the coronal plane, closely aligning with puborectal muscle fibers of the anal sphincter (big arrows).
Fig. 12: T2-weighted scan, sagittal plane. The image shows normal pelvic anatomy in a male patient.
Fig. 13: T2-weighted scan, coronal plane. The image shows normal anatomy in a male patient.
Fig. 14: T2-weighted scan, axial plane. The image shows normal pelvic anatomy in a female patient.
Fig. 15: T2-weighted axial plane image shows anal canal and its two inner and outer sphincters.
Fig. 16: Pubo-coccygeal line (PCL), in a sagittal plane, T2-weighted: it's a line extending from the lower edge of the pubic symphysis to the last coccygeal joint; this is the line of the pelvic floor and it is an anatomical landmark for the pelvic prolapse.
**Fig. 17:** H line, in a sagittal plane, T2-weighted: it is a line extending from the pubic symphysis to the posterior wall of the anal canal; normally is less than 5 cm long.
Fig. 18: M line, in a sagittal plane, T2-weighted: runs perpendicularly from the posterior tip of the H line to the PCL; it measures the descent of the elevator muscle complex from the PCL line (normal value less than 2 cm).
Conclusion

US and MR are the best techniques to visualize the anatomy of the male and female pelvic floor.

US includes supra-pubic, trans-labial, trans-vaginal, endo-anal, or trans-perineal approach and the use of three-dimensional imaging.

MR is the gold standard imaging for its multiplanar imaging capability, its intrinsic soft-tissue contrast, and the absence of ionizing radiation. In addition, the dynamic evaluation of the pelvic floor adds important information about muscular structures and normal functionality.

References


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