**Clinical practice**

# Sonography of the female pelvic floor: clinical indications and techniques

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*Abstract:* Severe pelvic floor prolapse represents a significant diagnostic and reconstructive challenge for clinicians. Using static and dynamic perineal sonography, preoperative evaluation of the entire pelvic floor can now be performed at rest, strain and during both voiding and evacuation to determine whether laxity is global or confined to specific compartments. However, this modality shares the limitations of other techniques in this section (i.e., lack of standardization, validation, or availability). Based on our experience with more than 500 female patients over the last 5 years, our technique for performing ultrasound imaging of the pelvic floor is described including information on transducer type and orientation, image display and interpretation and quantitative description in order to illustrate the clinical utility of this non-invasive diagnostic technique.

*Key words:* Transperineal sonography; Pelvic floor dysfunctions; Pelvic prolapse; Descending perineum syndromes.

## INTRODUCTION

Pelvic floor dysfunction usually leads to structural alterations in all compartments of the female pelvis.[1] In advanced cases, with involvement of more than one compartment, accurate identification of all structures is essential to surgical planning and success. Clinical diagnosis may be difficult so an examination that provides a wide and simultaneous evaluation of all pelvic regions is highly desirable. In the past, dynamic contrast radiography (i.e., colpocystodefecography) [2-3] has provided the only means of determining the inter-relationships which occur among pelvic organs in most common dysfunctions including double incontinence, obstructed defecation and pelvic prolapse. More recently, MRI [4-7] has provided impressive multiplanar views of the pelvis but it is limited by the duration of examination and cost. Conversely, due to its non-invasiveness, rapidity and the absence of ionizing radiation, ultrasonography of the pelvic floor (PFS), either by the transperineal (TP) or the endovaginal/introital (E/I) approach, has been successfully employed in a number of gynaecological and nongynecological conditions.[8-10] Currently, it is considered the examination of choice to start with in the diagnostic workup of urinary incontinence [11-21] and there has recently been an increased demand of it particularly on the part of coloproctologists (Tab. 1).[22-40] As the painless nature of pelvic floor sonography has resulted in high patient acceptance, we have also found that clinicians have lowered their threshold for obtaining an ultrasound examination as compared to conventional radiography. It is hoped that this lowered threshold will contribute to the earlier diagnosis of pelvic floor abnormalities.

It is important, however, to point out that a substantial "learning curve" exists with PFS and that, because of the complex anatomy being imaged, this technique may be more difficult to master than other ultrasound examinations. The purpose of the present paper is to provide the clinician with the fundamentals of the technique, the examination procedure and image interpretation to be used as a standard of reference in health and disease in order to take the best advantage of this low-cost imaging modality.

## PATIENT PREPARATION AND POSITIONING

No specific preparation is required for PFS except for a partially filled urinary bladder. If needed, the rectal ampulla can also be distended just prior to the examination with hypoechoic contrast medium which is injected through a bladder-syringe. The typical dose is 60-80 ml of a 113% wt/vol semisolid barium sulfate suspension (Pronto Bario E, Bracco, Milan, Italy). This helps distinguish the pelvic organ relationships and permits the dynamic phase of rectal emptying to be depicted as well.

To maintain patient dignity, patients are appropriately covered with a draw sheet at all times, while a female assistant is brought into the diagnostic room to act as a chaperon. In addition, after adequate explanation of the procedure, patients are offered the opportunity to insert the probe themselves, if preferred.

For the examination the patient lies supine on the table with her knees bent and feet flat on the table, approximately shoulder width apart, the exposed buttocks placed over a soft rubber support. The up-right or squatting position is also used when needed.

## INSTRUMENTATION AND PROBE PREPARATION

At our institution, pelvic floor sonography is initially performed by a transperineal (TP) approach, using a curved sector transducer placed between the vaginal labia minor and operating at 3.5 MHz frequency to penetrate the desired anatomy (bladder base, urethra, vaginal vault and anorectal junction) and produce a pear-shaped image on the screen. However, as a second step a 6.5-MHz phased array, end-fire vaginal endoprobe, positioned just beyond the introitus is also routinely used in order to place the transducer closer to the region of interest and provide superior axial and lateral resolution of the pelvic anatomy. In both cases, the sound waves are emitted forward from the surface of the probe tip, in line with the probe shaft, while the transducers scan through an arc of 100° and 200° degrees, respectively, over a focal range of 1 to 6 cm. Probes are used in conjunction with an ultrasound scanner machine (MyLab 50, Esaote, Genova, Italy) equipped with advanced software, freeze-frame and post-processing facilities.

Once the 6.5 MHz endoprobe has been disinfected and wiped clean a small amount of coupling gel is placed inside the finger tip of a surgical glove which is pulled over the shaft of the probe in order to prevent cross contamination between patients. The coupling gel should eliminate any air from the beam path. When the 3.5 MHz sector probe is used, its surface is draped in a layer of translucent film which is removed after use.

The sonographer wears gloves when preparing the probe and is seated on a low rotating stool nearby the patient when performing the examination.

## IMAGE DISPLAY

In order to reduce difficulties in interpretation and eliminate discrepances with MRI views of the female pelvis, sonograms are adjusted so that the transducer is displayed at the bottom of the screen and the image is always generated from below upwards. To obtain this, the upside-down facility is activated, so that movements of probe and image correspond when the patient is asked to squeeze and strain. Thus, the caudal aspect of the patient's body is seen at the lower edge of the scan and the cranial at the top, the posterior on the right side and the anterior on the left (Fig. 1). On all other planes, the right and left sides are designated following the convention used for abdominal ultrasound, where the left side of the monitor corresponds to the right side of the patient and viceversa.

## SCAN TECHNIQUE

It is preferable to begin the examination with the 3.5 MHz convex probe positioned at the interlabial region to obtain an overall view of the pelvic area before shifting to the higher frequency 6.5 MHz vaginal endoprobe which can be inserted or withdrawn to position the structure of interest within the focal zone of the transducer. Regardless of the probe used, the scanner image is unfrozen and the examination starts with the transducer oriented anteriorly and upward in a sagittal plane (position one) for a thorough survey of the anterior pelvic compartment. Noting the consistent position of the inferior border of the symphysis pubis on the left lower side of the screen makes it a good landmark to use when making the initial assessment. A sagittal section (longitudinal scan perpendicular to the table) of the anterior pelvis in the plane of the symphysis pubis is produced first so as to obtain direct images of the bladder base, bladder neck and urethra. From position one, the transducer is moved in a backward direction to a point where the uterovesical junction is seen (position two). This is obtained by slowly sweeping the beam posteriorly to permit visualization of the cervix, vaginal vault, Douglas pouch and the perineal body. Then, moving the transducer even more posteriorly (position three) the probe is held vertically just inside the hymenal ring for proper identification of the anorectal region and the post-anal space (Fig. 2). After this, the probe is turned 90 degrees in an anti-clockwise direction into the axial plane (scan direction perpendicular to the body's long axis) and a second series of images is obtained through the proximal urethra, anal sphincters and the puborectalis muscle. After this, the beam is sweeped again through position one, two and three to obtain also coronal views (scan direction parallel to the table) so as to demonstrate the urethra through its entire course together with the surrounding sphincters, the urethro-pelvic ligaments and levator ani muscles (Fig. 3). Following the acquisition of this basal series (at rest) from all three compartments in a rational sequence (i.e., antero-posterior direction), dynamic images of the anatomical relationships of pelvic organs during cough, strain and squeeze maneuvres are also recorded on a VHS videotape. Care should be taken so that neither the probe nor the patient moves during straining. The dynamic portion of the examination is documented as follows: after the bladder base and urethra are visualized at rest on the monitor screen, the image is frozen and stored on one half of the screen, while a second image is obtained on the other half during maximal Valsalva (or squeezing) maneuvre. The same procedure is repeated when exploring the ano-rectum and genital organs. In specific cases, as described by us in a previous paper,[40] the expulsion of hypoechoic rectal contrast can also be documented while the patient assumes a squatting position.

## IDENTIFICATION OF SONOGRAPHIC ANATOMY

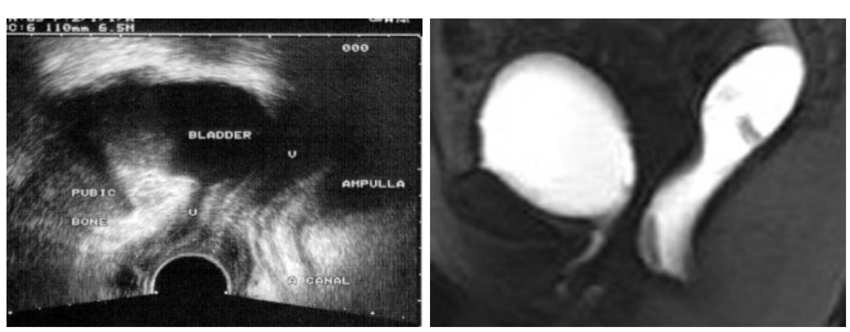
*Pubic bone* - It is consistently seen (identification rate, 100%) as a hypoechoic oval-shaped image on the left side of the screen, just in front of the half-filled bladder, reflecting the fibro-cartilagineous disc which connects the bony structures of symphisis pubis. Its lowermost and posterior aspect is partially surrounded by an incomplete hyperechoic ring that corresponds to the arcuate ligament; the latter is contiguous to a coarse, intensely hyperechoic laminar area representing the pubo-cervical component of the endopelvic fascia.

*Bladder* - Immediately posterior to the pubic bone and anterior to a normally anti-verted uterus lies the bladder. A minimally distended bladder can be seen as a thick-walled, anechoic space, lying anterior to the cervix (identification rate, 100%). The ureterovesicular junction appears as a small ridge along the posterior wall of the bladder. Often, a cloud of dynamic echoes, referred to as a urine jet, may be seen emanating from the distal ureter, reflecting normal peristalsis and a patent uretero-vesical junction.

*Urethra* - The female urethra is a short muscular structure that extends inferiorly from the bladder and lies just anteriorly to the vagina. To image the urethra, the endoprobe must be withdrawn from its starting position at the vaginal vault until it is only partially inserted at the entrance to the vagina with the sound beam directed markedly forward and upward. In the absence of any intraurethral fluid, the apposed walls of the urethral mucosa and muscle layers can be seen on sagittal scans as a single hypoechoic line (identification rate, 100%) extending inferiorly and anteriorly to the bladder, whereas on axial scans the same structures are less frequently visualized (identification rate, 35-40%) as multiple concentric circles of various mixed echogenicity (Fig. 3*c* ).

*Ligaments and Muscles* - Accurate scanning by PFS in

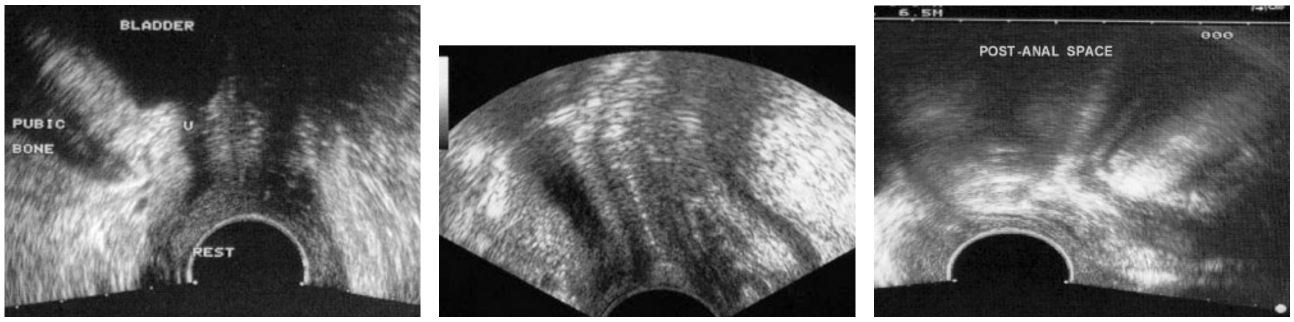
*a*




*b*

Fig. 1. – Standardized documentation of female perineal sonogram. (*a*) Longitudinal scan: with the transducer displayed at the bottom of the screen, caudal of the patient is seen at the lower edge and cranial at the top; the left side of the scan is ventral and the right side is dorsal. The same orientation is displayed in this standard MRI sagittal scan of female pelvis (*b*).

a




b, c

Fig. 2. – Transperineal sonographic technique: with the transducer positioned on the sagittal scanning plane just under the symphysis pubis (position one) the typical appearances of the bladder, urethra and urethro- pubic ligaments are displayed (*a*); moving probe handle anteriorly (position two), permits inclusion of the vaginal canal, utero-vesical junction and Douglas pouch (*b*) within ultrasound beam. When transducer handle is moved even further anteriorly so that a vertical position (position three) is reached the end of transducer points more caudally and the anorectum is depicted together with the post-anal space (*c*).

the coronal plane usually leads to consistent recognition (identification rate 100%) of the arcuate ligament and urethro-pelvic ligaments (Fig. 3*b*) which appear as symmetric triangular shaped hyperechoic images boundered medially by the hypoechoic urethra and laterally by the levator ani muscle.

*Uterus* - The normal uterus usually can be imaged in its entirety from cervix to fundus regardless of uterine version or flexion. The closest part of the uterus to the vaginal probe is the cervix. It is best delineated when the probe tip is 2 or 3 cm from the external os. The cervix appears as a relatively homogeneus and moderately echoic, smooth-walled structure. The closed endocervical canal is seen as a central stripe that appears to originate from an interface consisting of cervical mucosa and mucus. This endocervical echo is usually more echogenic than the cervical wall. During the periovulatory period, the endocervical canal may appear to be less echogenic than the cervical wall, which is probably related to a greater fluid content in the cervical mucus. Immediately lateral to the junction of the cervix and the lower uterine segment are the uterine vessels which are readily visualized as a tortuous conglomerate of anechoic "tubes". A frequent finding in the cervix is given by Nabothian cysts, which are typically less than 2 cm in size.

Depending on the menstrual cycle, both endometrial thickness and echogenicity change, as follows: endometrium is thin, patchy and difficult to appreciate during menstruation; it remains relatively thin and displays an echogenicity similar to that of the myometrium in the early proliferative phase (days 5-9); the superficial portion is sonographically hypoechoic whereas the deeper portion appears as a uniformly echogenic band, giving the endometrium a stratified appearance in the late proliferative phase (days 10-14); finally, the superficial endometrium continues to thicken and become more echogenic until it is intensively hyperechoic, making the central endometrial canal echo difficult to identify.

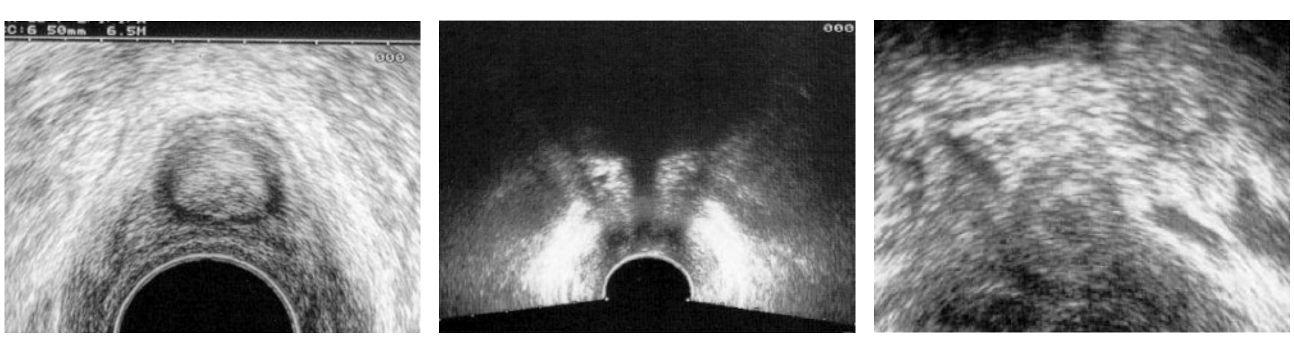
The corpus of the normal uterus has three layers of myometrium which are referred to as the outer, the middle and the inner layers. Of the three, the intermediate is the most echogenic, the outer the less visible and the inner the most hypoechoic (myometrial halo), due to its relatively sparse vasculature, compact musculature and little extracellular matrix.

*Vagina* - It is best demonstrated on sagittal views after gentle penetration of air by patient self digitation as a linear shaped image of hyperechoic dots (Fig. 2*b*) which correspond to air bubbles within the virtual lumen, surrounded on both sides by two symmetric and parallel hypoechoic stripes due to the mucosa-submucosa wall complex (identification rate, 67%). Overall, the vagina appears embedded and firmly fixed within a hyperechoic area which is thicker posteriorly and represents the reinforcement of the endopelvic fascia (anterior and posterior septa).

*Douglas pouch* - The posterior cul-de-sac (Douglas pouch), which is the most dependent region of the peritoneal cavity, is occasionally seen (identification rate, 31%) as an echogenic "V-shaped" stripe just posterior to the cervix, reflecting the interface between the posterior vaginal fornix, peritoneum and bowel loops These can easily be recognized due to their peristaltic movements. In cases of vaginal vault prolapse, dissection of the recto-vaginal septum and enterocele, free fluid, omentum or even the gut are frequently seen to impinge onto this potential space when the patient is asked to strain.

*Rectal Ampulla* - It is infrequently seen at sonography

a



b, c

Fig. 3. – The scanning plane depicted in Fig. 2*c* is rotated 90° counterclockwise until a short axis view of the anal canal is obtained which displays the internal and external anal sphincters (*a*), together with the mucosa-submucosa complex and the puborectalis muscle. Then, the transducer handle is moved posteriorly to permit inclusion of the bladder, urethra and urethro-pelvic ligaments within ultrasound beam displayed on the coronal plane (*b*). Occasionally, depending on proper inclination of the urethral axis, an axial view of the four-rings target like urethra is seen (*c*).

TABLE 1. – *Clinical application of PFS: historical "road map".*

| *Author* | *Year* | *Journal* | *Clinical application* |
|---|---|---|---|
| Brown | 1985 | Br J Urol | Stress incontinence |
| Kohorn | 1986 | Obstet Gynecol | Stress incontinence |
| Kolbl | 1988 | Arch Gyn Obstet | Stress incontinence |
| Quinn | 1988 | Br J Urol | Stress incontinence |
| Rubens | 1988 | AJR | Coloproctology |
| Hertzberg | 1991 | AJR | Obstetric |
| Chang | 1993 | AJR | Nongynecological |
| Sultan | 1994 | Dis Colon Rectum | Coloproctology |
| Kilholma | 1994 | Ann Chir Gynecol | Stress incontinence |
| Sandridge | 1995 | Obstet Gynecol | Anorectum |
| Schaer | 1995 | Obstet Gynecol | Contrast-enhanced studies |
| Schaer | 1995 | Obstet Gynecol | Stress incontinence |
| Halligan | 1996 | Br J Rad | Enterocele |
| Stewart | 1996 | AJR | Anal sphincter |
| Khullar | 1996 | Br J Obstet Gynaecol | Detrusor instability |
| Teele | 1997 | AJR | Pediatrics |
| Peschers | 1997 | Br J Obstet Gynaecol | Anal sphincter defects |
| Alexander | 1997 | Radiology | Fecal incontinence |
| Kleinubing | 2000 | Dis Colon Rectum | Anorectum |
| Kim I-O | 2000 | J Ultrasound | Imperforate anus |
| Sarnelli | 2000 | It J Coloproct | Posterior perineum |
| Piloni | 2001 | Techn Coloproct | Pelvic floor |
| Beer-Gabel | 2002 | Dis Colon Rectum | Pelvic floor disorders |
| Pregazzi | 2002 | Br J Obstet Gynaecol | Urinary incontinence |
| Lohse | 2002 | Eur J Obstet Gynec Reprod | Anal sphincter tears |
| Beer-Gabel | 2002 | Tech Coloproct | Obstructed defecation |
| Sendag | 2003 | Aus J Obstet Gynnaecol | Stress incontinence |
| Sarnelli | 2003 | Rad Med | Perineum |
| Beer-Gabel | 2004 | Int J Colorect Dis | Evacuatory difficulty |
| Wedemeyer | 2004 | World J Gastroenterol | Perianal Crohn |
| Piloni | 2005 | Tech Coloproct | Evacuation |

(identification rate, no more than 27%) unless artificially distended by hypoechoic contrast medium. This will lead the apposed walls to diverge just above the ano-rectal junction thus allowing better visualization of relationships with adjacent structures and permitting to delineate the presence of various abnormalities such as rectocele and intussusception.

*Anal Canal* - Via the transperineal or the transvaginal route, the undisturbed anatomy of the anal canal is always displayed (identification rate, 100%) as follows: the internal anal sphincter is the innermost muscular structure which is the continuation of the circular part of the rectal mucosa wall. It is clearly defined as a symmetric 3-mm thick, hypoechoic ring encircling completely two-to-three triangular-shaped images of intermediate echogenicity which represent the submucosa. The virtual lumen of the anal canal is wrapped up by the hypoechoic mucosa that reproduce the shape of a clover. Directly outside the internal sphincter there is the mixed echogenic intersphincteric space. Within this space there is the relatively hypoechoic longitudinal muscle which is a continuation of the longitudinal part of the rectal muscular wall. The intersphincteric space is bordered by the relatively echoic external sphincter. The intensively hyperechoic puborectal muscle is the most peripheral structure of the upper part of the sphincter. The upper part of the anal sphincter complex is connected to the levator ani muscle (Fig. 3*a*).

*Retro-anal space* - It can not sharply be demonstrated on either the axial or sagittal plane (identification rate, 8-10%); the latter occasionally displays the levator plate as a thick hypoechoic stripe running parallel to the posterior rectal wall, in an almost horizontal direction until it joins the tip of coccyx. The space below the levator plane is characterized by a thick carpet of high level echoes corresponding to the sacro-coccygeal ligaments and ano-coccygeal raphe which in the axial plane are seen to assume a hayfork-like shape.

*Coccyx* - This anatomic landmark is only rarely and partially seen (identification rate, 4-5%) as a hypoechoic pointed shadow, directed upward in a slightly concave manner, just behind the anal verge. A thin hypoechoic linear image, representing the intermediate loop of the external anal sphincter, is inconsistently seen to connect the tip of coccyx to the anus.

## MEASUREMENTS

There is considerable variation in the literature regarding the optimal method of performing quantitative assessment of pelvic floor structures by US perineal imaging. Our protocol includes the following:

• *Bladder neck position* - With the inferior border of the symphysis as the reference point, the x axis is constructed by drawing a line between the superior and inferior border of the symphysis (central line). The position of the anterior margin of the bladder neck with respect to x axis is noted at rest and on straining. Its minimal distance from the reference line is calculated in millimeters and expressed as a number preceded by – (above) or + (below).

• *Posterior urethro-vesical (β) angle* - According to Schaer[17] it is defined as the angle formed between a line drawn tangent the proximal half of the urethra and a line tangent the lowermost back aspect of the bladder base.

• *Anterior urethral (α) angle* - It is measured as described by Sarnelli.[36] It refers to the slope of the proximal half of the urethral axis with respect to the x axis of the pubic bone. Values are expressed in degrees and range from 60° to 110° in control groups.

• *Urethral sphincter width and thickness* - These measurements are only performed when an endoprobe operating at 6.5 MHz frequency is available. A mean width of 17.33 mm (range 15 to 20 mm); thickness of 9.3 mm (range 8 to 10 mm); smooth sphincter length of 15.1 mm (range 13 to 19 mm) and striated sphincter length of 7 mm (3 to 11 mm) are reported.

• *Bladder wall thickness* - According to Khullar [19] it is measured, when the urinary residual volume is ≤ 20 ml, perpendicular to the bladder lining at the thickest part of its four walls. A mean wall thickness of < 5 mm is seen in over 85% of patients with no evidence of detrusor instability.

• *Anal length* - According to Sandridge DA et al,[23] it is measured on sagittal scans with caliper placed at the anal verge and the anorectal junction. The latter, is assumed to be located where the gut lumen turns down over the puborectalis muscle. The same anatomical landmark is used to measure the diameter of the anus from the outside borders of the muscolaris propria.

• *The internal and external anal sphincters* - These are measured in their short axis at either the 3-, 6- or 9- o'clock position from the cross section of the anal canal at a point where it is seen to assume a perfect ring shape. The reported mean thickness is 5 mm ±1.3, range 3-7 mm (external sphincter); and 3 mm ± 0.9, range 2-5 mm (internal sphincter).

• *The thickness of the puborectalis muscle* - This is measured on axial scans in the midpoint of its lateral portion, where the muscle diverges from the anal canal. The same anatomic landmark is also used to draw a line tangent to the lateral aspect of the muscle on both sides to allow measurement of the angle formed in between, which is referred to as the *puborectalis angle*. Mean values reported are 5 mm ±1.04, range 2.5-7 mm ( thickness); and 40° ± 8.8 (angle).

• *Cervix descent* - The lowermost dislocation on straining is measured relative to a line drawn tangent the central axis (x axis) of symphysis pubis.

## FINDINGS IN URINARY INCONTINENCE

Sonographic changes associated with stress incontinence include (*a*) opening of the bladder neck with coughing and straining; (*b*) significant downward displacement of bladder base, and proximal urethra (mean values of –10 mm, +1-3 mm, and + 9-12 mm, are reported in conjunction with 1st degree, 2nd degree and 3rd degree urethro-cystocele, respectively); (*c*) widening of the β angle to more than 105° degrees at rest; (*d*) a 1st and 2nd degree urethral hypermobility (α angle of 110° to 135° and 135° to150°, respectively). Conversely, in conjunction with 80% of patients with intrinsic urethral defect, the following findings are noted (*a*) opening of the bladder neck and proximal urethra on minimal straining (funneling); (*b*) overall reduction of urethral muscular wall thickness; and (*c*) loss of the characteristic four-rings targetlike appearance of the urethra and hazy echogenic texture; (*d*) shift of the blood flow away from the subepithelial connective (inner) layer toward the periphery probably reflecting increased resistance within the venous plexus. Finally, in the absence of proven bladder tumor, inflammatory disease or urinary obstruction, an increase of the bladder wall thickness above 5.5 mm after voiding is seen in up to 87% of women with urge incontinence from detrusor instability.

## FINDINGS IN FECAL INCONTINENCE, PERIANAL SEPSIS AND OBSTRUCTED DEFECATION

Following delivery or accidental trauma, a sphincteric defect is seen on axial images as a discrete gap in the normal continuity which corresponds to the replacement of the muscle fibres with scar tissue and fibrosis. However, given the differences in the echogenic texture present in the normal internal and external anal sphincters, the disruption appears alternatively as an hyperechoic break in a hypoechoic ring (internal sphincter defect) or a relatively hypoechoic area in a hyperechoic ring (external sphincter defect). The gap itself is usually displayed as a non-homogeneus irregular area of mixed echogenicity including high level echo spots and focal lower level echoes. Both the relative involvement of the two sphincters and the position and extent of the defect can be clearly demonstrated by PFS.

Perianal abscesses appear on axial sonograms as irregular thick-walled hypoechoic collections containing occasional bright echogenic dots (air bubbles), whose location with respect to the skin and sphincters should be established precisely. Sonographic guided localization of a fistula may also be tracked through its oblique course as a hypoechoic tract extending midway between the two sphincters and exiting just beneath the skin surface. Both the fistulous tracks and abscesses turn brilliantly hyperechoic after injection of hydrogen peroxide. This contrast is used to enhance visualization of the main track routing towards the lumen of the anal canal and to point out possible secondary tracks.

Obstructed defecation from sphincteric dyssynergia occasionally exhibits characteristic sonographic features on axial scans as follows: an inverted internal/external sphincter ratio can be seen, leading the former to reach thickness as high as 4-to-6 mm. Sagittal scans are worth to display lack of anorectal angle widening on straining in those patients with obstructed defecation due to paradoxic contraction of their puborectalis muscle.

## FINDINGS IN PELVIC PROLAPSE

• *Bladder* - The key feature of prolapse of the bladder base either at rest or on straining, is its low position relative to the inferior border of the symphysis pubis. Additional changes, include distortion of urethral axis and hypermobility, bladder neck opening and descent, and increased pubo-bladder neck distance.

• *Genital organs* - With the plane of hymen (and probe) taken as the point of reference, it is possible at sonography to diagnose (*a*) 1st degree prolapse of uterus, as displayed by descent of cervix below the plane of the bladder base and (*b*) cervical elongation as displayed by an anterior fornix projecting significantly lower than the posterior one. It has been argued, however, that PFS cannot accurately reflect any suspensory failure of the sacro-cardinal ligament complex or focal defect occurring in the endopelvic fascia since the presence of the probe at the introitus may prevent free descent of organs from reaching their deepest potential level on straining.

• *Rectal prolapse and rectocele* - On axial sonograms, the transverse diameter of the anal verge increases significantly on straining when mucous or full-thickness prolapse develop, while the typical mucosa-submucosa clover-like pattern becomes distorted. In the meanwhile, the diastasis of the internal anal sphincter makes it thinner and the external sphincter is pushed outward. Other abnormalities seen at sonography in the sagittal plane include rectocele, which appears as an outpocketing of the anterior rectal wall on straining, together with stretching of the rectovaginal septum and impingement on the perineal body. Characteristically, such an outpocketing usually disappears spontaneously when the maneuvre is discontinued.

• *Enterocele* - It is a herniation of the lining of the peritoneal cavity that extends into areas of the pelvis where peritoneum is not usually found. Its most common site is the upper portion of the posterior vagina. Frequently, a deep rectovaginal pouch is also present to serve as the entering wedge by which the hernial sac dissects downward in the space between the posterior vaginal wall and the anterior wall of the rectum. Depending on the content of the hernial sac (*i.e.* free fluid, fat or small bowel loops) the sonographic pattern varies accordingly. Traditionally, a "traction" enterocele is diagnosed when the posterior cul-de-sac is pulled down with the prolapsing cervix or vaginal cuff but it is not distended by intestines; conversely, a "pulsion" enterocele is diagnosed when the intestinal contents of the enterocele distend the recto-vaginal septum and produce a protruding mass.

## PITFALLS

Sonographic evaluation of the pelvic floor is highly operator dependant, and recognition of the more common pitfalls is important. The most common problem is a poor understanding of pelvic floor anatomy and motion, which leads to confusion over the structures being imaged. Poor positioning is another common problem. Scanning the anal canal too obliquely, for example, instead of in a perfect axial plane may artificially mimic the appearance of a sphincteric defect or lead to evidence of an hypoechoic "perianal collection" and sinus tract. It is therefore important to hold the transducer in the correct position in the axial plane and continuously check it to confirm the imaging finding. Failure to maintain proper orientation and position as the transducer is moved from structure to structure and while the patient is asked to strain, cough or squeeze also produces confusing images. After surgery, the new anatomic appearances present also a common and difficult diagnostic problem because normal landmarks may be distorted. As such, an understanding of the surgical procedures is important for interpretation of ultrasonic appearances. To date, the evaluation of pelvic floor structures with US imaging has been hampered by the considerable variation existing in the literature regarding the optimal method of performing the examination in patients with pelvic floor dysfunction. Besides the differences concerning the probe and the approach used, patients may be imaged at rest, while straining, or while voiding and even defecating. Studies have been performed with and without contrast material via the vaginal, urinary or the anorectal route. Hydrogen peroxide,[16] acoustic gel [35] and Barium sulphate suspension,[40] have been used as contrast material to enhance visualization of a sinus tract, urine leakage or rectal expulsion, respectively. Imaging studies have been performed with patients in the supine and upright position whereas, for defecatory studies patients are asked to assume a squatting position. Some investigators have obtained only sagittal or axial images, while others have obtained sagittal, axial and coronal images. A similar variety of techniques affects the methods chosen by researchers for calculating the most commonly used parameters including the bladder neck – to symphysis pubis – distance, the reference lines for uretrho-vesical angles and axis inclination and so on. This variation mainly affects the measurement of bladder neck movement and urethral angulation on straining. With the inferior border of the symphysis as the reference point, some investigators have used a coordinate system based on two axes and movement was calculated as a vector length, whereas others preferred the one (central) axis system for its' simplicity in calculating the distance from the anatomic landmark mentioned above. As far as the posterior compartment is concerned, a method for calculating the depth of rectocele, one for rectal prolapse and one for the inclination of the levator plate have been described. Obviously, such a variation in technique represents a formidable obstacle when comparing the results of studies between different centres.

## CONCLUSIONS

Sonographic imaging of the pelvic floor (PFS) in women, has advanced rapidly since its first introduction in 1985. It affords superior image resolution compared to the traditional transabdominal scanning approach when scanning the pelvis. Structures such as the anorectum, bladder and the rectovaginal septa are seen with excellent detail, which permits more precise interpretation of normal and pathologic states. After going through a pattern of technical evolution and equilibration with earlier techniques, PFS has become established and is currently included among the routine available imaging techniques when assessing pelvic floor dysfunction. Although the true cost-effectiveness of this imaging modality and its impact on patient care have not been established as yet, PFS has come into greater use today and progress continues at a rapid pace. The reasons for the recent unexpected upsurge of interest in PFS include the following: (*a*) a greater awareness of the fundamental and technical limitations of sonography on the part of the clinicians who now understand the optimal indications for the examination; and (*b*) an increased awareness of the needs of the pelvic floor clinicians on the part of the ultrasonographer or radiologist, who then is able to provide the expected answers to specific questions.

Provided a standard and meticulous technique is employed, PFS can produce important diagnostic information regarding the precise relationship of abnormal structures with other pelvic organs and it represents a significant step forward in the surgeon's ability to treat patients with symptoms related to pelvic prolapse, double incontinence and obstructed defecation.

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