APPLICATIONS OF ULTRASONOGRAPHY IN FEMALE LOWER URINARY TRACT SYMPTOMS: DIAGNOSIS AND INTERVENTION

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SUMMARY

Lower urinary tract symptoms (LUTS) are a common health problem causing considerable inconvenience to many women. Moreover, they are non-specific and can be caused by a large number of disorders. A thorough evaluation, including physical examination, imaging studies, and urodynamic investigation of the lower urinary tract, is crucial for appropriate management of bothersome symptoms. Ultrasonography has the advantages of non-invasiveness, reproducibility, no radiation exposure, and low cost. With the use of a high-resolution transducer, pelvic organs can be demonstrated clearly on ultrasonography. In addition, three-dimensional sonography provides a clear demonstration of the spatial orientation of the female lower urinary tract. Both color and power Doppler scanning can not only reveal the vascular flow in pelvic organs, but also demonstrate urinary flow. Ultrasonography has dual functions in the management of female LUTS: diagnosis and intervention. It may help physicians to recognize the anatomic characteristics of specific pelvic floor disorders, to explore the pathophysiologic mechanism responsible for pelvic floor dysfunction, and to assist in the surgical management of LUTS with minimal invasion. Since female LUTS may originate from gynecologic or non-gynecologic conditions, it is more convenient and helpful to obtain transvaginal and introital sonograms at the same time by using an endovaginal probe. [Taiwanese J Obstet Gynecol 2004;43(3):125-135]

Key Words: color Doppler, detrusor overactivity, interventional ultrasonography, lower urinary tract symptoms, stress urinary incontinence, voiding dysfunction

Introduction

Lower urinary tract symptoms (LUTS) are a common health problem causing considerable inconvenience for many women. LUTS consists of irritative and obstructive symptoms, which are non-specific and can be caused by a large number of disorders. A thorough evaluation, including physical examination, imaging studies, and urodynamic investigation of the lower urinary tract, is crucial for appropriate management of bothersome symptoms.

Since the introduction of real-time technology in the 1980s [1], ultrasound has been widely applied and has replaced radiography in the evaluation of pelvic floor disorders [2-4]. It has the advantages of non-invasiveness, reproducibility, no radiation exposure, and low cost. With the use of a high-resolution transducer, pelvic organs can be demonstrated clearly. Moreover, three-dimensional technology with simultaneous axial, transverse, and coronal views of pelvic floor organs clearly displays the spatial orientation of the female lower urinary tract [5]. Both color and power Doppler scanning can not only reveal the vascular flow in pelvic organs, but also demonstrate urinary flow. Color Doppler ultrasound analyzes the frequency shift of flow velocity information, while power Doppler technology uses the amplitude component of received signals to
quantify the number of moving particles.

**Basic Procedure**

Many approaches have been proposed for the ultrasound evaluation of the lower urinary tract. These include transabdominal [1], transvaginal [6], transrectal [7], perineal (or translabial) [8], and introital approaches [9,10]. As the lower urinary tract can be shaded by the acoustic shadow of the pubic symphysis, the transabdominal approach is rarely used except for measurement of bladder volume [10]. For dynamic assessment, the transvaginal approach may exert a compressive effect on the lower urinary tract [11,12]. Therefore, in order to prevent the distortion of the anatomy of the lower urinary tract by probes, the perineal or introital approaches are currently widely used. The differences between perineal and introital approaches are the site where the transducer is placed and the probe used in scanning: perineal ultrasound uses a linear- or curved-array convex probe with frequency between 3.5 and 5 MHz [13], while introital ultrasound uses a sector endovaginal probe with frequency between 5 and 7.5 MHz [9,10]. The transducer is placed on the perineum in the perineal approach, and is positioned between the labia minora just underneath the external urethral orifice in the introital approach [14]. Both of these approaches have been proved to be devoid of potential morphologic artifacts resulting from the distortion of the bladder neck or urethra [2].

It has been suggested that the information obtained during ultrasonographic evaluation of the female lower urinary tract should include the patient’s position, bladder volume, liquid used for bladder filling, method of bladder filling (spontaneous or retrograde filling), simultaneous pressure measurement (cystometry, urethral pressure profile, or voiding study), size of ultrasound transducer, ultrasound machine (type and manufacturer), ultrasound frequency, picture orientation, and approach (introital, perineal, vaginal, rectal, or abdominal) [10,15]. There is disagreement regarding the optimal orientation of images. Some authors prefer an orientation as on conventional transvaginal ultrasound [16]. However, others recommend showing superior structures above, inferior structures below, anterior structures on the right, and posterior structures on the left [10].

The examination can be performed in a dorsal lithotomy, semireclining, or standing position [16,17]. There are no significant differences in the dynamic assessment of the bladder neck between the semireclining and standing positions [17]. The ultrasonographic evaluation of the lower urinary tract begins with the midsagittal plane. This results in an image including the symphysis pubis, urethra, bladder neck, vagina, cervix, rectum, and anal canal (Figure 1). By moving the transducer to the left or to the right, additional areas of periurethral structures can be assessed [17]. The pressure exerted by the transducer should be kept as low as possible, while being sufficient to obtain good images with high resolution. The presence of a full rectum may impair diagnostic accuracy, and sometimes, necessitates a repeat assessment after defecation [16].

The bladder volume should be fixed on examination: 300 mL for the evaluation of dynamic changes in the bladder neck, and less than 50 mL for the assessment of bladder wall thickness [10,17,18]. The bladder volume can be estimated by either a transabdominal or transvaginal approach, although the accuracy is not reliable for bladder volumes less than 50 mL. In the transabdominal approach, three parameters, including height (H), depth (D), and width (W), are obtained from two perpendicular planes (sagittal and transverse). In sagittal scanning, height and depth correspond to the greatest superior–inferior measurement and the greatest anterior–posterior measurement, respectively. Thus, the bladder volume can be calculated from the formula: bladder volume (mL) = H × D × W × 0.7, where 0.7 is a correction factor for the non-spherical shape of a full bladder. The approximate error rate of the above formula is 21%. Transvaginal ultrasound has also been recommended to measure bladder volumes of 2 mL to 300 mL. Horizontal height (H) and vertical depth (D) are obtained from sagittal scanning, and the bladder volume can be estimated according to the formula: bladder volume (mL) = H × D × 5.9 – 14.6 (95% confidence limits around ± 37 mL) [19].

![Figure 1. Pelvic floor scan using introital ultrasonography. Ut = uterine corpus; BL = bladder; sp = symphysis pubis; u = urethra; v = vagina; A = anus; r = rectum; cx = cervix.](image-url)
Normal Images of the Female Lower Urinary Tract

On ultrasonography, the symphysis pubis is displayed as an ovoid-shaped structure with a homogeneous hyperechogenic nature. Without signs of infection, the bladder content is uniformly echoluent. The bladder wall is smooth and intact. The normal bladder wall is no more than 6 mm thick [20] and can be divided into two layers: the outer endopelvic fascia and the inner bladder mucosa. The former is more echogenic than the latter. The thickness of the endopelvic fascia is fixed regardless of bladder volume; however, the thickness of the bladder mucosa varies with the degree of bladder distension. While scanning is a little deviated to the right or left parasagittal plane, two tiny nodules – the ureter papilla – located at the junction of the trigone and bladder can be visualized with peristalsis. The position of the ureteral orifice can be identified by urinary flow from the ureter orifice (ureter jet phenomenon) displayed on color and power Doppler scanning. The urethra is a tubular structure with a central echolucent area and surrounding echogenic sphincters [21]. Color and power Doppler ultrasonography can reveal blood supply signals within and around the urethra, whereas scanty vascular signals are noted in the bladder wall. Less bladder neck hypermobility and no bladder neck funneling are noted in normal continent women compared with those with stress urinary incontinence (SUI) and pelvic organ prolapse [9,17]. The normal range of bladder neck motion has not been defined and there is a wide range of overlap between normal and abnormal values. In addition, measurements of bladder neck position are reported to be influenced by bladder filling, patient position, and catheterization [22,23]. Using the introital approach, Yang and Huang found that in healthy continent patients, the angles between the bladder neck and the midline of the symphysis pubis are 81 ± 15° at rest, and 113 ± 27° during straining, with a rotational angle of 30 ± 20°; the distances between the bladder neck and the midline of the symphysis pubis are 25.7 ± 4.9 mm at rest and 22.9 ± 3.3 mm during straining [9]. Bader et al reported that in women without SUI and prolapse, the posterior urethrovescical angle is 96.8° at rest and 108.1° during stress [24].

Ultrasonographic Characteristics of Pelvic Floor Disorders

Without infection, urine is anechoic in nature, occasionally with some free-floating particles on ultrasonography. With infection, the echogenicity of the urine increases or even forms a fluid-debris level. The bladder wall is focal or generally thickened. Intravesical blood clots, which are echogenic in nature, may be demonstrated in some rare conditions, such as surgical damage to the lower urinary tract, postoperative bladder bleeding, or hemorrhagic cystitis. Hemorrhagic cystitis is defined as gross hematuria associated with bladder inflammation, and may be caused by infection, medication, chemical toxins, or pelvic irradiation [25]. A thickened and hypervascular bladder wall with either active bleeding from the bladder wall or formation of intravesical blood clots, or both, are the usual findings on color or power Doppler ultrasonography [25,26]. The detection of distal ureteral calculi or bladder stones by sonography appears promising [27–29]. However, excretory urography is still helpful because not all urolithiasis can be detected by ultrasonography. The sonographic characteristics of a distal ureteral calculus include unilateral dilatation of the ureter, which is invisible in normal conditions [30], and the existence of a hyperechogenic stone within the ureter accompanied by a strong acoustic shadow and surrounding edematous tissue [31]. Bladder calculi account for 5% of urolithiasis and usually occur as a result of foreign objects, obstruction, or infection [32]. In the situation of bladder calculus secondary to a suture from a bladder neck suspension, hyperechoic suture material and bladder stones can be clearly demonstrated on ultrasonography [29,33]; however, radiography and cystoscopy may fail to identify the underlying pathogenesis of the stone [29]. Abnormalities of the bladder wall include focal or generalized thickening, loss of integrity, and abnormal vascularity. In addition to infection, pelvic radiation, pelvic surgery, bladder outlet obstruction, and neoplasm may also cause bladder wall thickening [20,34]. In patients with bladder outlet obstruction, a thickened bladder wall with trabeculation, or even formation of diverticulum, and high post-void residual urine volume may be displayed on ultrasonography. Transvaginal ultrasonography has been suggested as a useful tool in the detection of bladder wall invasion by cervical cancer [35]. The mobility of the bladder wall can be assessed by the ability of the bladder to slide along the uterine cervix when the probe is pushed up against the bladder from the anterior fornix. Mobility is considered to indicate an intact bladder wall [35]. With further invasion of cervical cancer into the bladder, the relationship of free mobility between the cervix and bladder is lost, the integrity of the endopelvic fascia is broken, and a tumor nodule may be formed and protrude into the bladder cavity. Transvaginal ultrasonography has been reported to have 95% accuracy in detecting bladder wall invasion...
by cervical cancer [35].

Ultrasonography is also a useful diagnostic modality for screening and detecting bladder tumors [36]. On ultrasonography, bladder tumors can be polypoid, sessile, or plaque-like, with a regular or irregular surface and with or without calcified foci [36]. Color and power Doppler ultrasonography may demonstrate neovascularization within the tumor, with a low resistance index in the tumor vessels (Figure 2). Vesicovaginal fistula and vesicouterine fistula can be displayed by transvaginal ultrasonography. Factors aiding the visualization of vesicovaginal fistula are edematous changes in the bladder and vaginal walls, accumulation of urine inside the vagina, and urine flow induced by coughing or the Valsalva maneuver [37–39]. Reverse urine flow from the fistula into the bladder may be induced by increased intravaginal pressure secondary to reflex pelvic floor contraction or the inward motion of the vaginal probe during coughing [38]. This should be differentiated from the urinary stream coming from the ureter orifice (ureter jet phenomenon).

Thirteen percent of cases with bladder outlet obstruction are secondary to urethral stricture [40], which appears as distortion of the central hypoechoic urethral mucosa on ultrasonography [41]. Better delineation of a urethral stricture can be achieved by increased abdominal pressure on a full bladder, permitting pseudoadjacent filling of the proximal urethra [42]. A hypoechoic structure around the urethral mucosa on ultrasonography indicates a fibrotic and nondistensible urethral segment [43], which is histologically consistent with spongiosis [43,44], and is visible even in the presence of extensive stenosis. It is closely related to the ultimate prognosis of urethral stricture [43,44]. Urethral diverticulum is an uncommon cause of female LUTS. The reported incidence of female urethral diverticulum is 1% to 6% [45]. Transvaginal ultrasound is effective in the evaluation of suspected urethral diverticulum [45], which is demonstrated as single or multiple cystic lesions with hypo- or mixed echogenicity surrounding the urethra (Figure 3).

Ultrasound is useful in detecting retroperitoneal hematoma following retropubic urethropexy, especially in patients with postoperative febrile and micturition problems [46]. Retropubic hematoma is displayed as an echolucent cyst between the symphysis pubis and the urethra and bladder. The size and progression of the hematoma can be determined by ultrasound, allowing timely and sufficient management to alleviate symptoms.

Ultrasound can identify different compartmental defects of the pelvic floor. Pelvic organ prolapse has been quantified using translabial ultrasound [2]. Enteroceles are often difficult to recognize on clinical examination, but are easily detected by perineal or introital ultrasound. Disadvantages of these methods are incomplete imaging of the cervix and vault with large rectoceles, and the possible underestimation of extensive pelvic floor relaxation because of the limited field of view depth of the transducer.

Pathophysiologic Changes in Pelvic Floor Dysfunction

**Detrusor overactivity**

A well-known sonographic finding in patients with unstable bladder is wavelike detrusor contractions accompanied by bladder neck opening [2]. Khullar et al and Soligo et al reported that an increase in mean bladder wall thickness is unique to detrusor overactivity
Ultrasonography in Female Lower Urinary Tract Symptoms

With a cutoff value of 5 mm, bladder wall thickness together with symptoms of overactive bladder have sensitivity of 84% and specificity of 89% for detecting detrusor overactivity [47,48]. These authors speculated that the increased bladder wall thickness in this disorder was secondary to detrusor hypertrophy associated with increased isometric detrusor contraction, urethral sphincter volume, and urethral closure pressure [47,48]. Robinson et al reported that in patients without evidence of genuine stress incontinence on laboratory studies, a cutoff of 6 mm was highly suggestive of detrusor instability [4]. However, Yang and Huang reported that a thickened bladder wall was a common finding in female LUTS, except in hypersensitive bladder [18]. Age, resting bladder neck angle, urethral mobility, and maximum urethral closure pressure are significantly associated with bladder wall thickness at the trigone and dome. Demographic, anatomic, and urodynamic factors may affect the bladder wall thickness at the trigone, dome, or both [18].

Stress urinary incontinence

Ultrasonography is not used for differential diagnosis of SUI. Instead, together with clinical examination and urodynamic data, it has been utilized to detect anatomic alterations associated with SUI, to select appropriate therapy, and to evaluate surgical outcomes and postoperative complications [2]. Ultrasonographic studies for SUI should provide quantitative measurements and qualitative descriptions of the lower urinary tract [10]. The German Association of Urogynecology recommends both posterior urethrovesical angle and bladder neck position as quantitative parameters in ultrasonographic study [10]. There are three methods for the measurement of bladder neck position: from one distance and one angle (Figure 4A) or two distances (Figure 4B), or from the height of the bladder neck with reference to a horizontal line drawn at the lower border of the symphysis pubis (Figure 4C). The first two methods use the symphysis pubis with its central line and inferior border as references, and have good reproducibility, whereas the third method is reliable only when a stable transducer position at rest and during straining is guaranteed.

The differences between resting and stress bladder neck angles yield the rotational angle, which represents urethral or bladder neck mobility [9], in a similar way to the Q-tip test. There are no definite values of normal bladder neck descent or urethral mobility, possibly because of the methodologic variations such as patient position, bladder filling, quality of the Valsalva maneuver, and measurements of bladder neck position. Although the positions of the bladder neck in patients with SUI are lower than those of continent women [9,11], there is an overlap between these two groups. Urethral mobility is reportedly related to incontinence grade [49,50]. On ultrasonography, the qualitative analysis of the female lower urinary tract consists of observation of bladder neck funneling [9,14,16,51–53] and bladder neck descent during stress [2,9]. The occurrence of bladder neck funneling suggests poor urethral closure pressure [52,53]. In addition to SUI, bladder neck funneling may also be found in urge-incontinent women [3,53], but it does not occur in normal continent women unless the bladder is full [17,52]. On some occasions, the opening of the bladder neck may be followed by egress of urine, which is manifested as hyperechoic flow from the bladder through the urethra on real-time scanning. This can be confirmed by color or power Doppler ultrasonography. During straining, the bladder neck may move in a semicircular fashion with the tip of the symphysis pubis as the center (rotational descent), or move downward along the urethral axis (sliding descent) [2,9].

Although the exact pathophysiology of SUI is unknown, the great majority of women with primary
SUI have urethral hypermobility [9,52,54,55]. Open Burch colposuspension is a well-accepted procedure for treating SUI secondary to urethral hypermobility without intrinsic sphincter deficiency [55–57], and is the reference standard against which other procedures are compared [55–57]. Burch colposuspension elevates and stabilizes the bladder neck and proximal urethra in a high retropubic position. On ultrasound, higher bladder neck position, smaller bladder neck angle at rest and during straining, and less rotational angle can be observed after both open and laparoscopic Burch colposuspension [58–61]. Other reported ultrasonographic findings after open colposuspension include decreased posterior urethrovesical angle, ventrocranial displacement of the bladder neck, and reduced incidence of bladder neck funneling and bladder hypermobility [58–61]. Successful colposuspension is associated with a more anterior, although not necessarily more elevated, urethrovesical position [2,58–61]. However, a trend that urethral support decreases with time has been noted on ultrasound in patients who have undergone either open or laparoscopic Burch colposuspension [58,60]. In patients developing posterior bladder suspension defect, cystocele and enterocele may be detected on ultrasound.

Despite a high success rate of around 70% to 90%, urinary retention and late voiding difficulty occur after up to 20% of colposuspensions. One of the precipitat-
ing factors is bladder neck overcorrection with undue elevation and fixation of the bladder neck [59–61]. Viereck et al have shown that differences between the pre- and postoperative vertical height of the bladder neck are associated with postoperative voiding complaints, for example, urgency, de novo urge incontinence, or voiding difficulty [59,60].

The tension-free vaginal tape (TVT) procedure is becoming common for the treatment of female SUI and has the advantage of being minimally invasive. TVT is highly echogenic and easily identified posterior to the urethra on ultrasound [62–71]. On ultrasound, bladder neck mobility remains unchanged after TVT. Urethral angulation and ventrocaudal movement of the tape towards the symphysis pubis have been described during straining in patients who have received TVT [63]. The mode of action seems to be associated with dynamic kinking of the urethra during straining or compression of the urethra against the posterior surface of the symphysis pubis, or both (Figure 5) [63–66]. However, studies have reported variable effects of the TVT procedure on voiding function [63,67]. After the TVT procedure, the incidence of urinary retention or obstructive voiding symptoms is reported to be around 2.3% to 14% [68], and postvoid residual urine is increased postoperatively [69]. Profound angulation of the midurethra at rest suggests over-lift of the urethra by the tape [63,70], while acute narrowing of the central echoluent area of the urethra at rest implies voiding dysfunction postoperatively [71].

**Voiding dysfunction**

The cause of voiding dysfunction may relate to the bladder or urethra, or both. Bladder factors include detrusor underactivity or areflexia; urethral causes consist of functional or mechanical obstruction, which can further be categorized as compressive or constrictive. On sonography, the urethra is shown as a tubular structure with a hypoechoic center representing the urethra mucosa (Figure 1). The hypoechoic nature remains even when the urethral mucosa is prolapsed [72].

Voiding dysfunction may result from distortion of the anechoic urethral mucosa by an intraluminal lesion (i.e. urethral stricture) [41] or from extramural factors such as an over-lifted TVT [71]. The pathophysiologic mechanism of voiding dysfunction secondary to an impacted pelvic mass such as a retroverted gravid uterus or a fibroid in the posterior uterine wall is different from those for dysfunction secondary to over-elevation in the bladder neck suspension procedure or to genitourinary prolapse [29,60,61,73]. Voiding dysfunction in cases of an impacted pelvic mass is caused by a displaced cervix compressing the lower bladder, obstructing the internal urethral orifice [74,75]. The urethra itself is not compressed or distorted.

**Interventional Application**

Minimally invasive methods are the current trend in health care. Transvaginal ultrasound provides high-resolution imaging of the lower urinary tract, and may serve as an aid in the management of lower urinary tract disorders with minimal invasion. With the combination of ultrasonography and flexible cystoscopy, percutaneous suprapubic cystostomy may be performed via a stab technique with minimal risk to the surrounding pelvic organs [76]. In the procedure of urethral dilation...
for urethral stricture, transvaginal ultrasound is helpful in preventing urethral perforation and creation of a false passage, a possible sequel to blind dilation. Even in the presence of extensive stenosis, the urethral mucosa appears as a hypoechoic area on ultrasonography. Thus, under ultrasonographic guidance, advance of the dilator exactly through the echolucent part of the urethra ensures penetration of dilators into the correct tissue [39].

Vesicovaginal fistula will cause social inconvenience and have a psychologic impact on women. The treatment of a vesicovaginal fistula includes bladder drainage and surgery, depending on the size and location of the fistula. Adequate and undisturbed drainage results in closure of a small posthysterectomy fistula in 12% to 80% of cases, but the outcome is unpredictable. If the fistula does not close, then it must be repaired surgically. The timing of surgical intervention is most important and is best determined by periodic evaluation of the tissue. Transvaginal sonography offers serial, non-invasive assessment of the condition of the bladder wall and fistula, and helps in determining the timing of surgical repair [39].

After a major procedure in which surgical damage to the lower urinary tract or postoperative bladder bleeding is a possibility, the bladder must be adequately drained and not become overdistended. Cystoscopy may be helpful for determining the cause of blockage and evacuation of clots when bladder drainage fails because of obstruction, kinking, knotting, or displacement of the catheter. However, severe hematuria may obscure the cystoscopic view and necessitate high-flow irrigation, which carries a risk of bladder rupture [77]. Transvaginal sonography is an effective and safe tool in the treatment of acute urinary retention due to intravesical blood clots [78]. It can help in identifying and localizing the clots without causing further instrumental injury to the bladder wall, and it can also aid in estimating the irrigating volume infused in order to prevent bladder overdistension. Intravesical suction and irrigation to remove the clots may then be performed more efficiently [78].

Future Investigations

The levator ani muscle is believed to play an important role in supporting pelvic organs and maintaining normal pelvic floor function. Magnetic resonance imaging (MRI), which gives high-resolution images of muscular tissues, has been widely used for morphologic investigation of the pelvic floor. MRI findings in subjects with pelvic organ prolapse and urinary incontinence include focal changes in muscle width, configuration and signal intensity of the levator ani muscles, loss of connection with the urethra, and an increase in urogenital hiatus size, straining levator plate angle, and levator hiatus height [79]. However, not all women with pelvic floor prolapse have abnormal morphologic features [80]. There is considerable variation in the size and configuration of the pelvic floor structures in nulliparous asymptomatic women [81]. Therefore, it has been suggested that abnormal anatomic findings on MRI be regarded as pathogenic only if corresponding symptoms are present [81]. It would require a study with a large sample size and strict inclusion criteria to precisely define the functional implications of specific MRI findings. However, MRI is currently not suitable for a large-scale survey because of its sophistication and expense. On the other hand, ultrasonography is suitable for a large-scale survey owing to its popularity and availability [9,18,52]. Furthermore, three-dimensional ultrasound allows volume calculation and scans pelvic organs in axial, transverse, and coronal planes simultaneously. It is quite possible that ultrasound may replace MRI in evaluating the morphology and function of the levator ani muscle in the near future.

The function of the levator ani muscle has been assessed indirectly by the displacement of intrapelvic structures (e.g. bladder neck or bladder base) on its contraction by perineal ultrasound [82]. The bladder and urethra move upwards and ventrally during pelvic floor contractions. Correlations between the shift in the bladder neck and palpation/perineometry are good [82]. Ultrasonography can provide visual biofeedback in pelvic floor re-education [83]. However, the assessment of levator ani function is still regarded as inherently problematic in ultrasonography. Further studies will be needed to verify the reproducibility and validity of ultrasound in investigating the levator ani muscle.

Conclusions

A comprehensive evaluation of the female lower urinary tract is based on clinical history, physical examination, urodynamics, and imaging studies. Ultrasound is a valuable alternative to radiography and allows functional–morphologic documentation. With increasing knowledge of its application in the female lower urinary tract, more diagnostic and surgical procedures may be performed in a less invasive way with the aid of ultrasound. For female LUTS, it is convenient and helpful to perform transvaginal and introital sonography at the same time using an endovaginal probe, because LUTS may be secondary to gynecologic or non-gynecologic conditions.
References


